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EUROPEAN TECHNICAL COATINGS CONGRESS

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BOOK OF ABSTRACTS

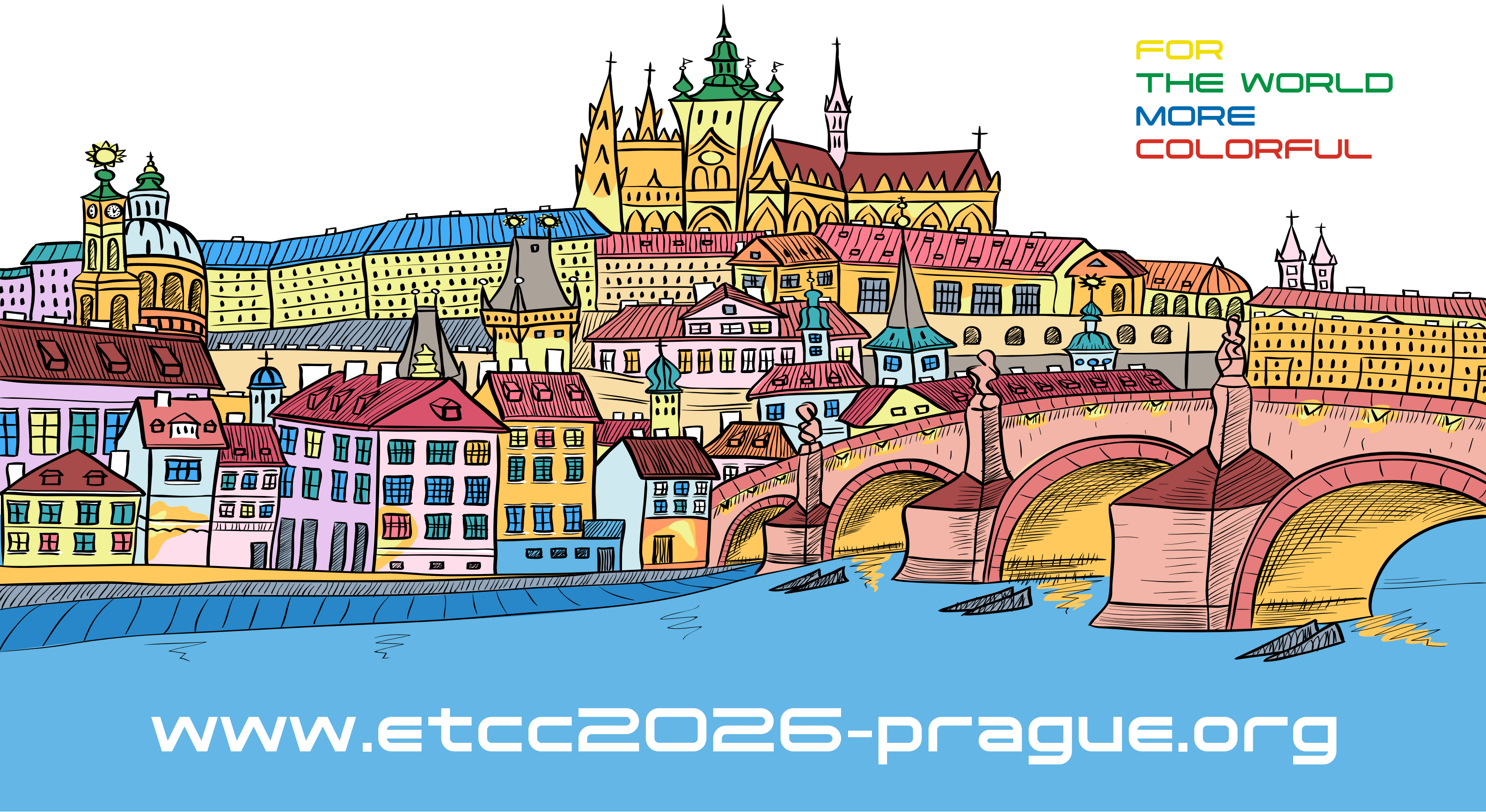

TABLE OF CONTENTS

ORAL CONTRIBUTIONS

POSTERS

ORAL LECTURES

Pioneering coating solutions: Advanced raw materials and value chain collaboration to tackle industry trends

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The coatings industry is undergoing a significant transformation driven by evolving regulatory frameworks, sustainability imperatives, and the demand for advanced functionalities. Increasing restrictions on volatile organic compounds (VOCs), substances of very high concern (SVHCs), and biocides are reshaping the selection of raw materials, compelling manufacturers to innovate in compliance with stricter environmental and health standards. Concurrently, there is a growing demand for non-petrochemical-based raw materials, such as bio-based polymers and renewable feedstocks, to reduce dependency on fossil resources and lower carbon footprints. These trends are driving the development of modern coatings raw materials that combine regulatory compliance with sustainability.

Beyond environmental considerations, the market is also seeking coatings with enhanced functionalities, such as antimicrobial surfaces for improved hygiene, properties for increased durability, and smart coatings that respond to environmental stimuli.

Achieving these advancements requires close collaboration across the value chain, from raw material suppliers to manufacturers, leveraging modern data assessment tools to optimize formulations and ensure superior results.

This presentation will explore how modern raw materials are addressing these key trends, highlighting innovative solutions that balance performance, sustainability, cost efficiency and regulatory demands.

From material design to coating performance: Pumpable bio-based thixotropic alkyd resin for wood protection

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Thixotropy is essential for maintaining the stability and application quality of paints and coatings by preventing pigment and filler sedimentation during storage and limiting sagging on vertical surfaces. Conventional thixotropic alkyd resins are commonly supplied as rigid gels that require heating or high shear for proper incorporation, which can complicate processing for coating manufacturers. To overcome these limitations, a new pumpable thixotropic alkyd resin has been developed. Supplied as a soft gel, it can be handled and incorporated at room temperature without heating, reducing energy consumption during production. The resin is dissolved in a dearomatized high–flash point solvent, ensuring safe transport, easy pumping, and simplified logistics without ADR classification. Its high solids content also supports low VOC formulations in line with current environmental requirements.

The bio-based resin, derived from soybean oil, is a polyamide-type long oil alkyd designed to modify the rheology of wood stains and decorative coatings. The development focused on achieving an optimal balance between thixotropic efficiency, pumpability, and high solids content. Rheological behavior was characterized using the five-interval thixotropy test, which simulates shear conditions encountered during pumping and mixing and provides insight into structural breakdown and recovery. Performance was further evaluated in combination with a commercial long oil alkyd resin for wood applications, with particular attention to sag resistance as a key indicator of coating performance on vertical surfaces.

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Protecting exterior wood with high-performance coating systems

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Protecting wood against moisture and UV light requires the use of coating systems. For non-durable wood species, a preservative treatment (containing TP 8 biocides) is essential before coating application. In various European countries (notably France, Germany, Austria), questions have recently been raised concerning the overall process of wood protection in the context of promoting the circular economy and responding to user demand for reduced use of biocidal preservative treatments. This generates very high expectations for exterior wood coating systems: can they help reduce the dose of biocides used before applying the coating? Can they even enable the non-use of biocides to protect wood? To achieve this goal, particularly high-performance coating systems are required. However, the current framework for evaluating the performance of exterior wood coatings in Europe is based primarily on visual observations (cracking, flaking, chalking, blistering) carried out on test specimens exposed for 12 months at 45° facing south. In addition, water protection is controlled for the non-weathered coating and associated with limit values. This evaluation system was developed in the 1990s at a time when coating systems were still predominantly solvent-based and contained far more TP 7 biocides than they do today. This current framework has several limitations and overlooks important issues for effective wood protection, which we address in this paper. We evaluated the performance of coating systems based on current performance criteria, while also assessing the consequences of ageing on other properties such as fungal growth and changes in general appearance, gloss and mechanical properties of the coatings. The general appearance of test samples is assessed visually but is not analysed because it is not currently associated with any performance criteria. Our studies show that this property provides important information about surface damage (sometimes invisible to the naked eye), particularly when it is associated with a significant change in gloss. The consequences of fungal growth on coating surface (including blue stain fungi) are clearly overlooked by the current assessment framework. These microorganisms can develop on most coatings and are not just an aesthetic problem: they compromise the water protection provided by the coating system, as they can perforate it. Therefore, investigating the water barrier after ageing is essential in a wood protection strategy where the coating system is expected to play a key role. Limit values for the water barrier of weathered coatings should be established in addition with those already existing for non-weathered coatings. We propose additional criteria to enable the selection of high-performance coating systems, thereby contributing to the objective of protecting wood with reduced doses of biocides or even without using them in certain applications.

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Fire resistant water-based coating

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Wood coatings aim to increase the lifetime of the wood to be used in cladding applications, by protecting the wood against water absorption, UV-induced degradation, mechanical protection and simultaneously maintaining the desired visual appearance of the cladding. Today, the most common used coatings are water-based due to their strong performance, especially for exterior use. However, most of the coatings have fossil-based binders and that is a disadvantage from a climate perspective as well as a resilience perspective since some of the fossil sources are outside Europe. This study explores the integration of colloidal lignin particles (CLPs) into water-based wood coating formulations as a strategy to create strong and resistant films on the wood surface, protecting the wood against water, UV light, improve coating adhesion to wood and mechanical properties. In addition, the colloidal lignin particles will be chemically modified with phosphor and nitrogen to increase the fire-retardant properties of the wood which can improve the long-term durability of fire-retardant coatings. Many fire retardants are water-soluble and leach out due to rain. Our initial results show that CLP-modified coatings formulations exhibit increased protection against fire and reduced water permeability. These findings demonstrate the strong potential of CLPs to advance next-generation bio-based coating systems.

Bio-MPA, a novel unique building block for an unusual combination of properties

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Dutch green chemical ingredients company Relement is a pioneer in the field of specialty aromatics, for which there are no sustainable alternatives today. By using proprietary and patented technology, Relement can convert agricultural waste streams into bio-aromatic building blocks. Relement's first product is called bio-MPA, a performance boosting bio-aromatic building block for alkyd coating resins.

Abstract

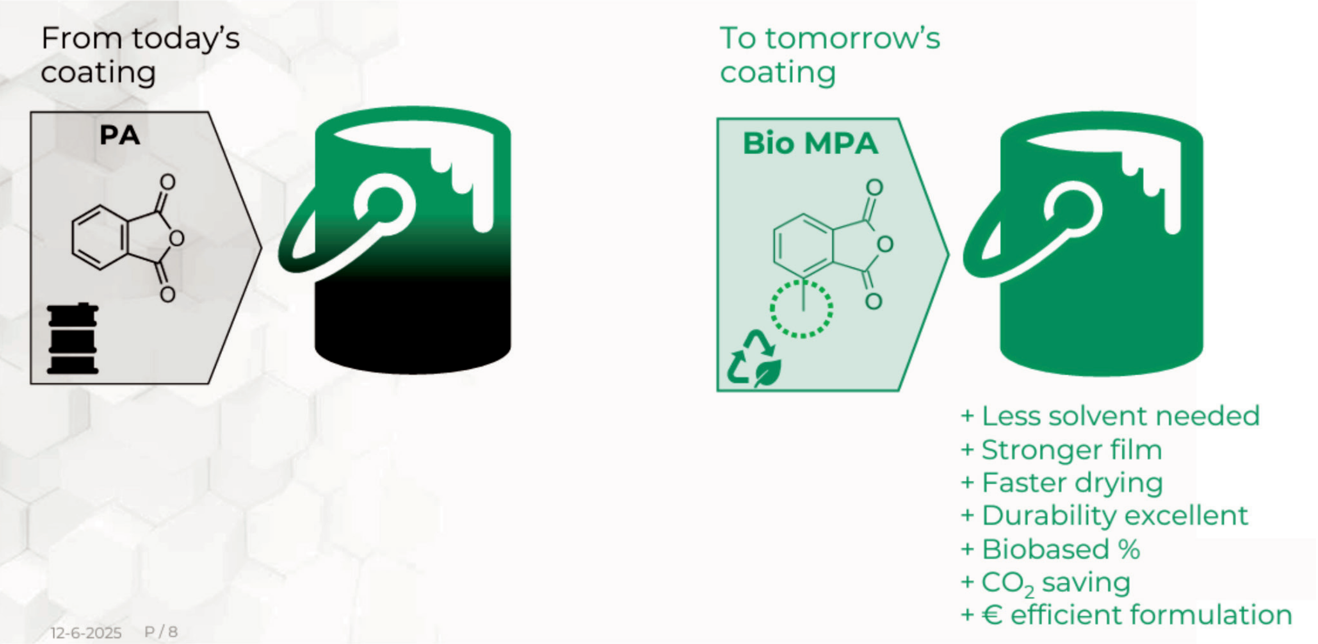
Phthalic anhydride (PA) is a cornerstone aromatic building block in alkyd binders, yet sustainable aromatic alternatives have historically been limited. Relement is developing **bio 3-methylphthalic anhydride (bio-MPA)** as a bioaromatic ingredient that can replace PA in alkyd resins while delivering distinct performance benefits due to its additional methyl functionality.

In this contribution we discuss how bio-MPA behaves when used in alkyd synthesis and how its molecular structure changes both resin making and film performance. Application research in alkyd coatings indicates that incorporating bio-MPA results in an unusual combination of properties: **higher hardness, improved drying and solvent/MEK rub resistance combined with lower VOC potential** and **higher gloss**. We can explain in detail why these properties are influenced.

From a processing standpoint, bio-MPA is not identical to PA. It is almost a drop-in but may require adjusted process conditions and/or catalysis. We summarize practical production guidance observed in comparative alkyd syntheses.

The presentation concludes with takeaways for formulators and resin manufacturers on selecting substitution levels, anticipating processing differences, and translating resin level advantages into coating performance—supporting the development of next generation, higher performing coatings with improved sustainability credentials.

REACH registration of bio-MPA is expected summer 2026. Industrial ton-scale production of bio-MPA will start end of 2026.



From today's coating

To tomorrow's coating

+ Less solvent needed
+ Stronger film
+ Faster drying
+ Durability excellent
+ Biobased %
+ CO_2 saving
+ € efficient formulation

Development and new application of multifunctional poly(phosphorylcholine) films

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Functional polymer films are a class of smart surface coatings used to design smart interfaces. Due to their specific physicochemical properties, which have been intensively studied in recent decades, this form of surface modification is promising for various applications. In this context, zwitterionic polyphosphorylcholines (PMPCs) and their use as multifunctional coatings have received increasing attention in recent years. Discussed applications include anti-fog, anti-fouling, easy-to-clean, and anti-freeze coatings [1-2]. This lecture will demonstrate that these applications are based on the chemical structure of PMPC and its specific interaction with water, resulting in a unique arrangement of the solvent molecules. This leads to pronounced swelling behavior, which can be controlled depending on the composition of the solvent. While PMPCs exhibit high solubility and undergo swelling in pure water and ethanol, the chains collapse at an ethanol content of 80% in water. This phenomenon, known as the co-nonsolvency effect, is used to selectively detach functionalized gold nanoparticles (AuNPs) on demand from model surfaces and real electronic devices, such as Si-FETs. Due to their unique optical properties, which manifest in a pronounced localized surface plasmon effect, AuNPs are being studied and used in biomedical, catalytic, sensing, and analytical applications. However, the production of such functionalized AuNPs is time-consuming, synthetically complex, and highly resource-intensive. Therefore, recovery strategies are considered. We demonstrate, through a series of desorption experiments, that by meticulously controlling the solvent composition, AuNPs can be regained from the surface functionalized by adaptive polymer coatings, such as PMPC films selectively and spatially resolved.

Obstacles to realize these applications include transferring PMPC coatings from small model surfaces to technically relevant substrates, ensuring scalability, and address stability concerns. Thus, the laboratory approach must be adapted to technical process standards. The lecture will address these issues and present application-oriented coating processes for films with easy-to-clean, anti-fog, anti-fouling, and anti-ice properties, as well as the new application of assembly and disassembly on demand for plasmonic nanoparticles. Additionally, strategies for enhancing stability against mechanical stress and degrafting by water will be discussed.

Acknowledgments

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Novel polyurethane dispersions meet oxygen barrier coatings

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Plastic flexible packaging is ubiquitous in modern life but presents pressing sustainability and functional challenges. Oxygen barrier coatings are essential for the preservation of food, but current multi-layered constructions hinder circularity due to poor recyclability. Progress depends on new materials that can operate on the mono-material packaging principle with max. 5% of functional coatings against the plastic.

With a deep-rooted commitment to sustainability driven by the convergence of green core technologies, allnex accelerates the transition towards renewable flexible packaging – favouring recycling and waste reduction. Novel proprietary polyurethane dispersions in water are presented based on their physico-chemical attributes. A strategy is developed to govern oxygen permeability by shaping the polymer architecture. The urethane and urea segments are the essential building blocks controlling gas barrier through lower diffusion (Fick's law) and solubility (Henri's law). As such, it is possible to maximize the level of these hard segments above 40% by weight, while controlling the resulting polymer microstructure (Fig. 1). The polymer shows consequently a very low solubility and a specific SEC technique was developed.

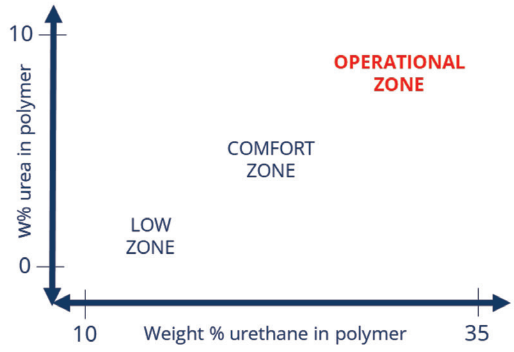

Figure 1: mapping of hard segments in the polyurethane and high barrier operational zone

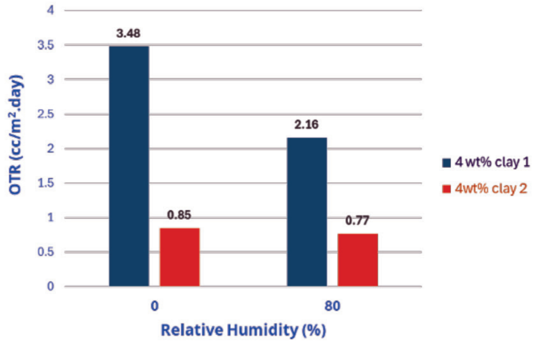

Figure 2: oxygen transmission rate (0–80% RH) at 5.5 gsm on PET using 2 clays (4w%)

Fundamentals on formulation and coating protocols are discussed with an emphasis on oxygen barrier measurement. It is important to obtain defect-free coatings at low coating thickness (2–6 microns) to reach ultimate barrier properties. The polymer dispersion presents a minimum film formation temperature (MFFT) ≤ 20°C, that avoids the formation of micro-cracks upon drying and does not require the use of additional co-solvents (VOC).

Finally, we present the key attributes of our new Ecowise-ChoiceTM prototype, passing our stringent blacklist of chemicals of concern and our competitive market analysis against five sustainability pillars. We highlight its barrier performance as a standalone coating and in combination with low-haze clay additives, hindering gas diffusion and delivering synergistic barrier enhancements. In that case, it is possible to reach oxygen transmissions <1 cc/m^2.day corresponding to best-in-class references, but without suffering from their defects (Fig. 2). We also show that optical clarity is very good as well as mechanical and chemical resistance. The product is approved for food contact in accordance with regulations in most relevant regions.

When AI meets reality: Data, models and limitations in coatings machine learning

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The rapid development and promising potential of AI methods have simplified their use in applications and sparked great interest in their widespread implementation. Machine learning (ML) is a subset of AI with algorithms learning patterns and relationships from data. The claim that every problem can be solved with large amounts of data is impossible in practice due to the lack of a universal method and the heterogeneity of data structures. Consideration should be given to the form in which data is described, how much data is available or can be collected, and what the actual goal of using ML is. This presentation introduces three very typical questions from the field of paints and coatings for implementation with ML in order to illustrate the differences in the choice of ML methods and the provision and preparation of data.

The first case addresses statistical optimization and machine learning algorithms for model development, which enable generalizable modeling even for previously unknown formulation cases [1]. Through sequential experimental design and data-efficient training strategies, a robust prediction model could be constructed with just a few experimental data points. In addition, explainable AI was used to present the modeled relationships in a transparent and comprehensible manner for users. The chemical system investigated comprised a two-component polyurethane coating whose optical and mechanical film properties were modeled as a function of the raw material composition.

Forecasting events in a time series requires extrapolation beyond the available data. The second case differs from the first in that, when applying the ML method as described previously, reliable predictions are limited to interpolation within defined system boundaries. Consequently, predictions concerning future developments, such as long-term damage progression, are not feasible using this approach alone. A concept is therefore presented that enables forecasting of long-term behaviour through similarity analyses of interpolated measurement series [2]. Using this approach, the thermal yellowing of a white pigmented coating was predicted with good reliability after only one third of the total test duration.

The last case deals with more complex data structures, where the source is not a single measured value but an entire spectrum. These applications are comparable to image recognition methods and require a targeted selection of methods based on neural networks and, as a rule, a larger amount of data. It shows how colour prediction based on spectral data achieves better results than, for example, individual values from the L*a*b* colour space, and how this approach was used to develop models for the transition from wet to dry paint in a coating [3].

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[2] Zhang, G., Borgert, T., Stoffelen, C., Schmitz, C. (2025). High-throughput and explainable machine learning for lacquer formulations: Enhancing coating development by interpretable models. *Progress in Organic Coatings* 205, 109265.
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Technical Paper: Advancing coatings formulation through AI and data-driven approaches

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This paper presents a unified approach to advancing coatings formulation by leveraging statistical modelling, design of experiments (DoE), and artificial intelligence (AI). The objective is to predict key decorative paint properties such as hiding power, gloss, and wet scrub resistance, through predictive modelling and systematic data analysis. Utilising tools such as statistical software or R Studio, the project significantly improved model accuracy, highlighting the potential of AI-driven methodologies in formulation development. Future projects focus on database expansion, automation, and enhanced inverse modelling techniques to accelerate formulation innovation.

Introduction

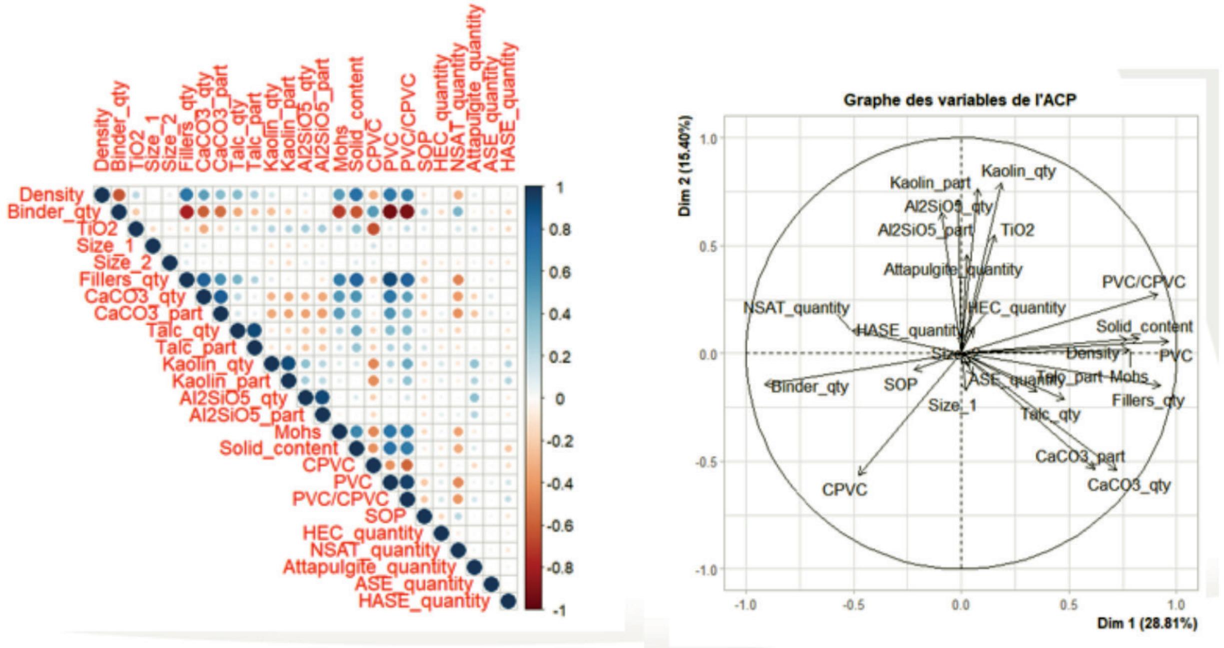
The coatings industry faces increasing demand for efficient and accurate formulation processes to cope with regulatory challenges, raw material shortage or increased demand for more sustainable solutions. Traditional methods, while reliable, often involve time-consuming trial and error. By incorporating AI and data-driven techniques, the industry can reduce development time while ensuring optimal performance. This paper consolidates efforts to integrate statistical modelling and experimental design to enhance predictive capabilities for key coating parameters.

Methodology

Parameter Selection and Database Structuring

A structured database of formulations collected over the past years in our laboratories was established, including critical input parameters such as pigment and filler content, binder quantity, additives composition and many more. Decorative paint formulations are complex and often based on more than ten raw materials with their own characteristics and influence on the final paint properties. Introducing too many input parameters creates the risk of overfitting and complexity. To mitigate that risk and simplify the model a parameter selection process was employed based on:

- Importance ranking in models.
- Correlations with target properties.
- Computational efficiency.



Graph 1. Selection methods of input parameters to limit correlation and risk of overfitting

The refined parameter set was consistent across models for hiding power, gloss, and wet scrub resistance.

Predictive Modelling Framework

Statistical and AI-driven techniques were implemented to predict paint properties:

- **Tools and Algorithms:** R Studio facilitated the creation of models using linear regression, random forests, decision trees, and neural networks.
- **Cross-Validation:** Data were divided into training and testing sets (80:20 split) to validate model performance.
- **Metrics:** Accuracy was assessed through metrics such as mean squared error (MSE), root mean squared error (RMSE), and determination coefficients (r^2).

Iterative Model Refinement

Successive iterations added new data points and formulas, improving model robustness and predictive reliability. Figure 1 illustrates the reduction in prediction errors with additional data.

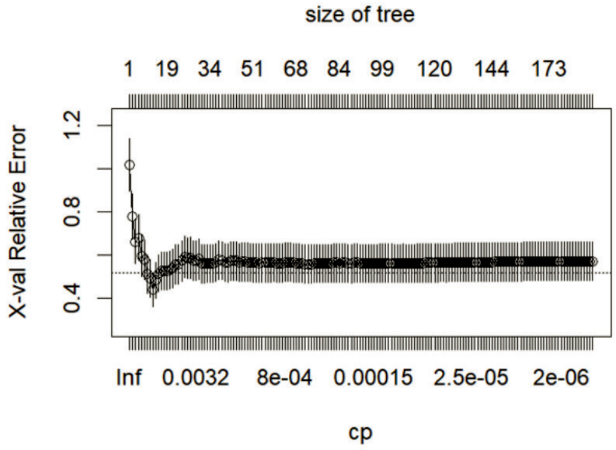


Figure 1. Defining the optimal size of the tree to find the best compromise between complexity and accuracy

Results and Discussion

Hiding Power Models for hiding power consistently identified PVC, cPVC, TiO_2 and filler selection as key factors. Decision tree models achieved r^2 values of 0.65, with further gains through parameter restructuring and additional data points. Figure 2 highlights the decision tree's accuracy for hiding power prediction.

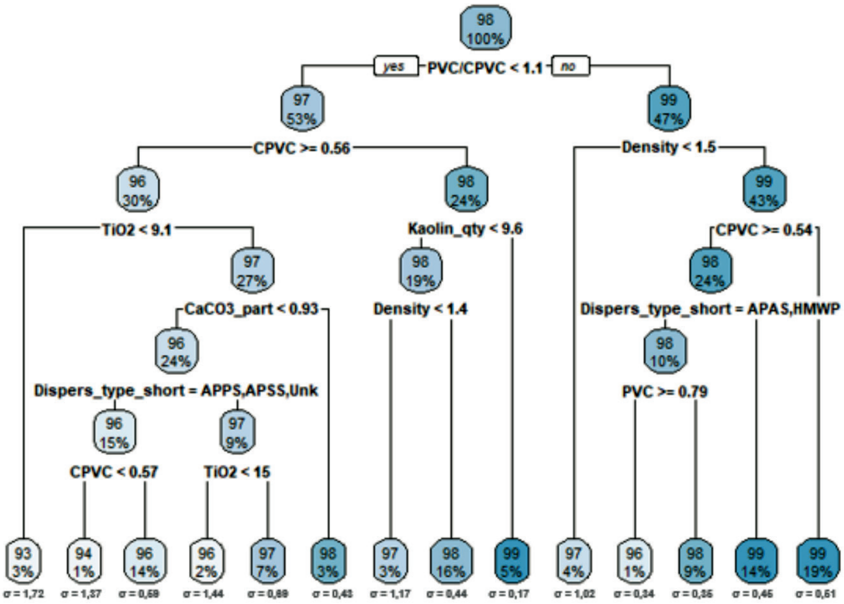


Figure 2. Decision tree for hiding power prediction

Gloss at 85° Binder quantity, filler quantity, and the size of fillers used emerged as influential factors for gloss. Predictive accuracy reached an r^2 value of 0.75. Higher binder quantities and smaller pigment particles contributed as expected to smoother surfaces and increased gloss.

Wet Scrub Resistance Wet scrub resistance depended on parameters such as binder quantity, particle hardness (Mohs), and TiO_2 content. Despite challenges with sparse data, models achieved acceptable predictive performance, with r^2 values around 0.69 for optimal decision trees.

Model comparison efficiency

To test the efficiency of the model, a formulation was prepared in the laboratory to evaluate its gloss, opacity and wet scrub resistance. In parallel the formulation was submitted on the one hand to our data model and on the other to 29 coatings scientists with an average experience of 17 years in the industry. The results that can be found in Table 2 prove that the model provides accurate results and outperforms the results that experienced scientists can predict.

	Opacity @8 m^2/l	Gloss @ 85°	Wet Scrub resistance [µm]
Lab results	98,13	3,3	9,15
Predictive model	98,04 ± 0,09	3,4 ± 0,1	6,74 ± 3,1
Coatings scientist	97,71 ± 0,42	10,93 ± 8,85	12,16 ± 8,74

Table 2. Performance of the developed model compared to experienced coatings scientists

Challenges and Limitations

During this project, some key challenges have been observed that should be considered in future developments:

- **Data Consistency:** Variations in measurement norms and missing data points introduced noise in model training.
- **Parameter Interdependencies:** Complex interactions required advanced models like neural networks to capture non-linear relationships.

Future Perspectives

- **Enhanced Database:** Expanding the database with additional formulations and parameters will increase model accuracy and applicability. The inclusion of parameters such as defoamer type and viscosity could enrich predictions.
- **Automation:** Automating data integration and model updates will streamline the prediction pipeline, ensuring real-time accuracy with minimal manual intervention.
- **Inverse Modelling:** Developing AI-based inverse models capable of suggesting parameter adjustments for desired properties will enable more efficient formulation development.
- AI Integration: Combining hybrid AI models, such as neural networks with random forests, can uncover deeper insights into parameter interactions and improve model robustness.

Conclusion

This work demonstrates the transformative potential of AI and data-driven approaches in coatings formulation. Predictive models developed for hiding power, gloss, and wet scrub resistance provide a solid foundation for future innovation. The integration of DoE and AI not only enhances efficiency but also opens new pathways for customer-specific formulation recommendations. Continued advancements in database management, automation, and modelling will further position AI as a cornerstone in the future of coatings technology.

Faster to the optimal formulation: Artificial intelligence in coating development

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Accurately analyzing and predicting coating properties during development is essential for reducing time to market and improving formulation efficiency. However, heterogeneous data sources, inconsistent structures, and complex interdependencies between raw materials, process parameters, and performance characteristics limit systematic evaluation and prevent the effective application of advanced AI methods.

To enable data-driven decisions and AI-based approaches in formulation development, this contribution presents a structured methodology. It integrates heterogeneous formulation and testing data, digitalized workflows, and AI-supported analysis into a unified material intelligence architecture. Fragmented datasets including recipes, analytical results, and process parameters are systematically consolidated into a harmonized and analyzable data model. Structured workflows ensure consistent data capture, contextualization, and traceability across projects.

Once consolidated into this centralized and harmonized data model, cross-experiment relationships become transparent, trends can be identified, and early property estimations become feasible based on historical data distributions. The approach is evaluated in a representative coatings development scenario involving interacting formulation variables and defined performance targets such as viscosity, solids content, or gloss level.

Building on this structured data foundation, predictive AI enables AI-based Design of Experiments (DoE). Bayesian optimization based on surrogate modeling is applied to iteratively identify promising formulation regions and recommend the next most informative experiments. Rather than exploring the formulation space uniformly on a trial-and-error basis, the model balances exploration and exploitation, efficiently converging toward defined target properties.

This approach results in a measurable reduction in experimental iterations, faster identification of optimal formulations, and improved resource allocation, while maintaining scientific robustness, transparency, and traceability.

100% Bio-based 1,3-propanediol enables bio-based resins to combine functionality with bio-renewability and carbon footprint reduction

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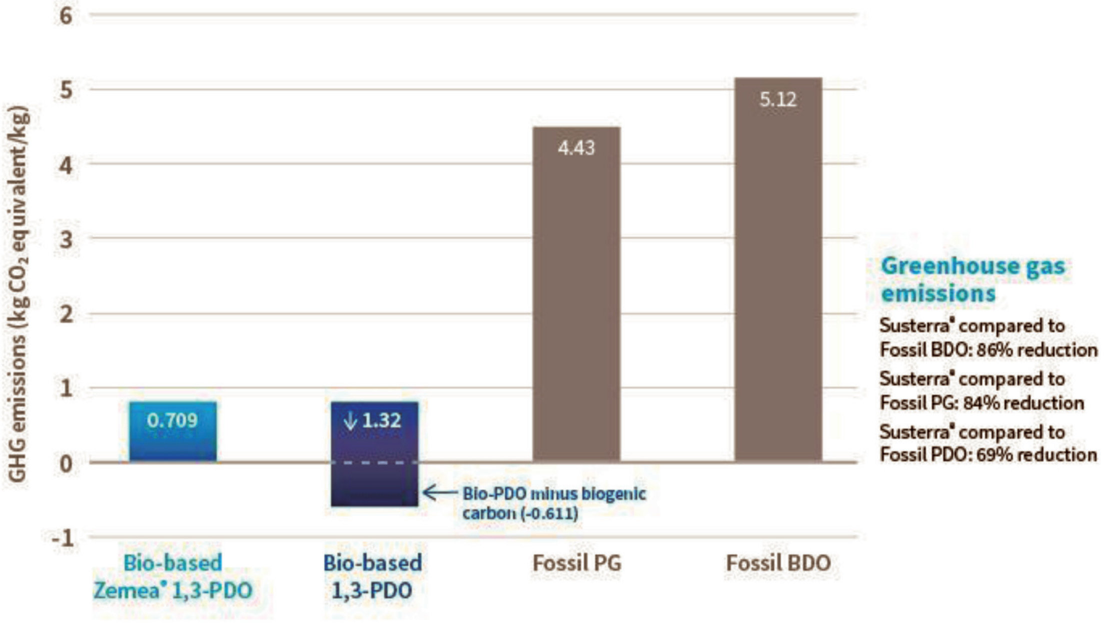
Using 100% bio-renewable 1,3-propanediol (1,3-PDO) as a building block to develop high performance resins allows downstream coatings producers to enter the high-end market with products that combine performance with a higher sustainable profile compared to corresponding fossil-based coatings. Reducing scope 3 emissions with science-based data is becoming critical and the recent LCA study performed by a 3th party for Primient Covation is enabling companies to move fast forward reducing their carbon footprint and achieving sustainability goals both from the use of renewables as from a GHG emission reduction perspective.

An overview on the renewable bio-based feedstock used and the regenerative practices will be combined with a detailed look at the 3th party peer reviewed LCA showing comparisons with fossil based alternatives and the opportunity to reduce GHG scope 3 emissions.



This presentation will also provide an overview of the recent technical work performed with 100% bio-renewable 1,3-propanediol in polyesters, alkyds and the functionalization with acrylates, di-methacrylates and diglycidylether into 1,3-PDO diacrylate, 1,3-PDO dimethacrylate and 1,3-PDO-diglycidylether.

From bio-circular raw materials to pure hydrocarbons: Applications in coatings, adhesives and sealants

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The Special Fluids division of TotalEnergies is a leader in the development and supply of high-purity hydrocarbon solvents and plasticizers for applications such as coatings, adhesives, and sealants. For more than 30 years, the company produces dearomatized hydrocarbons combining performance with health, safety, and regulatory compliance.

Aligned with TotalEnergies' ambition to achieve carbon neutrality by 2050, the Special Fluids division has continuously expanded its portfolio of bio-based products. This presentation will focus on the BioLife solvent and plasticizer range, highlighting the transformation from bio-circular raw materials to pure hydrocarbons.

The presentation will explain the bio-circular approach, including feedstock origin, ISCC PLUS certification, and how these elements ensure traceability and contribute to reduce the carbon footprint compared with fossil solvents. Life Cycle Assessment (LCA) aspects will be discussed to provide a balanced view on the benefits of bio-circular solvents.

In addition, practical formulation examples from coatings, adhesives, and sealants will be presented. These case studies demonstrate how bio-based hydrocarbon solvents can easily replace fossil solvents without compromising technical performance, while improving the sustainability profile of the final formulation.

Overall, the presentation will deliver a pragmatic and application-focused perspective on the role of bio-circular solvents in supporting more sustainable solutions for several applications where hydrocarbon solvents are needed.

Synthesis of sustainable unsaturated polyester resins from bio-based thiophene-2,5-dicarboxylic acid

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Commercially available unsaturated polyester (UP) resins are based on monomers derived from fossil resources, however there is increasing trend toward more sustainable options from bio-based feedstock. Favourable mechanical properties of UP resins are achieved by including rigid and flexible units in UP backbone. Typical UP backbone consists of phthalic acids, glycols such as ethylene glycol, propylene glycol, diethylene glycol and maleic anhydride [1]. Notable bio-based replacement for maleic anhydride is itaconic acid, a dicarboxylic acid with double bond [2,3]. In this study, we used itaconic anhydride, a bio-based compound produced by dehydratation of itaconic acid [4] or pyrolysis of citric acid [5]. This study is aimed to replace rigid phthalic segments with bio-based thiophene-2,5-dicarboxylic acid, which is accessible from adipic acid [6]. Series of polyesters was synthesized via condensation polymerization and then characterized with IR, Raman and NMR spectroscopy and size exclusion chromatography. To prepare fully bio-based UP resins, we replaced styrene with dimethyl itaconate. Mechanical and thermal properties of cured formulations were tested. It was found that bio-based resins can achieve Young's modulus of 3.5 GPa and glass transition temperature of 107 °C, comparable to commercially available UP resins [7].

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Synthesis and characterization of bio-inspired waterborne hydroxylated acrylic resin with applications to two-component polyurethane coatings

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Recent efforts regarding sustainability in the world of coatings are directed towards new film-forming agents from renewable resources [1]. This study presents the development of a partially bio-based, waterborne (WB), hydroxylated acrylic resin for use in low volatile organic compounds (VOCs) two-component polyurethane coatings.

The material was obtained via a two-step solution radical polymerization: hydrophobic monomers were added first, followed by hydrophilic ones. The resulting acrylic copolymer was then neutralised using amines and dispersed in water, forming core-shell particles with a hydrophobic core and a hydrophilic shell. Reagents' nature and equivalents, temperature and amount of solvent were varied. The obtained polyols were characterized by the determination of %Cbio (by 14C) [2], solid content, pH, acid number, hydroxyl number, Tg, viscosity, particle size, molecular weight distribution and dispersion stability. The rheological behaviour of the system was monitored with a cone-plate viscosimeter throughout both the polymerization and dispersion processes. The results were compared with those obtained from synthesizing the resin in solution.

The most promising polyol was selected for the development of two-component polyurethane (2K-PU) coatings and combined with a partially bio-based hydrophilic polyisocyanurate (%Cbio measured by ASTM D6866). Waterborne 2K-PU systems exhibit complex chemistry [3], as –NCO groups react not only with polyol –OH groups to form urethanes, but also with water, generating CO_2 and amines that can further form urea linkages. These side reactions occur during pot life and continue after film formation. Pot life was evaluated by monitoring viscosity evolution and –NCO group consumption over time, both in the absence and presence of a coalescing agent. Film formation was investigated by applying the mixtures onto glass substrates and curing under three different conditions. The presence of a coalescing agent and higher curing temperatures resulted in improved surface quality and enhanced mechanical performance as assessed by dynamic mechanical analysis (DMA). FTIR analysis indicated that these enhancements were associated with increased urethane formation and reduced urea content.

This study demonstrates the synthesis of partially bio-based, waterborne hydroxylated acrylic resins tailored for low-VOC 2K-PU coatings and provides a detailed understanding of the factors governing film formation and mechanical performance in these systems.

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Study of the effect of new organic pigments with Mg/Zn content on corrosion - Inhibition efficiency of epoxy ester coatings

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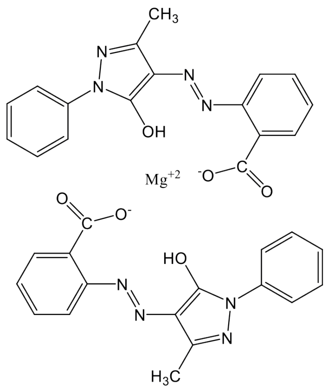
The aim of the work was to find a possible anticorrosion efficiency of novel magnesium/zinc organic pigments, improving the mechanical, anti-corrosion, and chemical properties of tested organic coatings.

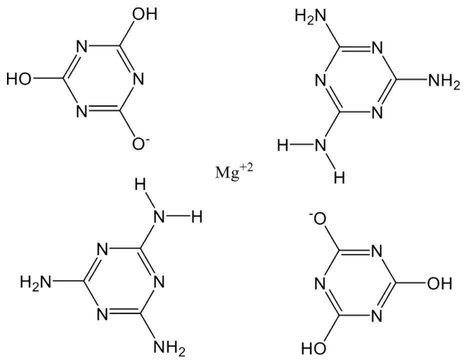
The first part of work deals with the possibilities of using synthesized novel magnesium complex dyes/pigments in zinc-pigmented organic coatings based on epoxy ester resin to reduce the zinc content in these coatings while maintaining or increasing the anticorrosive efficiency of these coatings. The magnesium complexes with a new series of azo carboxylate ligands were prepared by the diazo-coupling reaction and fully analytically characterised. In addition, the mechanical properties of the studied organic coatings were studied using standard tests. The novel yellow magnesium complex pigment $C_{34}H_{26}MgN_8O_6$ showed higher anti-corrosion performance in zinc-pigmented coatings compared to the industrially produced anti-corrosion pigment (Ca-Mg-HPO_4).

C34H26MgN8O6

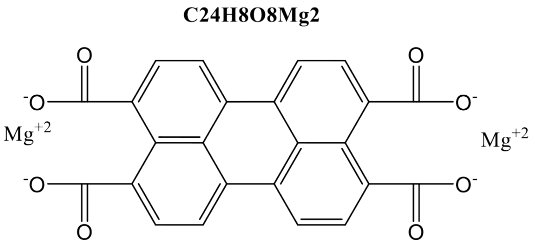


The second part deals with the properties and testing of newly prepared organic pigments based on melamine cyanurate containing magnesium or zinc cations. The synthesized pigments were fully analytically characterised. In addition, the basic parameters that are indicative of the applicability of the pigments in the binders of anti-corrosion coatings were determined. The highest anti-corrosion efficiency was achieved by the system pigmented with synthesized melamine cyanurate with magnesium cation ($C_{12}H_{16}MgN_{18}O_6$), In addition, these organic coatings achieved high mechanical resistance after being tested using the most used standardized mechanical tests.

C12H16MgN18O6



The third part deals with new anti-corrosion compounds, magnesium and zinc salts of perylene-3,4,9,10-tetracarboxylic acid, which were prepared and fully analytically characterised. The highest corrosion resistance was found for the coating containing $C_{24}H_8O_8Mg_2$. The organic coatings containing perylene acid salts also attained high mechanical resistance.



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Keywords

Magnesium complex; azo dyes; coating; corrosion; anticorrosion efficiency; anti-corrosion pigment; paint; organic coating; corrosion test; melamine unit; perylene-3,4,9,10-tetracarboxylic acid salts.

Acknowledgments

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Electrically and magnetically activated pigments

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Ferrites are among the most commonly used pigments and yet various of their properties are not yet fully explored within the paint industry. We present ferrites based on various zing and magnesium contents in the form of $Zn_{(x)}Mg_{(1-x)}Fe_2O_4$ pigments. The pigment properties for different Mg and Zn contents were investigated. While zinc ferrites are not magnetic, magnesium ferrites are slightly magnetic. However,

$Zn_{(x)}Mg_{(1-x)}Fe_2O_4$ show extremely broad magnetic properties depending on x. We show that for x=0.2 the pigments have two times higher magnetic saturation than bare Mg-based ferrites. The enhanced magnetic properties of these ferrites allow them to be used as magnetorheological fluids (MRFs). MRFs are composed of magnetic particles in a non-magnetic fluid. When exposed to magnetic fields the particles form chain-like structures and the material transforms from a liquid to a solid state. Various properties can be tuned and controllable through the intensity of the magnetic field. If cured under magnetic different magnetic fields, it is possible to control various properties of these paints i.e. roughness and colour (Fig. 1a, b). The pigments were also coated with polyaniline (PANI) which transformed them into anti-corrosive paints. Thanks to the PANI coating, these pigments also obtained good dielectric properties enabling them as electrorheological fluids (ERFs), the equivalent of the MRFs but activated through an external electric field instead. Both the MR and ER properties of these systems were investigated and compared with their corresponding analogues. It is important to note that systems with dual ER and MR response are very rare Fig. 1c [1,2]. As a result, these particles can serve both as multifunctional paints and as promising materials for MR and ER applications.

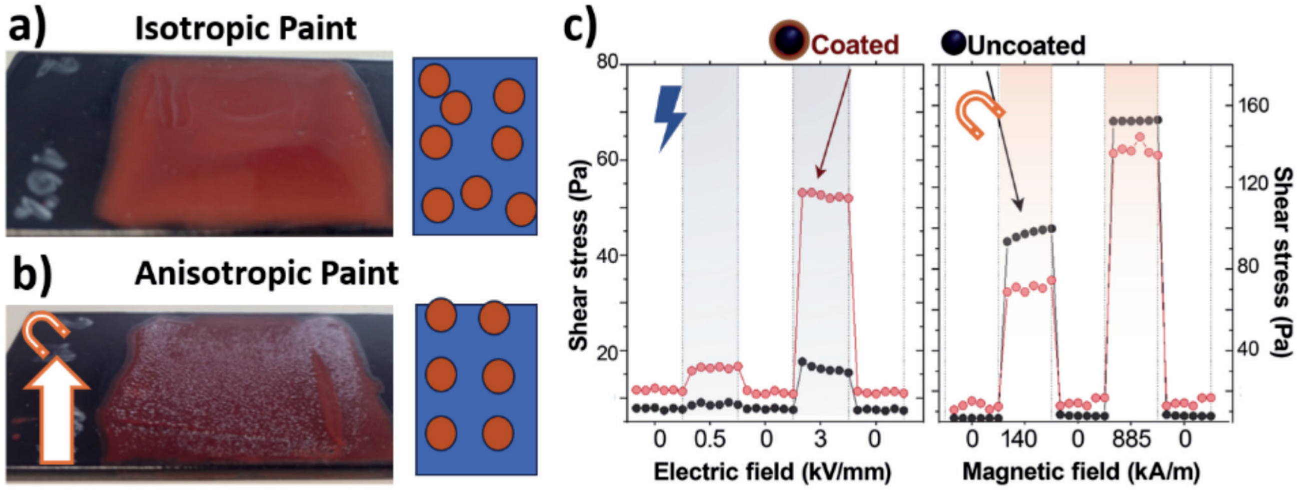

Figure 1 Display of electro- and magneto-active paints based on $Zn_{0.2}Mg_{0.8}Fe_2O_4$ pigments. a) Isotropic and b) anisotropic (cured under magnetic field) paints and their microstructure. c) Example of an ER and MR fluid under steady shear, the stress is increased several folds when E/M fields are applied. Black and red symbols correspond to bare and PANI coated pigments, respectively. At highest fields, the stress (thus viscosity) was increased by ≈ 700 and 1400 times under electric and magnetic fields, respectively.

Funding: DKRVO (RP/CPS/2024-28/007) supported by the Ministry of Educa tion, Youth and Sports of the Czech Republic.

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Push-pull dyes for light activatable curing of dark colored alkyd paints

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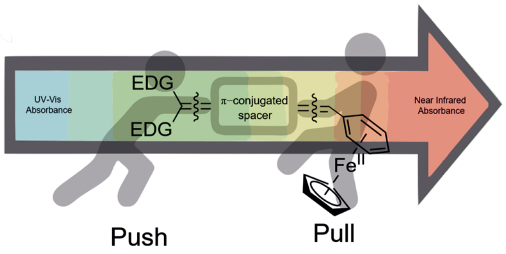
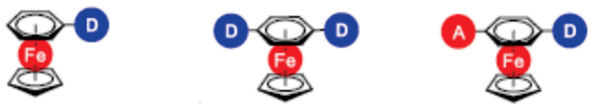
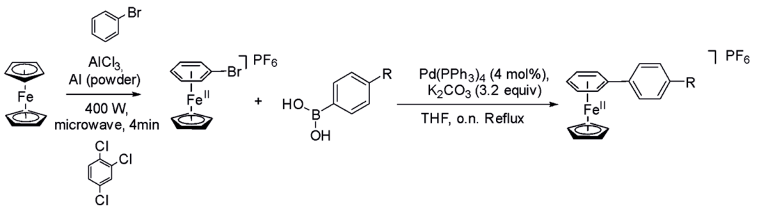
Previously, we demonstrated that photoactive iron complexes of the type [(Cp)Fe(arene)]$^+$ function as latent catalysts, enabling precise photochemical control over the initiation of alkyd paint curing. These catalysts represent a sustainable alternative to conventional cobalt salts and eliminate the need for anti-skinning agents. Upon blue-light irradiation, they exhibit high catalytic activity and perform excellently in transparent and light-colored coatings. However, their performance in more strongly colored and dark pigmented paints remains limited due to a low extinction coefficient, which restricts efficient light absorption – an important challenge for practical application.

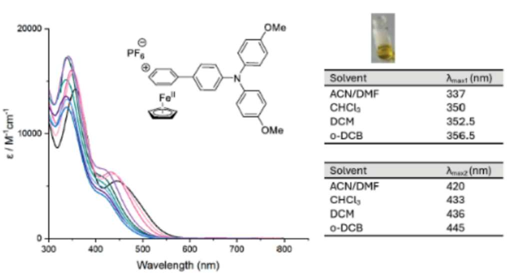
To address this limitation, we investigated the absorption behavior of [(Cp)Fe(benzene)]$^+$ derivatives and found that introducing electron-donating substituents into the aromatic system significantly enhances absorption and increases extinction coefficients. Guided by this insight, we implemented a push–pull dye strategy to further amplify light harvesting by incorporating additional electron-donating functionalities into the iron complexes.

Using an innovative and scalable synthetic approach, brominated and 1,4-dichlorobenzene derivatives of [(Cp)Fe(arene)]$^+$ were successfully isolated via both thermal and microwave-assisted methods. Subsequent Suzuki coupling of these precursor enabled efficient access to biphenyl-substituted complexes. These new photoactive push-pull iron catalysts show markedly improved performance, not only in clear alkyd formulations but also in dark pigmented paints, demonstrating a decisive step toward broadly applicable, light-triggered alkyd curing systems.



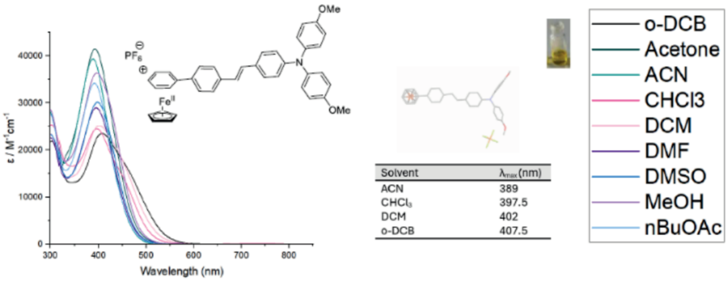






Solvent	λ_{max1} (nm)
ACN/DMF	337
$CHCl_3$	350
DCM	352.5
o-DCB	356.5

Solvent	λ_{max2} (nm)
ACN/DMF	420
$CHCl_3$	433
DCM	436
o-DCB	445



Solvent	λ_{max} (nm)
ACN	389
$CHCl_3$	397.5
DCM	402
o-DCB	407.5

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PORASPHERES® – The world's first hollow glass spheres for high-performance technical coatings

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PORASPHERES® represent a new generation of functional lightweight fillers designed to significantly enhance the performance, stability, and sustainability of modern technical coatings. Manufactured entirely from post-consumer recycled soda-lime glass, these innovative hollow glass spheres unite ecological responsibility with exceptional material characteristics. Their structure - a closed, robust glass shell enclosing a single internal cavity - results in a remarkably low density combined with high mechanical strength. This makes them particularly well-suited for formulations in which weight reduction, improved workability and long-term stability are essential.

In coatings and pasty systems, PORASPHERES demonstrate low water absorption and excellent dimensional stability. This ensures that even liquid or ready-mixed products remain stable over longer storage periods without swelling, densifying, or separating. The spherical geometry promotes uniform dispersion throughout the binder, resulting in consistent viscosity, smooth application, and improved surface characteristics. These rheological advantages help formulators achieve a more controlled and predictable coating process while maintaining high product quality.

Beyond improved handling, PORASPHERES also contribute to mechanical and functional enhancements in the finished coating. The mineral, non-combustible glass composition provides intrinsic fire resistance, chemical durability, and temperature stability. Because the spheres exhibit a significantly lower Young's modulus than many conventional fillers, they can impart improved elasticity, reduced brittleness, and enhanced crack-bridging capability. These properties are particularly beneficial for demanding industrial applications where coatings must withstand dynamic stresses, thermal fluctuations, or mechanical wear.

The broad grain-size spectrum available — ranging from fine fractions suitable for smooth, thin coatings to larger fractions designed for structured surfaces or specialty systems — allows formulators to tailor density, texture, and performance to specific application requirements. The recently introduced larger fractions further expand the design flexibility for manufacturers seeking customizable lightweight solutions with precise functional behavior.

Sustainability is at the core of the PORASPHERES concept. By using 100 % recycled glass sourced from post--consumer waste streams, the material supports circular-economy principles while reducing the consumption of virgin raw materials. This ecological value, paired with high and consistent technical performance, makes PORASPHERES an attractive option aiming to combine environmental responsibility with advanced material engineering.

With their easy handling, improved processing behavior and long-lasting material benefits, PORASPHERES offer a compelling route to lighter, more efficient and more sustainable technical coatings. They open new formulation possibilities for industrial coatings, mortars, plasters, adhesives, resin systems and numerous specialized applications where reduced weight, enhanced durability and optimized rheology are decisive. For manufacturers, PORASPHERES deliver not only performance advantages but also a future-oriented contribution to environmentally responsible product development.

Bridging coatings science and field practice: The critical role of paint inspection

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In the pursuit of innovative paints and coatings, the industry often emphasizes novel formulations and advanced chemistries. However, bridging the gap between laboratory innovation and real-world performance requires equal attention to quality assurance in the field and shop works. Based on findings reported in both academic literature and industry publications, other parameters like correct documentation (specification), choosing the correct coating system, surface preparation and paint application have equal or even higher effect on the final performance of the coating system. A Paint Inspector is a trained and certified professional responsible for verifying that all procedure related to the coating meet all specified requirements with precision and expertise. Their work ensures that coatings are chosen, applied and perform according to design expectations, thereby reducing the risk of premature failures, financial loss, or safety hazards. This presentation aims to highlight the vital role of paint inspection within the broader framework of coating system performance, focusing on the technical, practical, and educational aspects of inspection.

Furthermore, the presentation will include selected case studies from critical industries – such as marine, offshore, oil and gas, infrastructure, transportation, energy, and heavy industry – demonstrating the tangible impact of inspection practices on coating system performance across diverse application environments. These cases will illustrate how proper inspection can detect and prevent errors in surface preparation or application, ultimately enhancing coating lifespan and integrity. The insights gained from these practical examples underscore the indispensable role of inspection as a quality assurance measure and as a feedback mechanism for continuous improvement in formulation and application processes. By combining academic and industrial perspectives, presentation aims to foster dialogue between researchers, formulators, and field professionals to better integrate inspection into the life cycle of coating technologies.

As a science based and industry-driven practice, paint inspection strengthens the link between coating development in the laboratory and performance, making it an essential element in the successful implementation of advanced coating technologies.

Keywords

Paint Inspection, Industrial Paint and Coatings, Coating Quality Assurance, Corrosion Prevention, Industrial Case Studies.

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Synthesis of latexes from vegetable oil-derived monomers through emulsion polymerisation and their coating applications

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The demand for sustainable polymeric materials is growing rapidly, as there is interest in latexes from renewable resources as alternatives to conventional petroleum-based systems. In this study, latexes were synthesised from vegetable oil-derived monomers via emulsion polymerisation, and their potential applications in eco-friendly coating formulations were investigated. Vegetable oils were modified chemically to introduce acryloyl groups, yielding bio-based monomers. A semi-continuous non-seeded emulsion polymerisation process was carried out under controlled conditions using appropriate surfactant systems and free-radical initiators to obtain stable, high-solids latex dispersions from the synthesised bio-based monomers. The resulting bio-based latexes exhibited narrow particle size distributions, good storage stability, and high monomer conversion, demonstrating the feasibility of producing high-performance latexes from renewable feedstocks. Structural and physicochemical properties of the polymers were characterised using Fourier transform infrared spectroscopy (FTIR), differential scanning calorimetry (DSC), Dynamic light scattering (DLS), and Asymmetric flow field flow fractionation coupled with a multi-angle light scattering detector (AF4-MALS). The waterborne latex coatings were tested for their performance on various substrates. Properties such as film-forming ability, adhesion, hardness, and water resistance were assessed and compared with those of conventional petroleum-based latex coatings. The bio-based coatings demonstrated excellent film continuity, strong adhesion, and enhanced hydrophobicity, which is attributed to the long aliphatic chains derived from vegetable oils. The coatings showed good thermal properties while significantly reducing reliance on fossil-based raw materials. Overall, this work demonstrates the potential of vegetable oil-derived monomers as sustainable building blocks for latex synthesis through emulsion polymerisation. The results confirm that high-performance, eco-friendly coatings can be produced using renewable resources, providing a promising route to more environmentally friendly polymer technologies and reducing the environmental impact of the coatings industry.

Acknowledgement

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A universal TiO_2 grade for evolving regulatory requirements

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Emerging challenges in the coating market include regulatory and voluntary standards. In 2019, Trimethylolpropane (TMP) was self-classified by the TMP EU REACH registrants as a Suspected Reproductive Toxicant (Repr. 2) [1]. TMP is a widely used organic treatment in the TiO_2 industry. In 2020, over 50% of all pigmentary TiO_2 commercially available was estimated to use TMP (90% for coatings applications), and typical loadings are < 0.45 wt % [2]. TiO_2 products that use TMP typically exceed the threshold sets on the presence of substances with certain hazardous classifications for Ecolabel certification of paints and coatings. There is currently a derogation in the main EU ecolabel schemes for using TMP in paints and coatings [3, 3a, 3b]. Many Ecolabels are currently under revision or will begin the process in the next few years. The current TMP derogation will be scrutinized during these revision processes. It may be removed in the future, considering that Finland has added TMP to the registry of CLH intentions until the outcome and is preparing a CLH dossier with an expected proposal for reclassification as Repr. 1B [3c]. Chemours has decided to work proactively towards replacing TMP where possible. TMP has been used in industry for many decades. It enhances important properties like dispersion in liquid paints and dry powder flowability. A replacement for this unique raw material needs to meet several criteria: (1) non-classified chemistry, (2) universal use across various application areas, from architectural and industrial to powder coatings, and (3) excellent processability and flow behavior of the dry powder. We developed a universal TiO_2 coating grade free from TMP/TME. The sample has similar physical properties, dispersibility, and flow behavior compared to the current universal TiO_2 coating grade. The new TMP/TME-free sample was tested in various paint applications, including solvent-borne industrial coating and waterborne architectural coating, and it was shown to perform similarly to reference universal coating grade TiO_2. The TMP/TME-free universal TiO_2 grade was evaluated against a TMP-treated and an organic-free reference using dispersion tests in waterborne and solvent-borne paints, dispersant demand measurements, and powder flow analysis. The TMP/TME-free grade showed equivalent dispersibility, lower dispersant demand, and comparable powder flow behavior to the current universal TMP-containing grade and outperformed the organic-free material. Overall, the new TMP/TME-free TiO_2 provides a universal, regulation-ready alternative with performance comparable to existing commercial coating grades across multiple applications. This paper will focus on assessing available options and emerging technologies and how they stand up to meet performance, reliability, and emerging regulatory and voluntary standards.

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Novel nanocomposite surface additives for PFAS replacement

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Regulatory activity in both the EU and USA is targeting a large group of chemicals known as PFAS (per- and polyfluoroalkyl substances). As a result, formulators in many industries are working to replace additive powders based on PTFE and PTFE hybrids with alternative materials that provide the same level of performance.

This presentation will detail a unique nanocomposite approach to eliminate PTFE in surface additives by replacing PTFE with hard, inert, durable materials such as aluminum oxide and ceramics. Data will be presented to show that this portfolio of over 8 additives provides equal or (in most examples) improved surface durability (lubricity, scratch & abrasion resistance) without the use of PTFE.

Alkyd hardness development: A story of unsaturated fatty acid conversion

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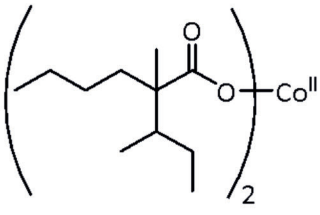
An important measure of a coating's protective quality is its hardness development. During this lecture, we discuss the (non-linear) relation between the (König) hardness development of cured alkyd coatings and the residual unsaturated fatty acid content of the alkyd binder using a combination of Raman and NMR spectroscopy.

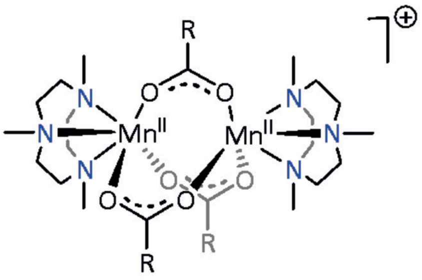
Specifically, we compare the industrially employed Co(neodecanoate)$_2$ (1), $[(Me_3TACN)_2Mn_2(\mu\text{-}OOCR)_3](OOCR)$ (OOCR = 2-ethylhexanoate) (2) and [(bispidon)Fe(Cl)](Cl) (3) driers to a photo-latent iron-based drier system we recently developed as a possible cobalt replacement [1,2].

Aerobic oxidation of [(Cp)Fe(Ch)] (4) leads to in situ formation of the corresponding [(Cp)Fe(arene)]+ complex, which generates active FeII catalysts for alkyd paint curing upon photo-activation. By a combination of Mössbauer, EPR and XANES spectroscopy we are able to understand the activation and fate of the iron species formed, and can relate this to the hardness development observed.



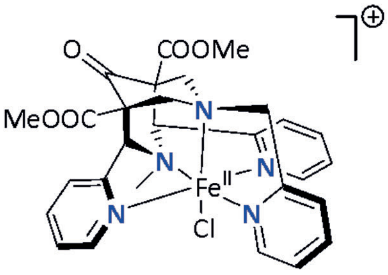
Co(neodecanoate)$_2$

(1)



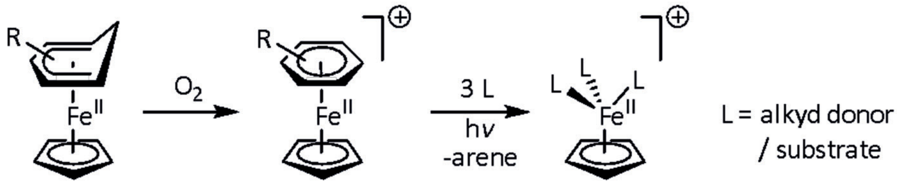
$[(Me_3TACN)_2Mn_2(\mu\text{-}OOCR)_3]^+$

(2)



[(bispidon)Fe(Cl)]$^+$

(3)



[(Cp)Fe(Ch)] **(4)** [(Cp)Fe(arene)]$^+$ [(Cp)Fe(L$_3$)]$^+$

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Polarity-related interaction effects in waterborne film formation

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Waterborne coatings have gained increasing importance as sustainable alternatives to conventional solvent-based systems. Despite their advantages, achieving defect-free and mechanically stable films remains a major scientific challenge. Film formation in waterborne systems involves water evaporation, particle deformation, and particle coalescence, all of which are strongly influenced by solvent–polymer interactions. In aqueous dispersions, these interactions are inherently complex, as they arise from the balance between water, polymer particles, and coalescing solvents. Since the relative contribution of these components changes continuously during drying, the interaction environment evolves over time, leading to shifts in polarity that directly affect coalescence behavior and final film morphology.

Coalescing agents temporarily plasticize polymer particles and enable film formation, yet their behavior during drying is not fully understood. Their evaporation cannot be described by volatility alone, as strong solvent–polymer interactions may delay solvent release and alter local composition during drying. As a result, interactions that appear favorable initially may change over time, potentially leading to incompatibilities or defects such as cracking, phase separation or haze.

Solvent–polymer interactions are commonly described using empirical polarity parameters. However, these often provide only a partial description of the complex processes occurring in aqueous dispersions. In this work, interactions are therefore investigated using two complementary approaches. Hansen Solubility Parameters (HSP) provide a macroscopic description of compatibility through dispersive, polar, and hydrogen-bonding contributions, while Kamlet–Taft parameters offer a microscopic perspective by describing hydrogen-bond donor and acceptor abilities as well as dipolarity/polarizability. The central hypothesis is that combining both approaches enables a deeper understanding of film formation by linking global compatibility with specific molecular interactions.

To relate these interaction effects to film formation behavior, systematic single-solvent screening experiments were performed. The results showed that different solvents can produce similar defect patterns, particularly crack formation, even when compatibility appears comparable based on conventional descriptors. This indicates that defect formation cannot be explained solely by macroscopic compatibility parameters and suggests that additional interaction mechanisms govern the drying process. Surface-sensitive techniques such as atomic force microscopy (AFM) are employed to further investigate coalescence and morphological evolution during drying.

Overall, this work aims to improve the mechanistic understanding of solvent–polymer interactions during film formation and to identify parameters governing defect development. A deeper understanding of these mechanisms will support more rational coating formulation strategies, reduce reliance on trial-and-error approaches, and facilitate the development of more sustainable and tailored material systems.

Delcor – A LEAN, green method to analyze corrosion test panels

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Approximately 3–4% of the gross domestic product are lost by corrosion, so corrosion protection is an important sector. Consequently, improving the corrosion protection and the test method will have a big impact on the economy.

Using the traditional evaluation method for corrosion test panels [1], a test panel is taken out from the salt spray chamber at a certain time interval, dried and all loose or delaminated coating material is mechanically removed by a lab technician. The technician is then visually measuring the width of the corroded and delaminated area along the scribe. Once corrosion width is measured by this method, the test panel has to be discarded.

This method bears a number of disadvantages:

- Human interference and low reproducibility in evaluation
- High material usage, as many panels have to be prepared for the test
- High energy usage in the preparation of panels and exposure in the test chamber
- Large amounts of waste produced during and after the test
- Manual evaluation and documentation of test results

We introduce a new, non-destructive automated method to analyse corrosion test panels that uses impulse thermography. This method detects the change of thermal conductivity from the paint surface to the metal/substrate in intact versus corroded and delaminated areas. As the coating is not removed prior to analysis, the test panel can be re-used, allowing to cut the number of test panels necessary for a series of 4 data points by 75%. This will pay into the Product Carbon Footprint (PCF) of the products and corresponds well with LEAN principles. Additional advantages are the higher reproducibility of the data, the automated evaluation, photo archiving, the possibility to generate more data points without an increase in cost, and the large savings in material, waste and workload for the personal. The productivity of the salt spray chambers is enhanced, as more products can be tested simultaneously, and the number of necessary tests batches should also diminish as the reliability of the data should lead to less trial-and-error and more predictive elaboration.

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Vegetable oils as bio-based option in hydroxyethyl cellulose-based formulated rheology systems for coatings

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Hydroxyethyl cellulose (HEC) is widely used as a rheology modifier in water-borne architectural coatings to control viscosity, flow and application behaviour. However, the handling of HEC in powder form may present safety and processing challenges. This has led to the development of formulated rheology systems (FRS) in which HEC is dispersed in oil. These systems predominantly rely on mineral oils derived from fossil resources, which conflicts with the increasing demand for renewable and bio-based materials in the coatings industry.

Therefore, the aim of this study was to develop vegetable-oil-based formulated dispersions of HEC rheology modifiers as a bio-based option for use in architectural coatings. Several types of HEC were evaluated in combination with different ratios of a cellulose-based booster product. In addition, different vegetable oils were evaluated as carrier media in the formulated rheology systems. Both the blends and the formulated rheology systems were evaluated in a representative architectural coating formulation. Rheological behaviour and viscoelastic properties were characterised, while application performance was assessed through sag resistance and levelling tests. Furthermore, the formulated systems were evaluated for viscosity to confirm pumpability, and for physical stability.

The results show that blends consisting of certain HEC grades and a cellulose-based booster exhibit a strong synergistic effect, leading to a significant increase in mid- and low-shear viscosity, as reflected by higher Krebs Stormer and Brookfield viscosity values. An increase in sag resistance was observed, while acceptable flow and levelling behaviour was maintained. Viscoelastic measurements supported these observations. In contrast, other HEC grades did not benefit from the booster and resulted in reduced thickening efficiency and lower application performance.

Furthermore, when the blends were incorporated into vegetable-oil-based FRS, the synergistic effect was less pronounced. This reduced effect is assumed to be related to processing of the blend. In addition, the results show that thickening efficiency in formulated rheology systems is strongly dependent on FRS formulation composition. Nevertheless, FRS could be prepared within the viscosity range required for pumpability and showed good physical stability.

Overall, this study lays the foundation for the development of vegetable-oil-based formulated HEC rheology systems for architectural coatings and highlights the need for further optimisation.

Always on the bright side

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There is hardly any other performance criterion of daylight fluorescent pigments being discussed more frequently than their comparatively lower lightfastness (UV stability).

Lack of lightfastness is the main argument for the discrimination of daylight fluorescent pigments in many outdoor applications that are permanently exposed to sunlight.

The UV stability of fluorescent color systems depends on various factors, such as color, type and chemistry of the pigment and binder, pigment concentration, as well as the layer thickness and layer structure in the final application.

While fluorescence can remain stable for several years indoors, it decreases significantly faster under direct sunlight and in outdoor areas.

The current paper is explaining based on tested safety applications the 15 times higher light fastness of the ARAGEN / ARAQUA fluorescent pigments vs. “state of the art” pigments.

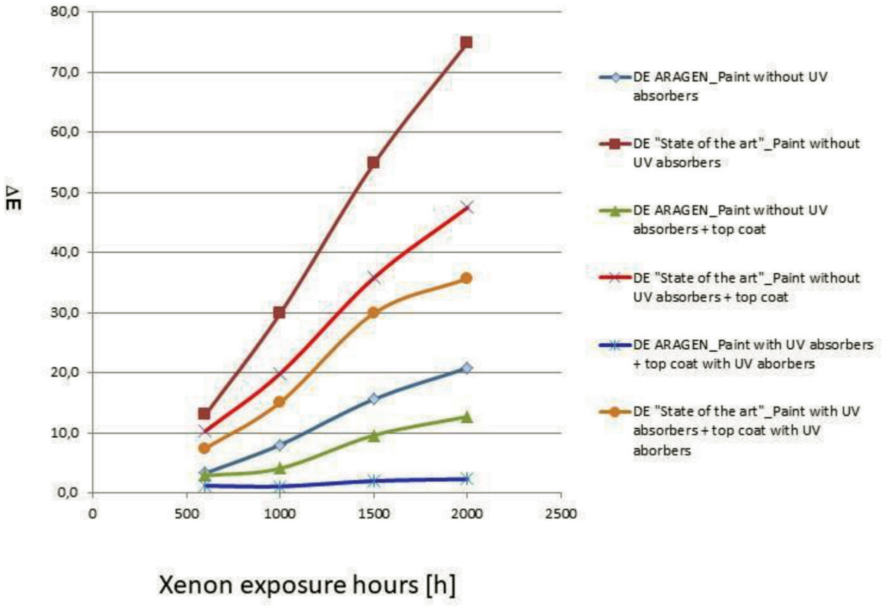

Fig.: Exposure table AG-105 RED compared to the “state of the art” technology

Mechanochemical functionalization of Biochar for the production of new hydrophobic coatings

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An innovative approach to providing a sustainable functionalization of biochar via amidation by mechanochemical route in the presence of octadecylamine is presented in this study. The proposed procedure is an attractive, cost-saving, and scalable alternative to the conventional approach meeting environmental sustainability expectations. The material obtained is widely characterized through spectroscopic and morphological techniques, confirming the presence of amide functional groups and ruling out simple amine sorption onto the carbon surface. As the long alkyl chains are introduced onto the biochar, an increase in hydrophobicity is induced, attributed to the exposure of hydrophobic groups and the increase in surface roughness, resulting in a new material for water-repellent coatings on hemp fibers. As a result of dip coating, the coated hemp fiber becomes hydrophobic with an angle contact value of 126° after a single deposition layer of biochar. Moreover, the biochar-coated hemp fibers showed a noticeable capacity (up to 1400%) to absorb several oils (frying, motor, pump, and sunflower) from an emulsion solution.

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Strong, clean, durable: The new pure-acrylic binder for facade coatings

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Facade paints play a crucial role in protecting buildings and structures from environmental influences. They shield against harsh weather conditions, UV radiation, and moisture (EN 1062), prevent structural damage and extend the lifespan of surfaces. A long service life with longer intervals between renovations contributes to sustainability. In addition to very good UV resistance, the aspect of low dirt pick-up is becoming increasingly important, as renovation of heavily greyed facades is often accelerated for aesthetic reasons. The innovative pure acrylic binder can be used in a versatile manner for low-VOC thin-layer as well as thick-layer, crack-bridging facade coatings. The binder exhibits a well balanced property profile with very good moisture resistance, excellent durability and an outstanding dirt-pick up resistance (DPUR).

Effect of surface preparation on paint durability in crude oil

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The internal side of steel pipelines in contact with flowing crude oil shows good corrosion stability. However, water can separate at the bottom of the pipeline under stagnant conditions, triggering a series of processes that lead to an increase in the corrosion rate of steel of up to 4 orders of magnitude, reducing the pipeline lifetime to as little as 8 years [1]. After considering numerous mitigation techniques, protection of the inner pipeline with a two-layer commercially available paint system designed for protection of crude oil tanks was selected. This work examined limits of surface contamination prior to protective organic paint application. The effects of sand-blasting medium and oil remnants, the presence of soluble salts, flash rust and condensed water, over- and under-blasting, and high-temperature oxidation were systematically investigated under immersion in a mixture of water and crude oil and using the neutral salt spray test according to ISO 9227 for 3000 hours. Particularly critical was the presence of chloride- and sulphate-based soluble salts, which led to blistering and acceleration of paint delamination from defects. The safe limit of salt contamination was established in experiments with controlled deposition of sodium chloride and sodium sulfate solutions on steel prior to primer application. The results were expressed in view of the maximum time of exposure of clean steel surface in atmospheres characterized by different deposition rates of SO_2 and chloride ions. In parallel, the applicability of Scanning Kelvin Probe (SKP) [2] and Field Kelvin Probe techniques was investigated for detection of surface contamination under paint films before exposure to corrosive environment. It was proved that both techniques can detect the presence of soluble salts.

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Barrier coatings for the reduction of hydrogen permeation in tank and transport systems

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For hydrogen tanks and similar applications, metallic materials (e.g., steel or aluminum) are still predominantly used today, either as solid materials or as liners in polymer materials, presenting significant additional weight. In order to utilize lightweight materials such as fiber-reinforced plastics for fuel tanks, which themselves do not provide an adequate barrier against hydrogen permeation, Fraunhofer IFAM is developing barrier coatings that significantly reduce hydrogen permeability, thereby offering versatile opportunities for lightweight construction in aerospace as well as other sectors.

Fraunhofer IFAM possesses extensive expertise in the development of barrier coatings against gases and liquids for a wide variety of applications. The focus is specifically on hydrogen barrier coatings. The need for these coatings extends beyond the aerospace industry to the transport sector and the entire hydrogen energy sector.

In recent years, barrier coatings have been successfully developed for the inner walls of fuel tanks in the aerospace sector to prevent hydrogen permeation. The goal is to utilize lightweight materials such as fiber-reinforced plastics for the construction of tanks, which do not provide an adequate barrier against hydrogen. The fuel tanks are intended for liquid hydrogen (LH2), where gaseous hydrogen is also present above the liquid. The barrier coating is designed to function for hydrogen in both aggregation states.

The coating solution developed within the "CryoCoat" project is based on a polymeric binder that contains plate-like pigments on a metal or silicate basis, which serve as the actual diffusion barrier. The formulations can be processed using coating technology and applied to large structures via spray application. Within the aerospace project, a prototype coating has been developed, demonstrating its barrier effectiveness against hydrogen.

This coating is currently being adapted in further projects. In the "TransHyDE" project, the coating is being tailored for use in gas pipelines and tanks for hydrogen storage as an energy carrier, as completely different requirements for the coating must be met for this application. Here, Fraunhofer IFAM also applies its extensive expertise in the development of barrier coatings against gases and liquids to develop the ideal coating for each specific application.

Coating systems on AZ91 magnesium alloy based on plasma electrolytic oxidation and powder coating

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Due to their high strength-to-weight ratio, magnesium and its alloys are increasingly used in industry as a construction material. However, this metal has poor corrosion resistance, which can be limited by using various types of protective coatings. Since classic liquid coatings require the use of large amounts of harmful solvents, powder coatings seem to be a good alternative. A problem that occurs when producing this type of coatings is the high-temperature hardening process, which may negatively affect the properties of the magnesium substrate. This study presents examples of the use of low-temperature hardened acrylic and polyester powder coatings to protect the AZ91 magnesium alloy. In order to increase the adhesion of the organic coating, a conversion coating was produced by plasma electrolytic oxidation (PEO) in an alkaline silicate electrolyte. The coating systems were assessed for anti-corrosion properties using the electrochemical impedance spectroscopy (EIS) method.

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Zinc silicate primers as an alternative to zinc thermal sprayed coatings

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Inorganic Zinc Silicate Primers (IZS) with silicate binders and high metallic zinc content (min. 80% by weight in solids), either solvent or water-based, are commonly used for anti-corrosion protection of blasted steel structures in severe atmospheres and other environments of almost neutral pH value (pH 5,5–10) constitute a specific group of coatings of distinctive features often different from the organic paints. As either single coat or more often topcoated with suitable organic coatings, they show excellent anticorrosion performance and long lifetime. For increasing their adhesion to a bit inferior surfaces and better resistance against so called “mud-cracking” in excessive dry thickness (above 150 μm), their formulation can be modified with some additives of selected types of organic resins, and, hence, they are specified as Organically Modified Zinc Silicates (OMZS).

In the lecture presented, the principles of formation, curing and protective mechanism and some features of a commercially available 2-component solvent-based OMZS with ethylsilicate binder and spherical zinc applied on blasted steel are briefly mentioned. Its protective performance and corrosion resistance was compared with those of alloyed Thermal Sprayed Coating (TSC) Zinacor 850 (composition 85%Zn/15% Al) together with hot dip galvanized (HDG) and TSC made of pure zinc in both electrochemical/potentiodynamic test in 0,6% NaCl solution and standard accelerated corrosion tests of scribed coated panels: neutral salt spray (NSS) and water condensation in presence of sulfur dioxide (SO_2). Electrochemical characteristics cover polarization curves J = f(E), electrode potential/open circuit potential (E_{corr}), polarization resistance (R_p) and corrosion current density (J_{corr}) and corrosion rate (v_c), determined both at the very beginning of the test and then during thirty days of immersion in NaCl solution. As for the results of both accelerated corrosion tests, they are photo documented, visually compared with the unexposed coatings and evaluated.

The results obtained indicate that the initial E_{corr} of OMZS and Zinacor 850 are very similar (from about -1 till -1,1 V/SCE) and its drop to a more positive values during the immersion in NaCl solution show the similar trend. On the other hand, R_p is min. by one order higher and, consequently, both J_{corr} and v_c lower for OMZS than for Zinacor 850. In the accelerated corrosion tests, both coating showed no signs of substrate red corrosion and no delamination at the scribe. As for the zinc corrosion, Zinacor 850 shows rather more surface white rust than OMZS in the NSS test, while it is exactly the opposite in the test of condensation with SO_2. Unlike the coatings made of pure metallic zinc (HDG, TSC), both tested OMZS and Zinacor 850, initially of very porous structure, at exposing in a corrosion environment, will form a barrier layer completely sealed with insoluble zinc corrosion products and become impermeable for corrosion stimulators such as chlorides/SO_2. Based on the tests carried out and evaluated from the point of view of corrosion performance, it is possible to conclude that OMZS might be an alternative to pure zinc TSC or even to alloyed TSC Zinacor 850.

Reference

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Characterization of molecular structure of paint binders using light scattering and related techniques

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Molecular structure of polymer binders used for paint manufacturing affects not only many of their properties, but also brings valuable information about kinetics of polymerization reactions. The term molecular structure includes molar mass distribution and topology of macromolecular chains. Size exclusion chromatography (SEC) is nowadays the dominant technique for the determination of molar mass distribution. However, in its conventional form when the molar mass is obtained from a calibration curve established by standards of known molar mass, the technique suffers from several limitations. Most importantly, the obtained molar mass distribution is a priori incorrect as the sample being analyzed is typically of different chemical composition than that of standards used to calibrate the SEC columns. In addition, the polymer standards are linear while polymer binders often contain branched macromolecules. This fact further increases the errors of molar mass obtained from calibration curve. The limitation of conventional SEC is the most effectively solved by coupling an SEC chromatograph with a multi-angle light scattering (MALS) detector which measures correct molar mass from the intensity of scattered light irrespective of chemical composition and molecular topology. In addition to the molar mass, the MALS detector yields radius of gyration which describes size of macromolecules. Simultaneous determination of molar mass and radius of gyration allows studying the long-chain branching of polymer chains.

Although SEC represents one of the most frequently used techniques of polymer characterization, its ability to separate certain types of polymers is strongly limited. Typical polymers difficult for SEC are those containing ultra-high molar mass fractions prone to shear degradation or highly branched polymer molecules with tendency to get anchored in pores of SEC column packing. Acrylic copolymers prepared by emulsion polymerization are typical examples of polymer binders that cannot be reliably analyzed by SEC-MALS. Asymmetric flow field flow fractionation (AF4) is an alternative analytical separation method which completely eliminates anchoring of branched macromolecules and strongly reduces shear degradation of macromolecules with very high molar mass.

The lecture offers a brief overview of the fundamental principles of MALS, SEC and AF4 and presents several examples of the application of the techniques for the characterization of molecular structure of various paint binders with special focus on acrylic emulsion copolymers including novel types with traditional monomers partially replaced with bio-synthetic monomers based on methyl esters of fatty acids from various vegetable oils.

Acknowledgement

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Sustainable electronics - Printed electronics on wood

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In the EU-funded HyPELignum project, wood and wood-based materials are investigated as a substrate for printed electronics. Among the key outcomes of this project are PCBs (Printed Circuit Boards) based on wood (ecoPCBs). Conductive paths are printed onto the wood substrate, using either inkjet or screen-printing technologies. The main idea of the plywood ecoPCB is to print the desired circuitry in each veneer layer of the plywood before gluing them together. The different layers are connected using vias, thus mimicking the structure of a conventional multilayer PCB. Waterborne primers are used to homogenize the penetration behavior and fill out pores of the birch wood used for this purpose. The technology of screen-printing is also investigated for its application in timber construction (moisture and strain sensing) and in furniture (touch sensing, VOC measurements using a novel biomimetic smell sensors).

For the first iteration of HyPELignum´s plywood ecoPCB demonstrator, an Arduino-like board was designed and manufactured at Holzforschung Austria (Figure 1, left). Wood from birch (Betula pendula) was used as substrate as this is one of the most used wood species for plywood. Birch is a porous substrate and hence a bio-based primer was applied.

Following the successful demonstration of the plywood ecoPCB, the next activities focused on the integration of SMD (SMD: Surface Mount Devices) components and on refining/expanding the multilayer structure. The next iteration of the plywood ecoPCB demonstrator had, therefore, only SMD components. The use case is a humidity/temperature/strain sensor board, that is powered by NFC (NFC: Near Field Communication) via a printed antenna (Figure 1, right).

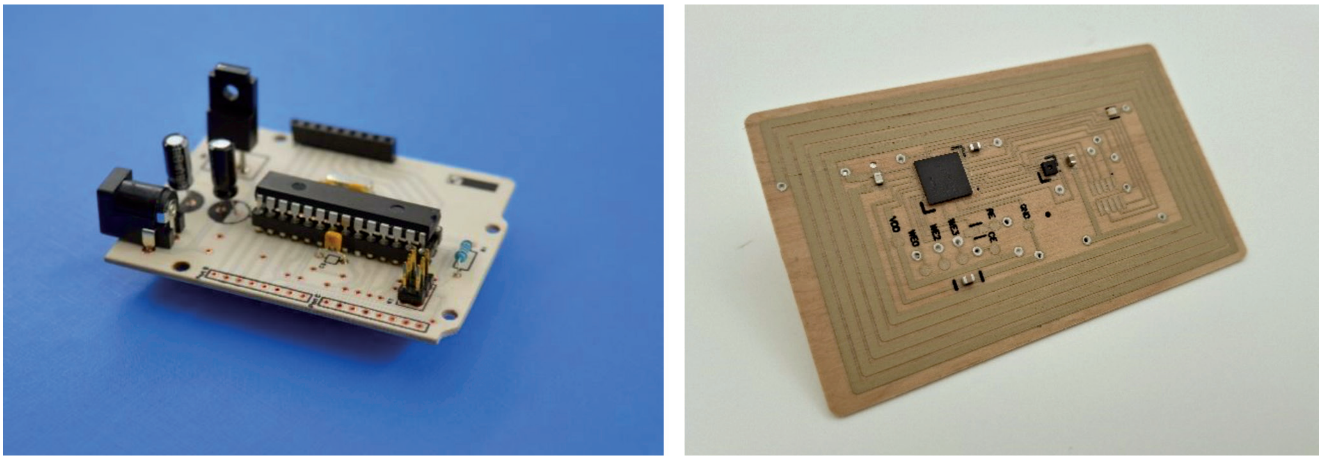

Figure 1: Left: Printed circuit board on plywood, using PTH ("Plated Trough Hole") electronic components. Right: Printed circuit board for measuring the moisture content underneath parquet flooring.

Thermal-electrical coupling in flexible bio-derived printed circuit materials

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Recent advances in printed electronics on lignocellulosic materials have enabled sustainable multilayer wood--based circuit boards; however, their inherently low thermal stability and pronounced thermal expansion anisotropy impose fundamental limits on electrical reliability under thermal loading. In this work, we propose a flexible lignocellulosic printed circuit board architecture that addresses these limitations by exploiting mechanical compliance to mitigate thermally induced stresses and interfacial failure. Thin fibre-based substrates are pre-treated to control surface energy, porosity, and moisture-related dielectric variability, enabling stable charge transport in printed conductive networks. Low-temperature additive manufacturing is employed to form conductive paths, interconnects, and sensing elements while preserving the substrate's structural integrity. Designed for low-power operation and wireless energy transfer, the proposed flexible PCB concept targets smart construction elements, furniture, and adaptive surfaces, extending sustainable electronics beyond rigid wood-based platforms toward thermally resilient, multifunctional bioelectronic systems.

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Bio renewable reactive diluents for high performance resins and coatings

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Reactive diluents play a critical role in advanced resin and coating systems by reducing viscosity while becoming an integral part of the cured polymer network. This work explores the functionalization of bio-based 1,3-propanediol (1,3-PDO) into a range of high-performance reactive diluents, including 1,3-PDO diacrylates (PDDA), 1,3-PDO dimethacrylates (PDDMA), 1,3-PDO diglycidyl ethers (PDODGE), and polytrimethylene ether glycol diacrylate (PO3GDA). These materials were evaluated across UV-curable coatings, two-component polyurethane acrylates (2K-PUA), and epoxy resin and composite systems, with direct comparisons to conventional fossil-based, even-carbon benchmarks such as 1,4-butanediol and 1,6-hexanediol derivatives.

Across all resin platforms, 1,3-PDO-derived reactive diluents delivered effective viscosity reduction while maintaining or improving cured-network performance. Coatings and resins formulated with these materials exhibited increased crosslink density, enhanced hardness, improved mechanical strength, and superior chemical and solvent resistance, without compromising thermal properties. In epoxy systems and glass-fiber composites, the 1,3-PDO diglycidyl ether provided comparable glass-transition temperatures alongside improved fiber–matrix interaction and composite strength.

The observed performance benefits are attributed not only to the renewable origin of 1,3-PDO but also to its distinctive odd-carbon molecular architecture, which influences crystallization behavior and network regularity. Overall, this study demonstrates that 1,3-PDO is a versatile, bio-based building-block monomer that enables both sustainability gains and measurable performance advantages in advanced resin systems.

Mastering surface morphology: Designing ultra-low gloss coatings with enhanced durability

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Coatings commonly serve dual purposes, providing both protective and decorative functions across diverse many applications. In recent years, there has been a growing demand for very low gloss systems, particularly in fields such as architectural coatings and wood coatings.

Achieving such low gloss levels requires careful optimization of particle packages within coating formulations. However, combining very low gloss with high mechanical robustness presents a significant challenge for formulators. To address this, detailed assessments of surface morphology have proven essential in understanding and balancing gloss reduction with mechanical performance. By fine-tuning particle interactions and distribution, it is possible to meet the stringent requirements for both aesthetic appearance and durability.

This presentation will explore the formulation strategies and characterization techniques that enable the development of advanced coatings with optimized gloss and robustness properties.

Polyallophanate powder coatings with modified lignins as resin component

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Highly weather-resistant, emission-free polyurethane powder coatings based on petro-based polyester polyols as resin and uretdione crosslinkers as matrix components offer a very balanced property profile and have therefore been used for many years, especially for high-quality, durable coatings in the architectural sector. In the presence of metal βdicarbonyl compounds, such as $Zn(acac)_2$, such matrix components can be cured at temperatures ≤ 150 °C to form high-quality, durable, and weather-resistant polyallophanate films [1,2], depending on the chemical structure of the resin monomers. In light of the CO_2-reduction targets set out in the UN Agenda 2030 sustainability goals and the EU Green Deal, there is also an increased focus on the use of bio-based raw materials in organic coating development. The BMFTR project PulLi is therefore investigating whether lignin, a waste product of cellulose production that amounts to ~10 million tons per year, could be a potential alternative to the petroleum-based polyester resins used to date. To achieve this, it is necessary to lower the glass transition temperature of lignin to a range between 60 and 120 °C. Two strategies were pursued:

- Depolymerization of Kraft lignin to achieve a defined reduction in molecular weight.
- Modification of lignin via esterification and etherification reactions.

Both methods successfully resulted in a reduction in the softening temperature to the desired temperature range. Selected modification products were then utilized to formulate polyallophanate model powder coatings.

These coatings were applied electrostatically to gradient sheets and cured in a gradient oven under conditions that were almost comparable to those used for a petro-based standard.

In comparison to the petro-based standard, the resulting films exhibit a medium gloss level with significantly higher roughness, lower film flexibility, and more or less pronounced self-coloration. This could be likely caused by the high aromatic structure content.

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Vitrimer-based self-stratifying multilayer coatings for electrochemical applications

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Lithium metal batteries are considered among the most promising next-generation technologies for high-energy-density storage in electric mobility. However, major challenges persist regarding safety, interfacial stability, and end-of-life management. In particular, combining strong adhesion to current collectors with sufficient ionic transport remains a critical limitation [1,2].

In this work, we propose a recyclable self-stratifying coating designed through vitrimer chemistry. Self-stratifying systems enable the spontaneous formation of multilayer architectures in a single formulation, application, and curing step3. This approach generates a bottom layer ensuring strong adhesion to the aluminum current collector and a top functional layer intended to promote ionic transport. The incorporation of dynamic vitrimer networks introduces thermally activated bond exchange, providing reprocessability, self-healing capability, and recyclability [3].

The coatings were formulated from an industrial epoxy resin (EPS35) crosslinked with pentaerythritol tetrakis(3-mercaptopropionate) and combined with a commercial fluoropolymer. To impart electrochemical functionality, lithium salts, nano- and micro-scale fillers were incorporated.

In this configuration, the epoxy layer fulfils a dual role, acting both as an adhesion-promoting interfacial layer toward the aluminum current collector and as a binder matrix. Lithium salts were observed to be distributed across both phases of the stratified architecture, enabling ionic functionality throughout the multilayer coating. SEM/EDX analyses confirmed the formation of well-defined type I stratification profiles while preserving the targeted phase organization. Cross-hatch adhesion tests performed according to ISO 2409 (2020) consistently yielded a rating of 0, demonstrating excellent adhesion to alumnium substrates.

Removability tests showed that the coatings could be detached from the substrate at temperatures above 80 °C, highlighting their potential for repair and recycling. Ionic conductivity measurements are currently in progress to evaluate the electrochemical performance of the system under battery-relevant conditions.

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Automated corrosivity classification of outdoor atmospheres for coating system selection

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Accurate classification of corrosion aggressivity of environment is a critical input for the selection and design of coating systems defined in ISO 12944 for protection of structures such as bridges. Standard methods according to ISO 9223 rely on the mass loss technique, which requires a year of exposure of metallic coupons of steel, zinc, copper and aluminum, or an estimation based on environmental data. However, whereas the former approach is overly time consuming, the latter one may fail to capture specific local conditions leading to significant risks regarding the guaranteed service life of applied organic coatings.

This work focuses on the application of easy-to-use automated electrical resistance (ER) sensors for the real-time corrosivity classification. The aim is to demonstrate the ability of ER sensors to assess the corrosivity category from C1 to CX rapidly, precisely and cost-efficiently as no specialized laboratory needs to be involved. A battery-driven measuring unit is attached to the structure of interest and measurement data transferred via GSM to a server, which processes them directly to the appropriate corrosivity category.

Sensitivity, accuracy and precision of the ER corrosion monitoring device are demonstrated through laboratory experiments in a climatic chamber. Results obtained using the novel technique in outdoor conditions are compared to mass losses of standard coupons. It is shown that the ER corrosion monitoring is a powerful tool for coating system selection. The initial corrosivity estimates are available within a few months, whereas the standard ISO 9223 assessment requires a full year to yield reliable results.

Electrochemical Impedance-based coating quality measurement for lifetime prediction of protective coatings

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Protective coatings represent the first line of defence against corrosion in industrial assets exposed to aggressive environments. The integrity and degradation behaviour of these coatings largely determine asset lifetime and maintenance requirements. Currently, visual inspection remains the most widely used method for assessing coating condition. While simple and cost-effective, visual inspection is inherently qualitative and subjective, providing limited quantitative information and no insight into the rate of coating degradation or remaining protective lifetime.

Electrochemical Impedance Spectroscopy (EIS) is a non-destructive electrochemical technique capable of characterizing coating performance by probing barrier properties, water uptake, and defect development within the coating system. Changes in impedance response can be detected long before visible damage appears, enabling early-stage assessment of coating degradation. However, the complexity of EIS data interpretation has traditionally limited its practical application in field conditions.

Electrochemical Impedance Spectroscopy using Coating Quality Measurement (CQM) approach to enable quantitative, objective evaluation of coating condition. CQM translates complex impedance spectra into main physically meaningful parameters that reflect the protective quality of the coating and the stage of degradation of that quality. This simplifies data interpretation while retaining sensitivity to key degradation mechanisms.

Long-term handheld EIS measurements were conducted on coated steel samples under controlled exposure conditions. Also, sensor plates with full spectrum permanent monitoring units were used to obtain field data. The evolution of the CQM parameters was monitored over time and correlated with coating degradation processes. Based on these results, lifetime prediction models were developed that link changes in CQM to coating breakdown rates and failure probability. These models provide a quantitative basis for estimating remaining coating lifetime and enable comparison between different coating systems and environmental exposures.

The results demonstrate that EIS combined with CQM interpretation offers a robust, non-destructive alternative to conventional visual inspection methods and extend the possibilities of testing in laboratory and in-field. By quantifying coating degradation and enabling lifetime modelling, this approach supports predictive maintenance strategies, improved asset integrity management, and reduced corrosion-related risk. The methodology is well suited for implementation in portable and in-situ EIS systems, facilitating scalable coating condition monitoring in industrial applications.

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Revealing heterogeneities in waterborne coatings as a function of particle size using operando reflective microscopy

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European directives requiring reduced volatile organic compound (VOC) emissions have increased the importance of alternatives to solvent-borne protective coatings, such as waterborne coatings based on colloidal resin dispersions. Over the past two decades, significant advancements have been made in the development of waterborne coatings. However, compared to their solvent-based counterparts, the mechanisms underlying the protective properties of waterborne systems are not as comprehensively understood. This emphasizes the necessity for continued research to address this knowledge gap.

In this work, we investigate waterborne polymer colloidal coatings, where film formation is complex and its relationship to water transport and corrosion protection remains insufficiently understood. Operando reflected-light microscopy is applied to study how colloidal particle size influences the spatial and temporal evolution of water--induced optical activity in model coatings with controlled particle diameters and identical surfactant coverage. High-resolution optical imaging during immersion is combined with image-based descriptors that provide quasi--quantitative insight into the kinetics and spatial distribution of water-coating interactions. Gravimetric measurements are performed in parallel to provide complementary information on bulk water uptake.

The combined methodology enables direct visualisation of how water penetrates and redistributes within waterborne coatings and how this behaviour depends on colloidal particle size and film microstructure. Water-induced optical activity is observed to emerge within the first minutes of immersion and to evolve through highly localised domains that progressively homogenise over time. The results demonstrate the strongly heterogeneous nature of water ingress and highlight the limitations of bulk techniques for capturing the spatial complexity of water transport. This work establishes operando reflective microscopy as a powerful approach for probing microstructural water pathways in waterborne coatings and for advancing the understanding of coating durability and corrosion performance.

From by-product to resource: Sustainable coating systems from tree bark for the transport sector

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As part of the EU project SuperBark, the previously underutilized by-product tree bark is being harnessed as a valuable resource for the development of sustainable coating systems. The aim is to create innovative materials for highly stressed surfaces in the transport sector that combine high technical performance with ecological sustainability.

The project focuses on two complementary approaches: First, cellulose nanofibrils (CNF) derived from bark are integrated into mechanically robust composite coatings. Second, extracted polyphenols serve as reactive components in temperature-cured overlay papers, which additionally incorporate production residues from the wood industry. Both systems are characterized by a compelling combination of structural resilience and resource efficiency and are based entirely on renewable raw materials as well as industrial side streams.

The materials developed have already demonstrated their potential to replace conventional fossil-based coatings in the transport sector. SuperBark illustrates how biogenic residues can be transformed into sustainable, high-performance solutions through intelligent material design.

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Next-generation catalysts: Transitioning to safer drying agents

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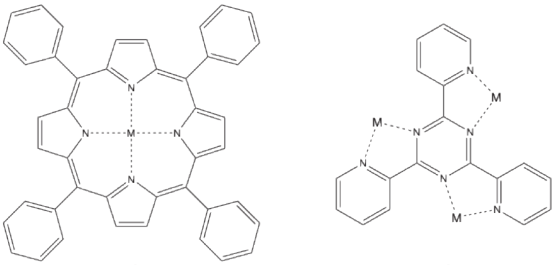
Key components in the paints and coatings industry are metal carboxylates, currently under strict scrutiny regarding their safety of use. This has required adaptive strategies, such as substituting 2-ethylhexanoic acid, classified as reprotoxic 1B, with safer alternatives like neodecanoic acid, or replacing solvents with non-VOC options. However, the greatest challenge is the substitution of cobalt, historically the primary drying catalyst, whose salts are either currently classified or face potential classification as reprotoxic 1B and, in some cases, potentially carcinogenic 1B [1].

The drying of a paint relies on an auto-oxidation process. The catalyst transfers atmospheric oxygen to the system through the formation of unstable hydroperoxides, which decompose into structures that carry out radical polymerization through the cross-linking of the alkyd resin's double bonds. The use of other metals, such as manganese or iron, has been studied as substitutes [2], requiring high doses and compromising the final properties of the film. The use of chelating ligands has proven to be an effective strategy, lowering the energy barrier between oxidation states of the metals. This allows the substitution of cobalt and a reduction in the required metal dosage while achieving the desired performance.

An example is the use of tetraphenylporphyrin (Figure 1, **1**), where the metal atom inserts into the centre of the tetradentate ring, making it from 100 to 120 times more active than cobalt [3]. Another is the novel use of 2,4,6-tris(2-pyridyl)-1,3,5-triazine (Figure 1, **2**), where the hexadentate ligand can coordinate up to three metal atoms facilitating metal accessibility thanks to its pincer structure, leveraging its extended aromatic ϖ-system to provide the electronic stability and oxidative robustness required for efficient catalysis. The high catalytic efficiency of these patented and patent-pending technologies, respectively, leads to fewer unreacted olefinic groups and fewer coloured by-products, which translates into good drying and hardening, a more precise colour, exceptional whiteness, and significantly lower yellowing over time.



1 **2**

Figure 1: Metal complexes with tetraphenylporphyrin (1) and 2,4,6-tris(2-pyridyl)-1,3,5-triazine (2)

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Polyester- and acrylic- based resins for sustainable coatings: An industrial perspective

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The development of industrial resins and its coatings have, especially in recent years, been strongly shaped by increasing sustainability awareness, evolving regulatory frameworks, and rising customer expectations. These drivers are accelerating the transition from conventional fossil-based raw materials toward more sustainable alternatives, while simultaneously raising the bar for performance, durability, and cost efficiency.

Current industrial research in coatings resins is therefore focused on identifying and implementing viable substitutes for fossil-derived building blocks in polymer synthesis. Among the most promising candidates are 2,5-furandicarboxylic acid (FDCA)[1] and a range of Itaconic acid esters [2,3]. These bio-based monomers offer significant potential for reducing environmental impact. However, their successful industrial adoption requires that they meet stringent visual, protective, and functional performance requirements comparable to established coatings systems.

Despite encouraging laboratory-scale results, market penetration of such novel materials often remains limited. Key barriers include higher raw-material costs, supply-chain constraints, and insufficient economies of scale, which collectively challenge competitiveness in large-volume industrial applications [4].

In this lecture, recently published research on sustainable polyester- and acrylic-based resin systems will be presented and critically evaluated from an industrial feasibility perspective. Emphasis will be placed on performance, scalability, and cost comparisons. In addition, ongoing and future research activities within Helios Resins & Atcoat will be discussed, highlighting practical pathways for bridging the gap between sustainability ambitions and real-world industrial coatings solutions and other applications [1–6].

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Acrylated cardanol as a bio-based building block for UV-curable coatings

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Cardanol is a phenolic lipid and is the main component of cashew nutshell liquid. Cashew nutshell liquid, a by-product of cashew nut processing, makes it an interesting source of biobased chemicals. Using a waste product to produce coating resins has an environmental and economic benefit. Cashew nutshell liquid contains anacardic acid, cardol, cardanol and 2-methyl cardol. The potential of cardanol as a biobased molecule, which can be used as an interesting raw material for biobased UV curing resins, was the focus of the research [1].

On average, a molecule of cardanol has two unsaturated sites. The molecule is hydrophobic and cardanol based resins exhibit promising thermal and mechanical resistance properties. The phenolic group, the active site of cardanol, can react with epichlorohydrin to add an oxirane ring to the molecule. Commercially available cardanol already reacted with epichlorohydrin was used during the research. The double bonds on the side chain are the other useful reactive sites for the formation of oxirane rings. Epoxidation using the Prilezhaev reaction was used to produce additionally epoxidized cardanol [2].

Described reactions formed an epoxidized cardanol with an average of three oxirane rings per molecule. The second step of the reaction was the acrylation step. The epoxidized cardanol reacted with acrylic acid in the presence of a tin catalyst and inhibitors that prevented the polymerization of acrylic acid. At elevated temperatures close to reflux, the product was an acrylated molecule of cardanol with three sites with double bonds that can undergo polymerization [3].

Synthesized resins were tested as reactive diluents and standalone resins in UV curable formulations for wood coatings and 3D print. Formulations ranging from 25 % to 50 % of the coatings resin composition were tested on basecoats for wood for UV and UV-LED hardening. Additionally, acrylated cardanol was tested in 3D print formulations for different applications.

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Rational design of ZnGa-sebacate/graphene nanoribbon synergy for effective anticorrosive polyurethane coatings

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The development of advanced hybrid organic coatings with long-term corrosion resistance remains a key objective in advanced surface protection technologies. In this work, Layered Double Hydroxide (ZnGa-LDHs) intercalated with an environmentally benign corrosion inhibitor, disodium sebacate (SB), were synthesised and combined with graphene nanoribbons (GNRs) to produce a multifunctional nanofiller for anticorrosive polyurethane (PU) coatings. GNRs were prepared by the oxidative unzipping of multi-walled carbon nanotubes (MWCNTs), and the ZnGa-SB/GNR composite was fabricated via an in situ hydrothermal method. The synergistic integration of high-barrier GNRs with ZnGa-SB generates a “labyrinth effect” that effectively impedes the ingress of corrosive species while enabling active corrosion inhibition. Structural and morphological characterisation by XRD, FT-IR, Raman, TGA, FE-SEM, and EDS confirmed the successful formation of the hybrid nanofillers. The nanofillers were first incorporated into acrylic resin (AC) for short-term anticorrosion evaluation in a 0.1 M NaCl solution and subsequently embedded into PU coatings for the long-term assessment in a 3.5 wt% NaCl solution using electrochemical impedance spectroscopy (EIS). The PU/ZnGa-SB/GNR coating exhibited an impedance modulus of 5.90 ×107 Ω cm^2 at $|Z|_{0.01}$ Hz after 2688 hours of immersion, demonstrating excellent barrier and inhibition performance. In addition, the hybrid coating showed superior adhesion, hardness and salt spray resistance compared with reference coatings. These results demonstrate that the synergistic combination of ZnGa-SB and GNRs offers a promising strategy for the design of next-generation, environmentally friendly anticorrosive coatings.

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Novel spherical calcium silicate anti-corrosion pigments for protective coatings

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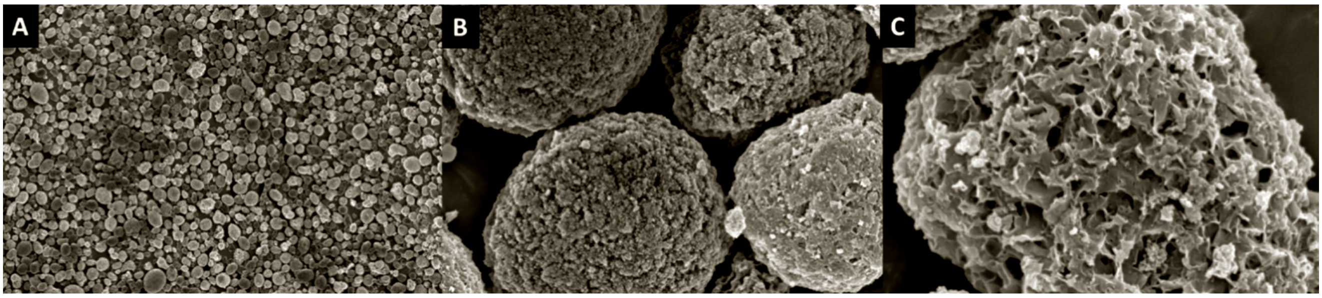
Corrosion protection pigments are essential for safeguarding materials, particularly metals, against environmental degradation. In response to increasing performance demands and regulatory pressures for sustainable solutions, Evonik studied two innovative spherical calcium silicate anti-corrosion pigments based on its Spherilex® technology. These novel pigments leverage unique particle morphology and advanced calcium silicate chemistry to deliver enhanced corrosion resistance across diverse coating systems, including waterborne, solvent-borne, high-solid formulations and powder coatings.

The Spherilex® technology represents a breakthrough in silica-based materials, offering spherical particles with tailored porosity and an optimized balance of anti-corrosive performance, mechanical integrity, and ease of formulation. Calcium ions on the pigment surface enable ion exchange with corrosion-stimulating ions, forming a protective layer of calcium silicate on the substrate.

The spherical calcium silicate anti-corrosion pigments addresses critical challenges in the market. Traditional pigments, such as chromates, are highly effective but carcinogenic and phased out due to regulatory restrictions. Phosphate-based pigments, while safer, face scrutiny due to their toxicity to aquatic life. Zinc-based pigments, widely used for corrosion protection, pose sustainability concerns due to zinc's environmental footprint. Calcium silicate anti-corrosion pigments offer a zinc-free, chromate-free, and environmentally friendly alternative, supporting compliance with global standards while meeting increasing demands for sustainable solutions.

Extensive testing compared spherical calcium silicate anti-corrosion pigments to established anti-corrosion pigments, including zinc phosphate, phospho-silicates, and ion-exchange silicas in various coating systems, e.g. epoxy, poly aspartic, high solid silicone systems and powder coatings. Results from salt spray tests (ASTM D1654, DIN ISO 9227) demonstrated superior corrosion resistance, with reduced corrosion creep and delamination even at low pigment dosages. Furthermore, formulations containing spherical calcium silicate anti-corrosion pigments showed corrosion protecting performance on various substrates, including sandblasted and blank steel.

Mechanical and chemical resistance tests confirmed that the spherical particle morphology supports coating integrity and enhance abrasion resistance, which is critical for applications exposed to physical wear. At the same time the studied two innovative spherical calcium silicate anti-corrosion pigments did not negatively impacting adhesion, flexibility, or humidity resistance.



Advancing aerospace coating systems: Synergizing Cr(VI) substitution with process optimization

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This presentation delineates the technical milestones achieved during the phase-out of Hexavalent Chromium [Cr(VI)] in rotor blade coating systems. By leveraging a continuous improvement framework, the project transitioned from legacy chromated primers to high-performance, REACH-compliant alternatives while simultaneously optimizing the manufacturing flow.

Technical Approach

The core of this transition was a non-one-for-one substitution strategy. Rather than simply replacing the inhibitor, the team re-engineered the entire paint stack to achieve superior interfacial adhesion and corrosion kinetics.

Key technical advancements include:

- **Surface Energetics & Adhesion:** Implementation of self-texturing topcoats designed to standardize surface morphology at the blade root, ensuring a "Right First Time" finish.
- **Curing Kinetics:** By reducing the drying stages from 5 to 3 per component, we effectively mitigated a major thermal bottleneck.
- **System Harmonization:** Transitioning to simplified, multi-functional coating schemes that fulfill stringent aerospace requirements for environmental resistance.

Experimental Validation & Results

The qualification process followed a rigorous hierarchy of testing to ensure airworthiness and durability:

1. **Coupon Level:** Evaluation of dry and wet adhesion, corrosion resistance, mechanical behavior.
2. **Part Level:** Full-scale demonstration on rotor blade geometries to validate application parameters and thickness consistency.
3. **Process Integration:** Analysis of the "turnkey" qualification, confirming that the new stack maintains structural integrity under cyclic fatigue and relevant environmental loading.

Conclusion

This project demonstrates that environmental compliance (REACH) can serve as a catalyst for **process intensification**. Through site specialization and the centralization of blade manufacturing, we achieved a highly profitable business case with an ROI of less than 2 years, all while enhancing the chemical safety and technical performance of the aircraft's primary flight components.

Recycled low-carbon circular zinc powders for sustainable zinc-rich coatings and thermal spray repair of galvanized steel

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Zinc is forth of the most used metals in general. Production every year is 12–16 milion tons, but only about 4 Mt is coming from recycling stream. Leaving the rest of zinc to be mined and processed. Therefore, the amount of recyclable zinc is increasing. Zinc is mainly used for corrosion protection of steel (60 %), die casting alloys (15 %), brass production (9 %) and zinc compounds production (11 %). There are in fact two groups of scrap to be recycled. Either "new scrap" generated during production and manufacturing or "old scrap" that is a zinc product which reached its end of life. However, process of recycling is far more divided than that and strongly depends on scrap's properties and on the final objective.

The objective here was to develop a 100% recycled product which have the same or similar properties as the product made from primary production. The input was new scrap from different industries. After laboratory research a small production line was build and a few promising products were produced. So far there are two 100 % recycled pure zinc powders, which has similar properties to primary products, but significantly lower CO_2 equivalent and are ready for industrial use.

Fine zinc powder, FZNP15, is pure zinc powder meant to be used in zinc rich paints for corrosion protection of steel, but is not limited for that only. It is fully compliant with the standard ČSN EN ISO 3549 and it has been successfully used in both organic and inorganic formulation of zinc rich paints. It has little wider particle side distribution and particles shape than commercially used powders, but this difference hasn't affected the protective and mechanical properties.

The other zinc powder, ZNP 38/16HS, is also for corrosion protection of steel but in form of thermal sprayed coating. It is primarily for repairs of galvanized steel and is also in compliant to ČSN EN ISO 1461 as a repair. It is recommended to use in galvanizing plants or on the construction site to repair the galvanized coating and maintaining excellent corrosion protection. Powder and application are also compliant to standards ČSN EN ISO 14232-1 and 2063-2.

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90% time and energy savings in paint production by high-intensity dispersion technology under vacuum

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Rising energy prices and increasing regulatory pressure have made energy efficiency a key performance indicator in industrial paint and coatings production. Reducing energy consumption is particularly essential for European manufacturers to ensure long-term competitiveness and sustainable production processes.

Conventional paint production technologies such as high-speed dissolvers and bead mills convert more than 90 % of the supplied electrical energy into heat. This is primarily caused by the undirected dissipation of energy over large product volumes and over long processing times. The resulting temperature increase requires additional cooling steps, leading to further energy consumption and extended process durations. Furthermore, these technologies repeatedly expose processed material to mechanical stress. This results in unnecessary reheating and damage to particle structures, polymers, treated pigment surfaces, and even additives.

New high-intensity inline disperser technologies represent a fundamentally different approach. Although they operate at comparable electrical power levels, the applied power is concentrated within a well-defined, high-shear dispersing zone with a volume of less than 250 ml and a residence time of only about one millisecond. Consequently, the volume-specific power density is approximately 30,000 times higher than in conventional dissolvers and around 75–100 times higher than in bead mills, while shear rates are increased by up to three orders of magnitude.

This high degree of process intensification enables powders and liquids to be completely dispersed already at the moment of first contact, eliminating the need for long recirculation times or multiple passes. Even hard agglomerates are effectively broken up into individual particles. Despite the high local power concentration, the product's overall temperature increase remains typically between 10 and 30% compared to conventional processes. This is often below one degree Celsius per passage, as the supplied energy is predominantly converted into useful dispersing work rather than heat.

As a result, process time and energy consumption can be reduced by up to 90 %. Manufacturing costs are significantly decreased, and additional savings may be achieved through reduced raw material usage due to improved dispersion efficiency and homogeneity. Furthermore, inline dispersion technology enables novel process concepts, including the substitution of energy-intensive bead milling, cold instead of hot processing, elimination of aging and intermediate storage steps, improved process reproducibility, optimized cleaning procedures and reduced batch sizes with smaller production footprints.

This paper presents the physical principles underlying high-intensity inline dispersion technology and compares it with conventional dispersing methods. It also discusses industrial production concepts and results based on numerous existing installations in paint and coatings manufacturing.

How to REALLY make use of AI in the value chain “coatings”

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AI is THE buzzword these days, also in the Coatings Industry. A lot of companies try to deal with it, with an ever increasing number of suppliers of software to help them in one way or the other.

The typical value chain “Coatings” features a linear process chain across the whole coatings company, with incoming goods from a supplier and outgoing goods to a client. Typical examples for AI initiatives are located in R&D or in production, maybe even across organizational silos, the so called “departments”. Quite often, these initiatives encounter problems in the form of data, either not available, not suitable or not of the right quality. Hence, huge efforts are made to remedy these problems, but the number of success stories remain rather low still.

In this presentation, the potential of AI in the Coatings Industry is highlighted by introducing a new concept, namely that of data sharing. It will demonstrate how modern measurement devices can help to understand product interaction and processes while providing digital data for further analysis, which in turn can help to close control loops. These control loops would be ideal to provide learning data for digital twins. Connect these along the whole value chain, and we have a completely new ball game.

This is the approach that the Smart Paint Factory Alliance wants to foster in the Coatings Industry, by introducing a holistic approach to the entire value chain. In this context, the data sharing would speed up getting a large amount of data to establish digital twins, which would subsequently learn continuously via the closed loops. Top that with a consumer-centric flow of data, and we would have a situation where all participants along the value chain could benefit.

Keywords
Digitalization; holistic approach; data-driven process optimization;

Eliminating tinting steps: The role of AI in modern paint production

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Paint production often relies on corrections at the end of the manufacturing process, when the complexity of the product is high, making the corrections very tedious and costly. ORONTEC is focused on early process control and aims at preventing error propagation along the production process to increase productivity by tackling this problem.

The presentation will demonstrate this philosophy with the example of pigment paste production and their subsequent use to formulate colored paint.

First, we will look into why we need tinting steps to begin with: variances in raw materials, process parameters and sample preparation are the main causes, together with measurement methods that are not suitable for the task.

Good methods need to fulfill 4Rs: they must be rapid, reliable, reproducible and relevant. We will demonstrate why traditional methods fail here, and show how to do better.

Last, we will demonstrate by a model calculation about the impact of early process control to the bottom line as well as the sustainability of a product. The role of AI in this process will also be highlighted appropriately.

Conductive nanocarbon-based composite coatings for electrothermal ice protection

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The icing phenomenon and its unfavourable consequences in various engineering fields are well recognized. These consequences span from simple daily-life applications, such as extra energy consumption in frosted fridges, slip and rollover of a car on an icy road, ice accumulation on power transmission lines and telecommunication infrastructures, to more catastrophic fatal accidents such as icing-related aviation accidents (e.g., American Eagle Flight 4184 and Air France Flight 447). Icephobicity, as a mitigation solution for icing, is generally defined as the ability of a surface or coating to inhibit ice formation, repel ice, or remove ice once it forms. This mitigation can happen through passive and active mechanisms [1]. Passive icephobic coatings rely solely on intrinsic surface properties (e.g., low surface energy, tailored roughness, or lubricant infusion) to reduce ice adhesion and delay freezing without external energy input. However, passive strategies often lose effectiveness under severe icing conditions or prolonged exposure. In contrast, active ice protection systems supply external energy to prevent or remove ice, most commonly via electro-thermal heating based on Joule’s effect. Conventional electro-thermal systems use embedded metallic heaters or wires, which add weight, require complex integration, and produce non-uniform heating. In contrast, nanocarbon-enabled coatings incorporate electrically conductive fillers such as carbon nanotubes (CNTs) and graphene directly into polymer matrices, forming percolated networks that convert electrical energy into heat uniformly across the coated surface. CNTs and graphene exhibit high electrical and thermal conductivity, enabling rapid heating, high electro-thermal efficiency, and low power consumption in thin conformal coatings. Therefore, nanocarbon-based composite coatings represent a new generation of lightweight, scalable, and energy-efficient electro-thermal ice protection systems [2].

In this study, electro-thermal de-icing coatings based on epoxy nanocomposites filled with CNTs were developed. The CNT-based coatings were fabricated by high-shear mixing and sonication to establish a homogeneous conductive network. To complement the active heating function, a plasma-polymerized organosilane topcoat was applied, providing a hydrophobic surface that limits water spreading and facilitates ice release. This multilayer architecture enabled rapid and spatially uniform temperature rise under applied electrical power, resulting in fast de-icing, with complete ice removal achieved in as little as ~20 s. Defrosting was achieved at relatively low power densities of 0.2–0.4 W cm^{-2}, which lie at the lower end of reported electro-thermal de-icing systems and therefore indicate a higher heating efficiency than conventional metallic heaters and many polymer-based heating films. The coatings also exhibited stable performance over at least 50 accelerated heating cycles without degradation, while offering key practical advantages including low added weight, tunable electrical resistivity via filler loading, and applicability to complex geometries.

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Research into bio-based components in coatings

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Bio-based components as an alternative to conventional raw materials are at the heart on new developments in coatings industry. The European Green Deal, which aims to achieve climate neutrality by 2050 and improve sustainability, is promoting research into the use of bio-based components in coatings. Bio-based components are already used in commercially available coatings as binders, additives, or solvents. Most of these products are made of raw materials as maize or sugar cane, leading to and create the food vs fuel conflict.

At Fraunhofer IPA, various publicly funded research projects are investigating the use of bio-based by-products as raw materials for coating components in order to avoid this conflict.

One focus of these research projects is the use of chitin and its deacetylated form, chitosan. Chitin is the second most common biopolymer and is generated as a by-product of seafood processing from crab shells [1].

When modified to chitosan, it is slightly soluble in organic acids such as acetic acid and can be processed into compounds for coating application.

One of these current research projects is the "Biogenic Coatings and Films for Transportation Protection – BIOschutz" project. In this project, temporary coatings were developed as transport protection coatings [2]. Such necessary surface protection causes a considerable amount of waste even before the actual product is used. As part of the project, a biobased and biodegradable temporary coating based on chitosan was developed. This can increase biomass in industry and reduce dependence on petrochemical products – a source of microplastics.

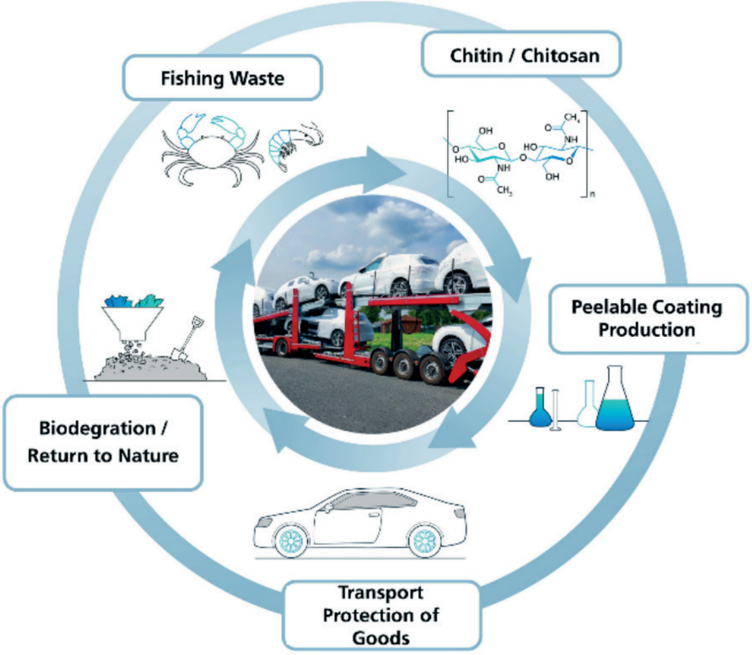

Figure 1: Concept of the temporary BIOSchutz Coating (source: Fraunhofer IPA)

Bio-based pigments were developed as part of the cooperation project "Crustacea-chitin based pigments (Crusty-Pigments)" [3]. Crusty Pigments are based on ground Chitin-particles, which can be produced in specific particle size distributions using high-pressure wet jet stream milling.

Natural dyes are precipitated onto these particles using polymer precipitation processes involving bio-based polymers. This process encapsulates the natural dyes together with the chitin particles, thereby hindering the solubility and thus the migration of the dyes within the binder matrix and reducing the washout effect. In a subsequent process, UV-stabilizers can be incorporated into the encapsulation layers to further address lightfastness issues.

Figure 2: Chitin-based pigments on bananas (source: Fraunhofer IPA)

Another by-product is chicken feathers from the food industry. The feathers consist of keratin, which was used as raw material in the “KerBe” research project in cooperation with Fraunhofer IAP [4]. The keratin was ground into microparticels and used as filler in organic coatings. The chemical functionalities of the keratin filler improve the barrier properties of coatings and their UV stability. Its good performance was proved in 2-component coating systems.

Figure 3: Keratin microparticles (Source: Fraunhofer IAP)

The projects mentioned are examples of how bio-based by-products can be used as raw materials in ways other than simply replace petroleum-based products on a 1:1 basis. The idea that bio-based raw materials must replicate petroleum-based components with the same properties should be abandoned. Their unique properties and functionalities can have a positive effect on coatings and open up new applications and functional possibilities.

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Operational properties of PLA based biopolymer coatings

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The transition from petroleum-based polymers to bio-based alternatives is driven by environmentally motivated sustainability demands. This trend reflects a broader shift away from plastics derived from fossil resources such as oil and natural gas toward materials produced from biological feedstocks, including microorganisms and plant-based raw materials.

A comprehensive approach that combines the use of bioplastics with strict control of carbon dioxide emissions at all stages of a product's life cycle can substantially reduce the overall carbon footprint. Such an approach contributes to making industrial production, product use, and end-of-life management more consistent with the principles of the circular economy.

Alongside their bio-based origin, an important desirable property of modern polymers is their ability to biodegrade under the action of microorganisms or other environmental factors. Among the materials that combine both bio-based and biodegradable characteristics, polyhydroxyalkanoates (PHAs) and polylactide (PLA) are particularly notable. Polylactide is widely used, for example, in additive manufacturing and in the production of food packaging films. However, its potential in the formulation of paints, coatings, and related surface-treatment systems remains largely unexplored.

Its durability and the mechanisms of degradation under environmental factors - well described for many conventional coating materials - remain insufficiently understood for polylactide. Systematic investigation of these processes is essential for determining how PLA can be tailored for specific applications. Questions such as its suitability for outdoor use, its stability under prolonged exposure to solar UV radiation transmitted through window glass, and its performance in indoor environments must be resolved before assessing the practical applicability of this polymer in various coating systems.

In this work, we focus not only on neat polylactide but also on its composite formulations. These include plasticized PLA systems designed to reduce the minimum film-forming temperature, as well as PLA filled with various additives to obtain compositions closer in structure and functionality to traditional composite materials. We investigate the kinetics and characteristic timescales of PLA degradation under ultraviolet radiation, elevated humidity, and increased temperature. Additionally, we examine how each component in these material groups influences the degradation pathways and overall stability of the resulting coatings.

The principal analytical methods employed in this study include FTIR spectroscopy, which enables quantitative assessment of polymer degradation through the evolution and shifting of characteristic PLA carbonyl absorption bands in the 1750–1730 cm^{-1} region. Additional techniques comprise surface free energy determination, calculation of the carbonyl index, and scanning electron microscopy, the latter providing insight into the morphological features and surface-level degradation patterns of the investigated composite materials.

This integrated approach allows us to move toward the ultimate objective of our study: the development of viable and stable polylactide-based coatings suitable for large-scale, practical applications.

Unsaturated polyester resins from poly(ethylene-2,5-furanoate)

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With the growing trend of replacing petroleum-based materials with sustainable alternatives, the need to recycle these new materials is becoming increasingly important. Poly(ethylene-2,5-furanoate) (PEF) is considered one of the most promising candidates among these materials and has the potential to replace poly(ethylene terephthalate) (PET) as a packaging material [1]. This study explores the chemical upcycling of PEF into unsaturated polyester resins. PEF was synthesized as a post-consumer model via melt polycondensation and solid-state polymerization, then recycled into glycolyzed oligomers using diethylene glycol. These oligomers served as polyols for preparing unsaturated polyesters with itaconic acid, which were subsequently blended with dimethyl itaconate to produce resins with low volatile organic compound (VOC) content. PEF was characterized by NMR spectroscopy and viscometry, while the polyesters were analyzed by IR, Raman, NMR, and SEC to assess composition and molecular weight. The resins were cured using a vanadium-based catalyst [2] and MEKP, and the resulting specimens were evaluated for mechanical and thermal properties. The results demonstrate that these upcycled materials exhibit performance comparable to conventional styrene-based unsaturated polyester resins [3].

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Nature-inspired hydrophobic self-healing PDMS coatings via dynamic metal–ligand coordination

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Introduction: The rapid progress in materials science has accelerated the development of multifunctional materials. Protective coatings act as the primary interface between substrates and the external environment, providing corrosion protection, anti-icing capability, and other surface functionalities [1]. However, conventional coatings remain susceptible to mechanical damage and environmental stresses, leading to performance degradation. Consequently, increasing attention has been devoted to coatings with intrinsic self-healing ability to improve durability and extend service life [2]. Hydrophilic self-healing systems can utilize ambient moisture to trigger repair, yet water may also disrupt dynamic bonding interactions. Therefore, advanced coatings are required to simultaneously deliver corrosion resistance, mechanical robustness, strong adhesion, and durable hydrophobic self-healing behavior an objective that remains challenging. Bio-inspired strategies derived from marine organisms such as mussels, octopuses, and barnacles have guided the development of water-resistant self-healing materials. Among candidate polymers, poly(dimethylsiloxane) (PDMS) stands out due to its excellent thermal stability, intrinsic hydrophobicity, and high elasticity after cross-linking [3]. These characteristics make PDMS particularly attractive for metal–ligand-based self-healing networks, while the incorporation of hydrophilic functionalities into hydrophobic matrices has been shown to further enhance interfacial adhesion [4].

Methodology: In this work, amine-functionalized PDMS was employed as the primary polymer matrix, while thiophene dialdehyde was used as the crosslinking agent at an equimolar ratio. The mixture was stirred for 24 h to ensure effective network formation. Subsequently, $VOSO_4$ was introduced into the system, and the reaction was continued at 40 °C for an additional 5 h. Vanadium-based species have been widely recognized as environmentally friendly corrosion inhibitors [5]. Therefore, the incorporated VO^{2+} ions were expected to not only enhance corrosion resistance but also serve as dynamic coordination sites contributing to the self-healing functionality. The resulting resin was deposited onto metal substrates via spin coating and subsequently cured in an oven at 100 °C for 8 h. The Surface hydrophobicity of the prepared coating (SHVa) was evaluated through contact angle (C.A.) measurements. Visual assessment was also recorded by the optical photos for both superficial scratches and full cut damages while electrochemical impedance spectroscopy (EIS) was conducted to assess both corrosion protection and healing efficiency of the coatings, with and without artificial scratches.

Results: Visual assessment confirmed the successful formation of the self-healing network. Superficial scratches disappeared almost immediately after damage, whereas deep cuts with a thickness of 7 mm were fully healed within 15 min (Fig.1a). The final coating exhibited a water contact angle of 119.26°, approximately 10° higher than that of Sylgard 184 (PDMS) (Fig. 1b). EIS analysis further demonstrated that the coating could autonomously recover after damage in a corrosive environment while maintaining satisfactory corrosion resistance over 21 days of immersion. In contrast, the corrosion resistance of the pristine PDMS sample decreased dramatically (by 97%) after scratching during the same period (Fig.2).

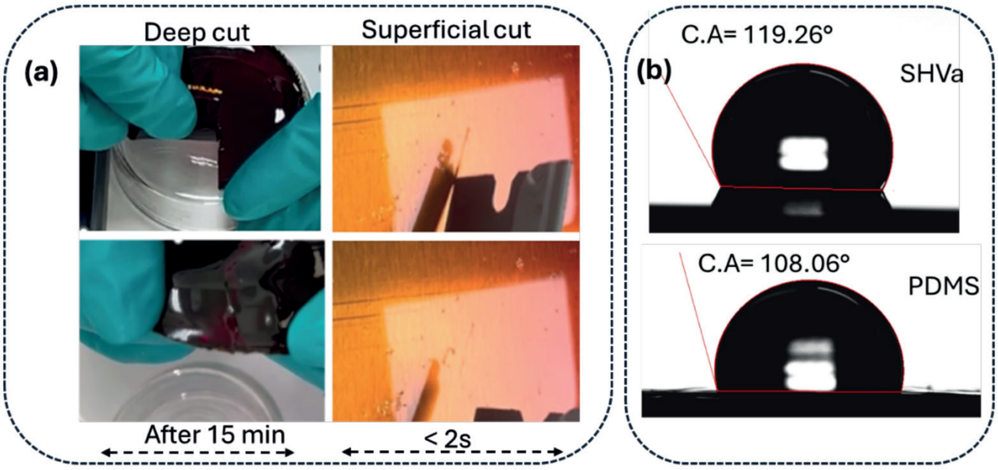

Figure 1: (a) visual assessment of self-healing ability of SHVa coating, (b) water contact angle value on the

surface of SHVa and PDMS coating

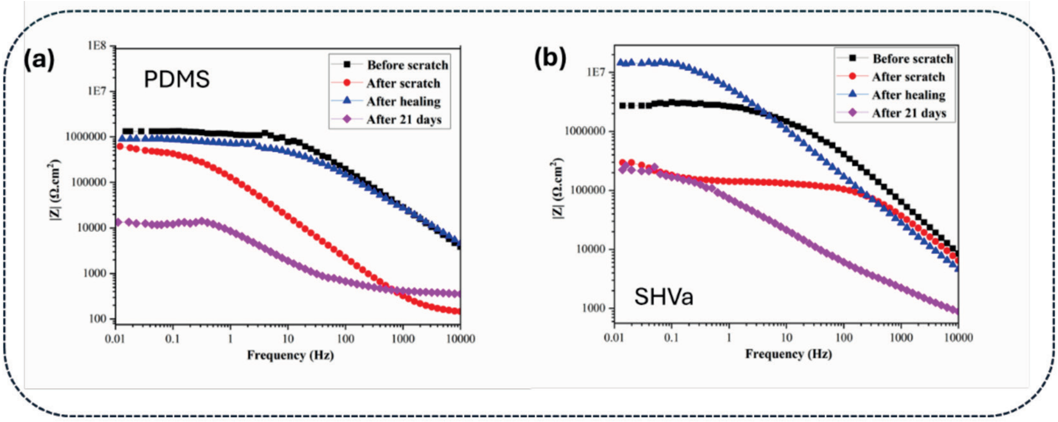

Figure 2: Bode impedance diagrams of prepared samples for 21 days immersion in NaCl 0.05 molar (a) PDMS, (b) SHVa

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Mechanistic insights into graphene-modified corrosion protective coatings

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Graphene has attracted significant interest in corrosion protection due to its mechanical, electrical and potential barrier properties [1]. However, many literature approaches rely on laboratory-grade materials and non-scalable dispersion routes, limiting industrial transferability [2,3]. In contrast, this work investigates commercially available few-layer graphene processed via an application-oriented and scalable dispersion strategy within an EU-funded interregional research project.

Beyond demonstrating performance improvements, the objective is to understand how graphene acts in different coating systems and under which conditions beneficial effects occur. Graphene was dispersed into liquid intermediates, and dispersion quality was monitored by laser diffraction. Raman spectroscopy, infrared spectroscopy and scanning electron microscopy were used to assess structural integrity and distribution within cured coatings.

Systematic variation of graphene type, particle size distribution and concentration showed that corrosion performance does not increase monotonically with decreasing particle size or increasing content. Instead, a defined formulation window was identified. Performance deterioration at higher loadings suggests network formation, increased additive demand or electrochemical side effects.

The materials were evaluated in a zinc-free epoxy coating and a zinc-rich system using salt spray testing (SST) and complementary electrochemical measurements, including electrochemical impedance spectroscopy (EIS).

In zinc-free systems, improved scribe performance was observed under defined dispersion conditions, raising the question whether the effect is purely barrier-related or involves defect-driven electrochemical interactions. In zinc-rich systems, enhanced performance at reduced zinc levels was achieved without deliberately targeting percolation, indicating mechanisms beyond simple conductive network formation.

The presentation discusses working hypotheses on barrier effects, defect-related electrochemical interactions and formulation-dependent network phenomena, linking dispersion characteristics with electrochemical response and exposure results

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Bio-based 1,3 propanediol as an universal building block for polyester resins

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Short-chained linear diols are widely used as building blocks in polymer chemistry [1]. Most of these monomers are still fossil-based e.g. ethylene glycol. One of the few commercially mature and available biobased diols is 1,3 propanediol (PDO) [2]. This later monomer has been chosen to modify polyesters, a versatile class of binders present in many applications. Using a biobased difunctional diol in polyesters was driven by multiple pragmatic reasons: increase the bio-based content, lowering the polymer viscosity, decrease the amount of toxic monomers and VOC, shorten the raw materials list in the recipe, increase the flexibility. In this work two radically different polyester formulation were studied: solvent borne alkyd resins (medium and short oil) and carboxy functional polyesters for powder coatings. In the alkyd resins either pentaerythritol (PENTA) or trimethylolpropane (TMP) where gradually substituted. Considering medium oil alkyd resins, a replacement of 3% of PENTA reduced the alkyd viscosity to about 40% while keeping the basic mechanical properties and drying almost unaffected. In short oil alkyds for two pack polyurethanes or stoving paints, a replacement of TMP up to 20% led to a VOC reduction in the alkyd of approximately 16% and a drop of viscosity between 3 to 10 times while keeping properties unchanged. In powder coatings, a slightly different approach has been followed: ethylene glycol (EG) and hexanediol (HDO) where replaced in hybrid indoor composition, while adipic acid or neopentyl glycol (NPG) were replaced in a durable outdoor formulation. Considering the hybrid powder coat, the replacement of two diols by one was successful: both EG/HDO and PDO formulation showed the same properties. In the durable formulation, introducing PDO in the diol blend helped to diminish the melting temperature of the NPG/water mixture. Replacing NPG led to a significant reduction of Tg and QUV resistance, Hence a limit has to be set according to the application. Completely replacing adipic acid might be an interesting way to use PDO in such formulation as well.

The results of these studies showed that the implementation of a significant amount of biobased material and improving final product properties is possible for dramatically different binders and applications.

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Novel waterborne acrylic binder for 1K fast dry and improved early rain resistance in external thermal insulation composite systems (ETICS)

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External Thermal Insulation Composite Systems (ETICS) are widely used façade solutions designed to improve the thermal performance of a building while providing a protective and aesthetically consistent exterior finish. These systems rely on multiple layers; including insulation boards, adhesives, reinforcement, and a finishing coat that must work together to deliver durability, energy efficiency, and long-term weather protection. Because the finishing render or coating is the outermost barrier, its application properties directly influence both installation efficiency and final appearance.

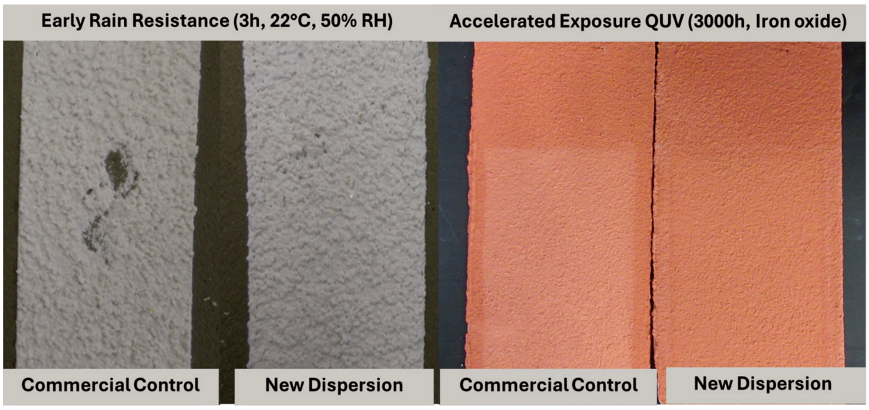
Freshly applied ETICS topcoats are vulnerable to rain, which can cause washing off, staining, or texture defects. [1] A faster dry coating with improved early rain resistance (ERR) greatly increases the reliability of façade installations, especially in regions with unpredictable weather. By reducing the time during which freshly applied surfaces remain susceptible to moisture/rain damage, contractors can maintain project schedules more effectively and avoid weather-related delays [1]. These improvements also reduce the likelihood of costly repairs or reapplication, helping minimize material waste and labor time. Overall, improved ERR supports consistent application quality, increased installer confidence, and higher construction efficiency.

Despite several efforts towards designing fast-dry polymers, the industry has struggled to find practically useful solutions [1–4]. Many of the systems that can dry faster are two-component, have strong odors, are unstable, utilize harmful chemicals or require external stimuli [2–4]. This prevented a wider adoption of these systems in the construction industry and calls for the introduction of an improved waterborne, one-component fast-drying polymer dispersion.

Dow developed a novel and patented one-component waterborne acrylic polymer dispersion that endows fast-dry and outstanding ERR properties to cement-free ETICS basecoats and topcoats, while offering improved sustainability profiles. ETICS topcoats containing the new acrylic binder show comparable or better dirt pickup resistance (DPUR) without using photoinitiators and good color durability. In addition to cost savings realized from less weather sensitivity and high durability, the new polymer dispersion affords formulators the ability to reduce TiO_2 levels while achieving similar hiding in white ETICS at lower cost-in-use.

The novel binder technology can also be leveraged for fast-drying prefabrication applications in white or lighter pigmented coatings. It also shows good DPUR and asphalt bleed resistance performance in elastomeric roof coating applications.

In our presentation, we share formulation expertise and laboratory data comparing current technologies with our novel acrylic polymer dispersion. With a focus on ERR, color retention, DPUR, and application performance of ETICS mortars, we will cover selected adjacent application segments too.



Left: Control topcoat panel damaged after water flow in ERR test, panel unchanged with new dispersion
Right: 3000h QUV color retention in exposed area better with new dispersion than with commercial control

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Latexes based on vegetable oil-derived monomers and their facade coating applications

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The need to produce synthetic polymers from renewable and sustainable resources also affects the area of emulsion polymerization. The present work, therefore, deals with partially vegetable oil-based latexes synthesized from acrylated derivatives of rapeseed oil and linseed oil, as well as standard acrylic and methacrylic petroleum-based monomers (25 wt.% of the respective bio-based monomer in the total monomer mixture), and their application as sustainable binders for waterborne façade paints. We followed up on our recent research on water-resistant latex coatings, which revealed a positive effect of using polymerizable emulsifiers [1,2]. In this regard, the influences of copolymerized vegetable oil-based monomer type and polymerizable emulsifier were studied simultaneously, particularly from the perspective of the protective and weather-resistant performance of the final façade paint coatings. The incorporation of bio-based derivatives into polymeric latexes was confirmed with infrared spectroscopy and asymmetric flow field flow fractionation coupled with a multi-angle light scattering. Evaluated coating properties showed that the partially bio-based latexes being used as binders provided façade systems with similar or better performance compared to a standard commercial acrylic latex binder, making them promising candidates for façade coating applications.

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Acknowledgement

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Detection of production relevant deviations in paint sprays

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The project pAInt-Behaviour focused on the use of machine learning in coating in the automotive and commercial vehicle sector in order to optimize process stability and reject rates.

The main causes of scrap and rework, apart from dust inclusions, are primarily defects caused by layer thickness deviations (e.g., runs, color deviations), which is why the project focuses on maintaining the paint layer thickness. Despite the very high degree of automation in painting systems and sensory monitoring, the coating process chain is not considered to be fully controllable in terms of process capability analysis, partly due to the lack of physical description models and partly due to the multi-causal relationships involved.

In this project, AI will be used for two reasons:

1. continuous monitoring of processes
2. early notification of losses in effectiveness (losses in quality, availability, or performance).

As production systems become increasingly dynamic, e.g., due to a modular production strategy, high product variance, or material changes, decision-making systems for evaluating product quality can no longer be created and maintained manually.

Using intelligent algorithms (behavioral model [1]), all data generated during the painting process could be evaluated and deviations detected (s. fig. 1). Measurements taken at the spray jet (SpraySpy, s. fig 2) enabled errors to be found early on in the process and their causes to be identified. In addition to visual quality assessments, layer thicknesses are also monitored using terahertz measurement technology. To this end, the project partners took the following steps:

- Addition of the missing spray sensor technology (measurement of the paint spray [2])
- Automation of the most important end-of-line quality parameter (layer thickness using terahertz technology)
- Networking of all data sources
- Generation of missing data sets (“error simulation”) in the technical center
- Selection of the most successful machine learning model
- Self-learning behavior models for networking process and quality data

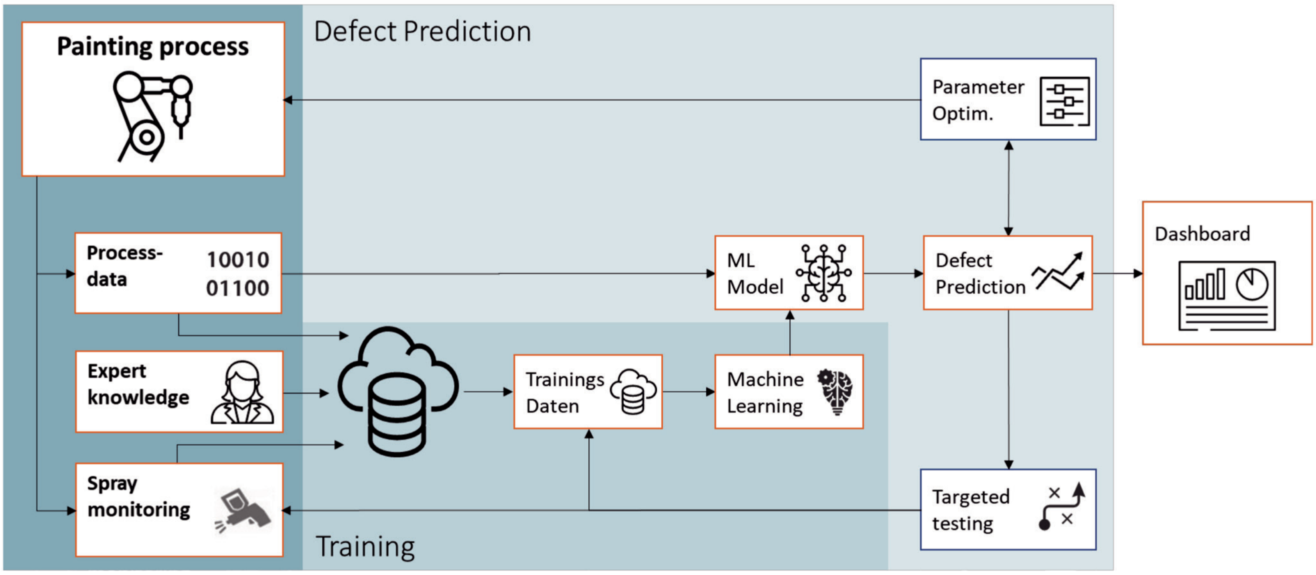

Fig. 1: Scheme of AI-controlled painting

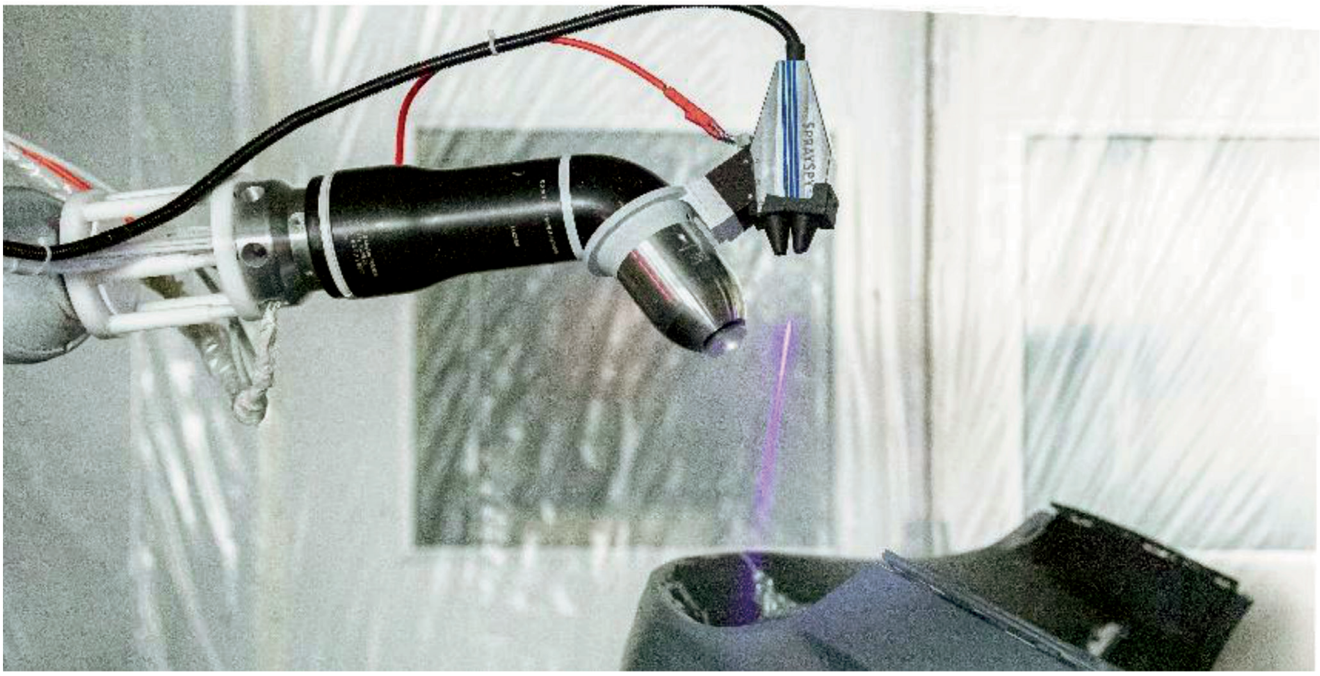

Fig. 2: Online Spray measurement while painting bumper

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Unleashing the power of azides – From surface modifiers to adhesion promoters

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Plastics—particularly polyolefins—are challenging to coat due to their low surface free energies and the scarcity of functional groups capable of forming covalent bonds. As a result, coatings on such substrates typically exhibit poor adhesion, relying only on weak intermolecular interactions. Conventional surface activation methods such as plasma, corona, or flame treatment temporarily increase surface polarity but often damage the polymer and lack long term stability [1,2]. These limitations can be addressed through grafting techniques, particularly the industrially relevant “grafting-to” method, which enables the covalent attachment of molecules and polymers to polymer surfaces [3]. Incorporating azides as reactive groups in this process allows precise tailoring of surface properties.

The azide group ($-N_3$), when stabilized by aromatic rings, readily releases nitrogen upon energy input to generate a highly reactive nitrenes [4] that insert into C–H bonds and form covalent linkages [5,6]. This chemistry enables durable functionalization of polymer surfaces (Fig. 1).

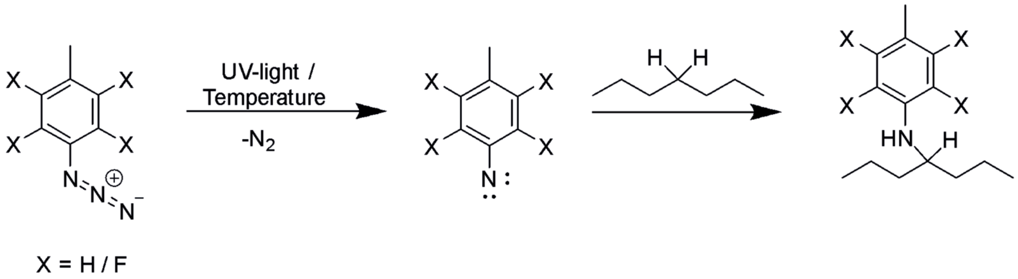

Figure 1: Reaction Scheme for the CH-Insertion of Nitrenes from Azides into Polymers

This contribution presents several case studies demonstrating the versatility of azide chemistry for the functionalization of polymer surfaces:

1. UHMW PE ski surfaces: Coatings based on (fluorinated) azide modified hydrophobic substances produced abrasion resistant, high performance ski waxes used in international competitions. Abrasion and extraction tests confirmed covalent bonding, and field tests demonstrated superior durability.
2. Hydrophilic catheter coatings: Azide technology enabled the creation of highly hydrophilic, low friction surfaces on polyamide for intervention catheters. The combination of small azide bearing molecules with azide functionalized polymers yielded coatings with excellent abrasion resistance and stable chemical bonding.
3. Polypropylene adhesion promoters: Formulations containing hydrophilic azides and hydrophilic polymers produced adhesion promoters for polypropylene with long open times and shelf-lives and significantly improved adhesion to polyurethane adhesives compared with plasma treatment. To address restrictions on fluorinated substances, it could be demonstrated that non fluorinated azides also perform effectively when combining multi azide crosslinkers with functional hydrophilic polymers.
4. Fluorine free ski waxes: A library of hydrophobic azide functional molecules and pol-ymers was synthesized to develop fluorine free ski waxes with strong performance in cold, dry conditions. All these advantages of the developed ski waxes resulted in their immediate employment in 2023/2024 FIS competitions, with extremely positive feed-back from the Swiss athletes. Work is ongoing to optimize formulations for humid and contaminated snow conditions.

All coatings were characterized using IR spectroscopy, XPS, SEM, and relevant performance tests. The azide functional molecules were synthesized in house from readily available raw ma-terials via straightforward synthetic routes, and the resulting technologies are protected by pa-tents held by our industrial partners.

We gratefully acknowledge financial support from Innosuisse – the Swiss Innovation Agency – and our industry collaborators.

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Keywords

Surface modification; adhesion promotion; coating of plastics; adhesives

Towards the curing of sustainable polyester resins

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Polyester resins are indispensable binders in the paint and coatings industry and are commonly classified into two principal groups: alkyd resins and unsaturated polyester (UP) resins. Alkyd resins are traditionally based on fatty acids and glycerol derived from renewable plant oils. In last decades, there has been a marked transition toward high-solid and waterborne alkyd systems to reduce volatile organic compound (VOC) emissions [1]. More recently, substantial research efforts have targeted the replacement of remaining fossil-derived components, such as phthalic acids, with biobased alternatives [2]. In contrast, commercially relevant UP resins are still predominantly synthesized from fossil-derived feedstocks, including maleic acid, phthalic acids, and various glycols. These resins are typically formulated with styrene, which acts as a reactive diluent and becomes incorporated into the polymeric coating network during curing [3].

In both alkyd and UP resin systems, cobalt carboxylates are widely used as curing accelerators. However, increasing legislative restrictions classify soluble cobalt compounds as suspected carcinogens, creating an urgent need for safer alternatives.

This presentation summarized recent advances in cobalt replacement strategies using transition-metal compounds. A range of manganese, iron, and vanadium complexes have been evaluated in commercial solvent-borne and high-solid alkyd binders of different oil lengths, as well as in commercial UP resin systems. Furthermore, this contribution outlines pathways toward sustainable, styrene-free UP resin formulations and discusses room-temperature curing strategies enabled by redox initiating systems composed of organic peroxides and transition-metal compounds. The results demonstrate promising directions for reducing health risks and enhancing the environmental profile of polyester coating technologies.

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Theoretical modelling of an energy-efficient process for the production of advanced speciality inks

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In many industrial sectors, including the printing industry, sustainable development has become a key objective, with particular emphasis on reducing energy consumption. The production of printing inks is a two-stage process consisting of the preparation of a pre-dispersion using high-shear mixing equipment, such as dissolvers and inline rotor-stator mixers, followed by the production of a dispersion in a bead mill [1]. At present, this process is highly energy-intensive, thereby creating significant opportunities for increasing process efficiency while reducing production time without compromising product quality. Insufficient pigment dispersion leads to reduced product quality, characterised by reduced colour strength and a tendency toward sedimentation during storage [2].

To enable theoretical analysis of the grinding process of synthetic organic pigments used in the ink production, it is necessary to perform a material analysis of the selected pigments. Synthetic organic pigments can be classified into two groups: polycyclic and hydrazone. Hydrazone pigments account for over 60% of the red and yellow pigments available on the market, whereas blue and green pigments are based on polycyclic structures [3]. Organic pigments contain little or no heavy metals, which is crucial in light of global efforts to reduce the toxicity of inks, coatings, and related materials. The development of energy-efficient processes for the production of advanced speciality inks, therefore, contributes to the preservation of environmental quality for future generations.

The aim of this research is to perform theoretical modelling of the production process for highly specialised inks. To this end, a material analysis was conducted on five industrial-grade synthetic organic pigments. The mechanical strength of the following pigments was investigated: yellow (PY13), orange (PO5), red (PR2), dark red (PR57:1), and blue (PB15:3). The analysis was performed to assess the susceptibility of the pigments to breakage and to establish a mathematical description for modelling pigment breakdown.

In addition, the rheological properties of the analysed product were taken into consideration. Based on this data, the pigment concentrate production process was modelled using computational fluid dynamics (CFD) software within the ANSYS Fluent environment [4].

The results of the mathematical modelling indicate that the reduction in both processing time and energy consumption can be achieved in the production of highly specialised inks. Consequently, these findings will contribute to more sustainable manufacturing practices and are of practical relevance for the industrial-scale production of inks.

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Silicone technologies for enabling UV-cure coil coating systems

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Reduction of carbon footprint is one of the major megatrends dominating the modern industrial sector, setting a path for new product and services development. This is also true for the chemical and coating industry where markets demonstrate consistent and steady paradigm shift towards renewable energy resources and the application of less energy-consuming technologies. Especially automotive OEM and industrial coil coating processes, traditionally dominated by solventbased, high-bake coating systems, can provide a lot of room for potential improvement. The quest for reducing carbon dioxide emissions opens-up a window of opportunities to innovate or revisit existing technologies available to address these challenges. Most certainly, UV/EB technology can be seen as one of such potential alternatives. Currently, being successfully used in various industrial markets such as printing inks, industrial flooring, plastics and wood coatings, radiation cure systems offer a few critical advantages versus. traditional incumbent technologies. High curing speed, low energy consumption and an opportunity to formulate 100%, emissions-free coating systems, makes such technology especially attractive for developing new generation metal coating systems. Notwithstanding versatility of radiation curing systems, their successful implementation will require multiple adaptations on both product and process sides. Among other technologies silicone chemistry can contribute with unique solutions to aid in achieving this ambitious goal. In the current paper we will demonstrate utility of various silane and silicone-based products for the formulation of durable- and resistant UV-based coil coating primers and topcoats.

Next-gen insulation: Silicone binders for heat and corrosion resistance

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Corrosion under insulation (CUI) continues to be a critical challenge across industrial sectors, threatening asset integrity, safety, and operational efficiency. Dow is leading a multi-generational innovation strategy to address this issue through the development of multiple low-VOC, waterborne silicone-based binders for sprayable thermal insulation coatings (TICs). The binders are engineered to deliver robust corrosion resistance and high temperature stability, while simplifying application and reducing lifecycle costs.

Unlike conventional organic sprayable insulations, which can suffer from limited temperature resistance, poor UV durability, and constraints on single-coat thickness, Dow's silicone-based technology offers a transformative alternative. Mechanical insulation, while widely adopted, introduces long-term uncertainty due to moisture ingress and hidden corrosion propagation.

Silicone polymers bring unique properties to coatings; the Si-O-Si bond energy and polymeric chain arrangements enable excellent UV resistance, water repellency, high flexibility, and the ability to resist higher temperatures. Liquid application of TICs eliminates the risks associated with mechanical insulation and enables a monolithic, adaptable solution for complex geometries, irregular piping, and hard-to-access areas.

Dow's new binder technology enables single-coat thicknesses up to 20x of incumbent spray-applied systems, dramatically reducing labor costs and asset downtime. This advancement has already shown success in field trials across various operating environments. In parallel, Dow is revolutionizing corrosion analysis. The industry's reliance on subjective visual inspection post-ASTM accelerated exposure tests has proven inadequate. These methods focus narrowly on scribe-initiated failures and overlook broader coating performance. Dow's novel approach leverages optical machine learning (OML) to objectively quantify corrosion, enabling data-driven decisions and more accurate assessments of coating integrity.

This presentation will showcase new binders for TIC applications, representing a step-change in industrial insulation technology, offering enhanced protection, simplified application, and measurable performance improvements.

Novel polymer additive for zero VOC architectural paints with improved open time

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Open time is the length of time the paint film remains “wet” or open enough to allow “workability” when paint is applied with a brush or roller. Open time is a key performance vector for paint and coatings, especially for better one coat hiding. In waterborne or latex coatings, the film formation phenomenon controls open time. Currently formulators use glycols which are soluble in water to slows down the evaporation of water during the film drying process to increase open time. However, these glycol solvents contribute to the volatile organic content (VOC) and this is a serious issue since the goal of most formulations is zero VOC. In addition, the type and amount of coalescent may lower the glass transition temperature (Tg) of the latex, leading to a softer film which improves resistance to cracking but negatively affects dirt pick up.

The most common open time additive is based on surfactants which will impact on other properties as: rheology modification if modifiers are based on surfactant association, decrease ICI viscosity due to the high level of surfactant in the final paint, scrub resistance decrease, surfactant leaching increase, color development negative effect depending on the colorant dispersion and lack of lubrification usually provided by glycols during the film formation.

This presentation will discuss the benefits with a novel multifunctional polymer additive for zero VOC architectural paints. This novel multifunctional additive replaces glycols helping coalescence during the film formation. Besides improve properties as: open time, freeze/thaw stability, color development, scrub corrosion resistance, satin resistance, storage stability, great compatibility with colorants, color development, opacity and hiding power during application with brush or roll.

Biobased acrylic polymer binder: Performance, durability, for concrete primer technology

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The coatings industry faces increasing pressure to deliver high-performance materials while reducing reliance on fossil-derived raw materials. In response, a range of biobased binder solutions is under development to support more sustainable architectural coatings. As part of this broader effort, a new acrylic polymer binder with high biobased carbon content has been developed for concrete primer applications. This work evaluates a waterborne, pure acrylic emulsion binder with biobased carbon content for use in concrete primer formulations, benchmarked against an established all-acrylic incumbents.

Clear primer formulations were prepared and tested to assess key performance attributes critical for construction coatings. Primer performance was evaluated using standard adhesion methods under both dry and water-exposed conditions on mineral substrates, alongside water resistance performance, using a representative architectural topcoat system to probe adhesion and durability.

On concrete substrates, adhesion performance was comparable to the incumbent system and met the stated peel adhesion requirements. In addition, the biobased binder demonstrated robust performance under water exposure, indicating suitability for demanding construction environments. These results show that high-renewable-content acrylic binders can deliver the application performance required for modern concrete primers, while contributing to increased sustainability in architectural coatings.

Optimising TiO_2 and hence the opacity of high PVC architectural paints using composite pigments and opaque polymer focussing on cost and carbon footprint

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Titanium Dioxide (TiO_2) is the most widely used white pigment due to its high refractive index and excellent light-scattering capability. However, its relatively high cost and limited efficiency at low loading have driven interest in strategies that maximize performance while reducing pigment demand. This study explores the combined use of composite pigments and opaque polymers (each with inherent light scattering properties) to enhance TiO_2 efficiency in coatings formulations. Composite pigments, which incorporate extenders or engineered structures, improve particle spacing and dispersion, minimizing crowding effects that reduce scattering efficiency. Opaque polymers further complement this mechanism by creating voids upon film formation, increasing refractive index contrast and extending light paths through the coating matrix. Together, these additives synergistically optimize TiO_2 utilization, delivering equivalent or improved opacity and brightness at reduced pigment concentrations. The approach not only lowers raw material costs but also supports sustainability goals by decreasing reliance on energy-intensive TiO_2 production. Experimental findings demonstrate significant improvements in hiding power, whiteness, and overall coating performance, highlighting the potential of composite pigments and opaque polymer technology as effective TiO_2 efficiency enhancers in modern paint formulations.

Field-applied high-durable coatings using Kynar® Aquatec® PVDF emulsion technology

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Durability and long-term protection of buildings & infrastructures remain central challenges for protective coatings, particularly under harsh environmental conditions. Kynar® Aquatec® emulsion technology —an ambient--curable polyvinylidene fluoride (PVDF) resin—offers a high-performance alternative to traditional field-applied coating systems. Unlike conventional solventborne fluoropolymer technologies that require elevated-temperature baking, Kynar® Aquatec® enables the formulation of waterborne coatings, while ensuring excellent weatherability and chemical resistance.

This study outlines the intrinsic material properties of Kynar Aquatec® PVDF resin, including its exceptional resistance to UV radiation, thermal degradation, chalking, and aggressive atmospheres, contributing to long-term color and gloss retention. Performance evaluations – including accelerated weathering, dirt-pickup resistance – demonstrate the resin's suitability for field applications on substrates such as façades, roofing membranes, metal surfaces, and concrete.

Furthermore, this work highlights the benefits of adopting a waterborne PVDF system in construction environments, such as low VOC emissions, ease of on-site application, and substrate compatibility, making them suitable for both renovation and new-build projects. These findings support the use of waterborne PVDF technology as a high-performance and long-lasting solution for extending service life and minimizing maintenance costs of architectural materials.

From potential to performance: Confirming the mineral advantage in UV-resistant coatings

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Exterior facade paints are constantly challenged by environmental stressors, where UV radiation remains a primary cause of optical and mechanical degradation. While the theoretical benefits of mineral fillers are known, achieving consistent, long-term performance in exterior formulations requires a deeper understanding of mineral synergies.

Building on our previous research on high PVC paints, this presentation provides an extended analysis of how specific mineral families influence the photo-stability of architectural coatings. We have refined our study to focus on the transition from experimental observation to formulation reliability. New data confirm that the strategic selection of minerals can significantly enhance UV resistance and mitigate common failures such as chalking and color fading.

The results presented validate an optimized mineral solution that offers a robust shield against UV damage. By bridging the gap between initial potential and proven performance, this study provides paint formulators with a validated framework for developing high-durability exterior finishes.

Keywords

Exterior, UV durability, minerals

Advanced resin modifier for enhancing durability of industrial waterborne & solventborne coatings

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This work discusses how resin modifiers can be used to integrate unique chemical structures into the backbone of a coating's cured polymer matrix, enabling formulators to design waterborne (WB) coatings that meet specific performance requirements for targeted applications.

These studies focus on a novel, hydrolytically stable, water-reducible (WR) polyester (PE) polyol resin modifier. The material is designed with multiple hydroxyl groups to ensure superior crosslink density, alongside hindered ester linkages to prevent hydrolysis. Its unique backbone, comprised of both hard and soft segments, establishes an optimal relationship between hardness and flexibility.

The studies evaluate performance across various waterborne formulation types, including both one-component (1K) aminoplast crosslinked coatings and two-component (2K) polyurethane (PU) systems. Furthermore, studies on modifying solventborne polyaspartic type coatings will also be discussed. Experimental data demonstrates how this material enhances impact resistance without compromising film hardness, as well as improves gloss, chemical resistance, corrosion protection, and adhesion.

Photonic drying of coatings in the winding wire industry as a possible replacement for oven techniques

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In current coating processes, insulating varnishes are applied in a horizontal or vertical oven at temperatures between 350 and 500°C. Although this process has been in use for many decades, there has long been a need to replace it. This is due to the long waiting times required to reach the temperature equilibrium. During this process, the applied coating undergoes a series of chemical and/or physical processes in a convection oven, as it is transferred into the final product. The coating oven can be up to 10 metres high and the machine length of the "empty wire" is between 400 and 600 metres . This means that every new order generates at least a waste of this length. It is a very energy-intensive drying process. Currently, these coating processes cannot be switched on or off ‘On Demand’. This results in enormous energy losses and material consumption, especially of copper, which is a valuable raw material. Organic hydrocarbons such as phenol, cresol, NMP, or dimethylphenol are used as solvents. The proportion of volatile components is between 30 and 77%. Most solvents are burned in exhaust gas treatment systems (system-integrated catalysts, external, thermal after-burning systems) or are chemically converted. However, complete thermal “combustion” or chemical conversion of the exhaust gases is not possible for technical reasons. The average combustion efficiency of exhaust gas cleaning systems available on the European market ranges between 95% and 98% for newer systems. Since residents live in the immediate vicinity of the company premises and ASTA is located in a relatively narrow valley, air emissions are even more significant. Photonic technology could be used to reduce or minimise the impact of air emissions on the environment. In comparison, photonic drying involves drying the wire enamels in a much smaller plant. Energy consumption is likely to be significantly lower than in conventional coating systems.

The following example illustrates the potential for energy and raw material savings (copper):

For a production volume of, for example, 15,000,000 kg of enamelled wires, approximately 800,000 kg of insulating varnishes (including solvents) or 600,000 kg of solvents would be used productively.

- An energy reduction of just 10% (e.g. 1,800,000 kWh) would lead to savings of 413,000 kg CO_2/a in the coating plant alone.
- An energy reduction of 30% (e.g. 5,500,000 kWh) would lead to savings of 1,300,000 kg CO_2/a in the coating plant alone.

The results so far indicate energy savings of at least 30 to 60%. The machine length of the bare wire is between 400 and 600 meters- minimum length of waste for each change in dimensions. The scrap rate for the machine length is approximately 1%. A copper saving of, for example, 250,000 kg/a would lead to a reduction of approximately 250,000 kg CO_2/a. Furthermore, during photonic drying of coatings, the solvents will condense and be treated for reuse. Advantages: Lower energy consumption, smaller coating systems, lower resource consumption. This technology is not yet used in these production processes. NIR absorbers based on polymethines, rylenes, porphyrins, oxonoles, and carbon nanodots chemistry absorb light in the wavelength range from 700 nm to 2,000 nm and convert it into heat with high efficiency. After absorbing light, it can convert it into heat, which is used directly in the coating material to be dried. This generated heat can be used for physical and chemical drying.

Unlocking structure-property relationships in UV coatings: A graph neural network approach for interpretable performance prediction

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The formulation-intensive field of coating science faces significant challenges with traditional trial-and-error development strategies due to the complex, non-linear interactions between raw materials and target properties. While machine learning offers new opportunities to accelerate material discovery, current approaches often treat raw materials as discrete, categorical variables, neglecting their underlying chemical structure and physicochemical properties. This "chemistry-unaware" simplification limits the ability of models to generalize to novel compounds and fails to provide the mechanistic understanding required for rational design. This work addresses these limitations by introducing a data-driven framework that leverages Graph Neural Networks (GNNs) to predict the performance of UV coatings directly from molecular structure, bridging the gap between chemical topology and macroscopic performance.

To enable robust and chemically transparent modeling, we first generated an experimentally consistent dataset using UV coatings as a model system, where monomer structures were systematically varied to assess their impact on mechanical and surface properties. In contrast to traditional modeling approaches that rely on fixed descriptors or labels, we employed GNNs to encode these monomers as molecular graphs, representing atoms as nodes and bonds as edges to capture both local atomic environments and global molecular contexts. Furthermore, to address the "black box" nature of standard deep learning models, we embedded attention mechanisms within the architecture. This integration allows the model to learn and highlight specific atoms or substructures that are most influential in determining the target property, thereby providing interpretable insights into the chemical drivers of performance.

The application of graph-based representations significantly enhances the predictive accuracy and generalizability of the models, particularly when extrapolating to previously unseen monomer structures. Beyond predictive capability, the use of attention mechanisms supports knowledge extraction, allowing chemists to validate model decisions against domain knowledge and rationalize structure-property relationships. For glass transition temperature, the model emphasizes the polymerizable functionality and overall chain rigidity, while for storage modulus, it focuses on side-chain topology and packing effects. This nuanced behavior indicates that the model has learned to associate specific structural motifs with their corresponding physical phenomena.

By combining rigorous data generation with chemically aware and interpretable deep learning, this work contributes to a more systematic and efficient approach to formulation design, demonstrating the transformative potential of AI in coating research.

How AI use in coatings and adhesives is moving outside R&D to technical services and beyond

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When coatings and adhesives companies first began adopting artificial intelligence five to six years ago, the primary focus was on accelerating R&D and achieving superior material performance-pushing the boundaries of what was technically possible. That work continues today, and reductions of 50–80% in the number of experiments required to meet formulation targets have become common.

However, as organizations have matured in their use of machine learning, a broader set of high-value applications has emerged beyond the R&D lab. This presentation explores how AI is increasingly being applied across the value chain through real-world industrial case studies.

Examples will include the use of machine learning to optimize processing conditions and reduce greenhouse-gas emissions; to develop application models that enhance technical service capabilities and improve customer responsiveness; to localize formulations while maintaining quality as manufacturing is reshored or offshored; and to increase supply chain resilience in the face of raw-material supply disruptions.

Repair coating of wet and powder coatings – Surface treatment and drusting using laser technology

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Corrosion damage is particularly common in older steel structures or steel surfaces in the maritime sector. Conventional mechanical methods such as particle blasting with air pressure are very costly, as corrosion products and old coatings, which often contain environmentally hazardous substances, must not be released into the environment. Therefore, an enclosure is required before the corrosive removal process, which is associated with enormous dust and noise emissions, can begin. Due to the redeposition or mechanical application of salt to the surface, rinsing steps are also necessary in order to achieve the required quality standards for the subsequent repair coatings in accordance with DIN 12944.

The IGF research project "Laser-based local surface preparation of protective coatings in steel construction – LaserRep" (project number 21684 N/1) aimed to develop a less complex and more environmentally friendly treatment concept. As part of the project, laser parameters were determined that achieve the Rz value of 70 µm required by ISO 12944.The repair areas were deliberately damaged and re-exposed. Both in the artificial aging test according to ISO 12944-9 and in a two-year field exposure test on Heligoland, the test specimens treated with lasers showed minimal under-rusting. (see Figure 1). As part of the project, scaling experiments were carried out with industrial-grade kW laser systems at project partners, which not only enable cost savings but also offer approximately twice as fast corrosion removal compared to conventional mechanical processes. However, surface roughening with lasers is time-consuming and currently cannot compete with the processing speed of automated blasting processes on large surfaces.

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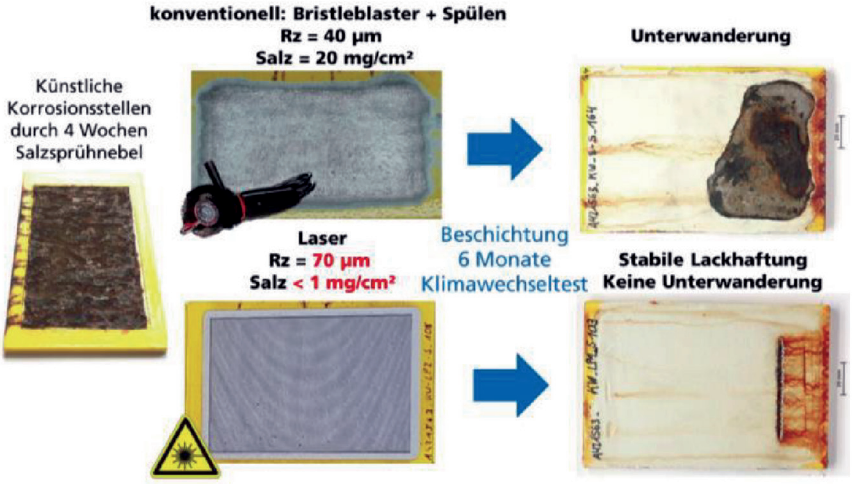

Figure 1: Exemplary corrosion images of wire-blasted test specimens (bristle blaster) compared to laser-treated test specimens

PLA-based barrier varnishes for flexible artificial leather

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In the production of coated textiles or artificial leathers, polyvinyl chloride (PVC) and polyurethane (PU) are commonly used materials. Owing to the structural diversity of these systems, their properties can be specifically tailored for a wide range of applications. Such materials are frequently employed in commercial interior design, automotive interiors, and public-use equipment (e. g., in transportation systems). Depending on the application, these materials are subject to varying degrees of mechanical, chemical, or environmental stress and must meet different performance requirements. To address these demands, the materials are often varnished. Studies have demonstrated that varnishes based on the biopolymer polylactic acid (PLA) exhibit favourable barrier properties. A barrier coating has already been developed for both PVC and PUR artificial leather that not only effectively minimizes the migration of additives, such as plasticizers or organophosphorus flame retardants, from the material, but also protects the surface against the penetration of a wide range of soiling agents.[1, 2]

However, in order to process PLA as a varnish, it must be dispersed in an organic solvent. Since PLA is optimized for thermoplastic processing, large quantities of organic solvents are typically required for this purpose. During the curing process of the coating, these solvents are released back into the environment. This poses a significant concern, as the solvents used can be harmful to both human health and the environment.

In this study, two approaches were pursued to reduce or eliminate the use of organic solvents. First, water-based PLA dispersions were developed using secondary dispersion technology. The primary challenge was the development of a suitable emulsifier-stabilizer system that would not adversely affect the advantageous of properties characteristic of solvent-based PLA coatings.

Second, the microwave-assisted synthesis of PLA copolymers is introduced. These copolymers not only enable a significant increase in the solids content of the varnish formulation, but are also specifically designed to substantially improve adhesion to PVC-coated materials.

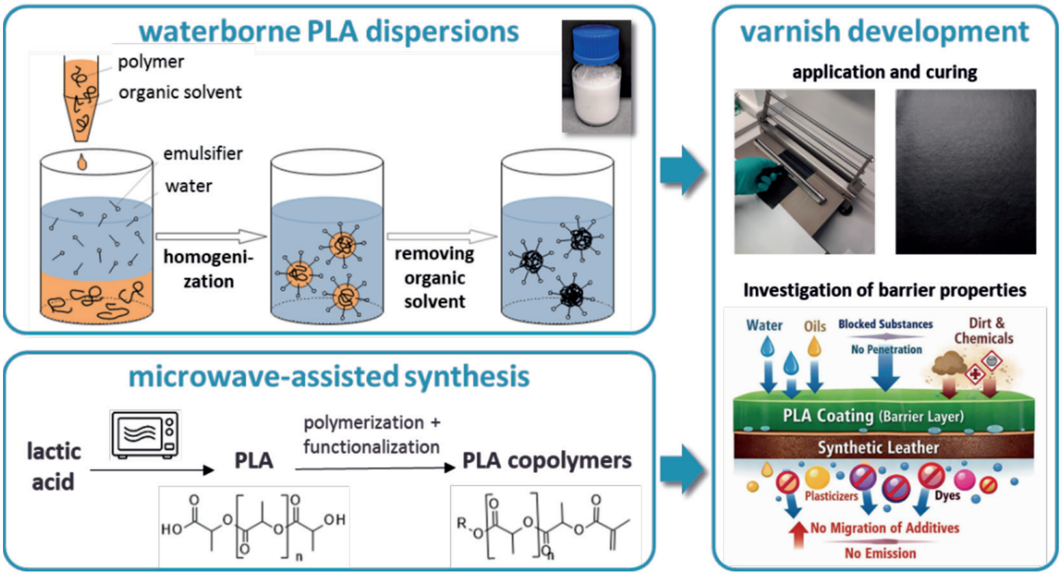

Figure 1: schematic illustration of the pursued approaches in the development of PLA based varnishes.

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Optimizing coating materials and processes for controlled release coated urea (CRCU) fertilizer in fluidized beds: Review of bio-based coating materials and encapsulation methods

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The strict legal requirements in the European Union (EU) mandating biodegradable components in fertilizers by 2026 underscore the urgent need for innovative solutions in controlled release coated urea (CRCU) fertilizers. Despite the critical importance of optimizing coating materials and processes for CRCU fertilizers, a comprehensive review of optimization methods is notably absent, leaving a significant knowledge gap in the development of efficient and sustainable CRCU technologies. This review addresses this gap by providing an in-depth analysis of bio-based coating materials, encapsulation methods, and fluidized bed processes for CRCU fertilizers. We critically evaluate existing research, identify key challenges and opportunities, and discuss future directions for developing biodegradable and efficient CRCU fertilizers that meet the impending regulatory requirements. This review serves as a timely resource for researchers, industry stakeholders, and policymakers seeking to develop and implement sustainable coating solutions.

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Keywords

Bio-based coating materials, fluidized bed technology, process optimization, coated fertilizer, controlled release

Colourful highlights of paint and coating research

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This lecture offers a broad and accessible overview of some exciting current developments in the paints and coatings industry. From digitalisation in the laboratory to advanced functional surfaces, the presentation explores how coating science continues to evolve across both industrial and cultural applications.

Topics include the growing role of artificial intelligence in coatings research and formulation development, where data-driven approaches are helping researchers accelerate experimentation and improve material design. The presentation also highlights UV light as a non-biocidal approach to reduce biofouling on submerged surfaces. In addition, recent scientific insights into the restoration and analysis of historical paintings will demonstrate how modern coating and imaging technologies contribute to the preservation of cultural heritage.

Further examples include developments in radiation-curable coatings, enabling faster and more energy-efficient curing processes, and advances in passive radiative cooling materials that can help reduce surface temperatures without external energy input. Together, these examples illustrate how coatings research connects sustainability, functionality, aesthetics, and innovation.

Alongside the science and technology, the presentation will also be colourful – reminding us that coatings are not only expected to perform, but also to inspire visually.

POSTERS

Thermal preservation of water-based paints

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This project focused on thermal preservation of water-based architectural paints. The preservation process was carried out at temperatures above 75 °C (i.e. at 100–140 °C under pressure, or at 90 °C as high pasteurisation). Different treatment processes (autoclave, stirred reactor, microwave) were tested. The thermally treated, water-based materials were subjected to application-related, analytical, and microbiological tests and comparison with its untreated counterparts. Before thermal preservation, microorganisms such as aerobic and anaerobic bacteria, bacteria spores, yeasts and mold cells were identified in the paints. After thermal preservation no significant changes were observed in parameters such as paintability, viscosity or film formation temperature. After thermal preservation, the paints should be stored in a closed package and once opened, they should be quickly consumed. This process allows you to limit the use of "in-can preservatives", which are currently widely used to protect water-based emulsion and paint formulations against the growth of microorganisms such as fungi or bacteria in order to extend their shelf life. However, in-can preservatives are currently under strong legal regulations such as use bans or concentration restrictions that prevent microbiological efficacy and economic pressure (high development and approval costs with low market volume).

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Silver-free antimicrobial powder coatings for protection of composite materials

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This work focused on obtaining a low temperature curing powder coating with antimicrobial properties. In this aim, epoxy resin and high reactive polyphenol curing agent or high reactive polyester resin and hydroxyalkydamide curing agent were used as a low temperature curing binders. Antimicrobial activity of powder coatings was achieved by incorporating hybrid additives composed of biopolymers immobilized on natural clays [1,2]. Polylysine (PLY) or chitosan (CH) were used as natural antimicrobial agents, while montmoryllonite (MMT) or halloysite (HAL) acted as a carrier. HAL/PLY and MMT/CH hybrids were incorporated into polyester coatings and evaluated for morphology, mechanical properties, water resistance, and antibacterial performance. The HAL/PLY or MMT/CH coatings demonstrated a strong bactericidal effect, reducing Escherichia coli and Staphylococcus aureus over 99.99%. Immobilization of biopolymers on montmoryllonite or halloysite improved dispersion and barrier properties while enabling a silver-free antibacterial effect. Immobilization of biopolymers on montmoryllonite or halloysite improved dispersion and barrier properties as well as reduced their leachability while enabling a silver-free antibacterial effect. Low temperature curing (130°C for epoxy or 160°C for polyester) enabled powder coating of composites based on polystyrene, polypropylene, polyamide and epoxy without damaging them during the curing process.The results demonstrate a sustainable development strategy for multifunctional powder coatings based on naturally derived antimicrobial components.

This research was funded by the National Centre for Research and Development (NCBR) in Poland and the AiF within the program for the funding of industrial research (IGF) in Germany, grant number CORNET/34/101/MicroSafeCoatings /2023 "Novel antimicrobial protection in powder coating for composite materials", acronym – MicroSafeCoatings.

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Investigations of polarity parameters regarding the influence of interactions between pigment surfaces and dispersing additives made from block copolymers

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A key requirement for coating systems is the effective dispersion of pigments within the coating matrix, as this strongly influences optical and functional properties. Copolymers are commonly used as steric stabilizers to prevent aggregation and sedimentation of pigment particles. To describe pigment-polymer interactions in terms of measurable quantities, detailed knowledge of the molecular structures involved is required. In particular, the polarity of both the pigment surface and the polymer must be considered, as it governs the type and strength of intermolecular forces. Examining these processes provides insight into the underlying binding mechanisms.

For this purpose, well-defined homo- and copolymers were synthesized via reversible addition-fragmentation chain-transfer (RAFT) polymerization and characterized in this work. Oligo(methyl ether methacrylate) was employed as a monomer to provide steric stabilization of the pigment surface, while 4-vinylpyridine was used as a functional anchoring group to promote specific interactions with the pigment. Controlled polymerization yielded polymers with narrow molar mass distributions and defined compositions, enabling a systematic analysis of the influence of polymer architecture on pigment interactions.

The known chemical structures of the synthesized additives allow a systematic investigation of pigment-additive interactions as a function of polymer polarity, pigment surface properties, and polymer composition. To quantify these interactions, Kamlet-Taft solvent parameters were determined for the polymers. These parameters describe specific interaction contributions, namely dipolarity/polarizability (π^*), hydrogen-bond donating ability (α), and hydrogen-bond accepting ability (β), enabling quantitative comparisons between the interaction potentials of polymers and pigment surfaces of differing polarity.

To assess the influence of pigment surface polarity on adsorption behavior and resulting stabilization mechanisms, both a polar and a non-polar pigment were investigated. Differences in interaction strength and adsorption efficiency were evaluated based on changeas in polarity parameters. Rheological measurements were performed to analyze the flow behavior of dispersions containing homo- and copolymers, while sedimentation experiments were used to assess long-term stabilization performance. By correlating these measurable coating properties with the determined polarity parameters, polymer adsorption at the pigment surface can be described more precisely and linked to the observed rheological and sedimentation behavior.

Reversible core-shell thermochromic pigments for deep-freeze monitoring application

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It might seem that almost everything has already been explored within the field of pigments. Yet this area continues to evolve in the search for new directions of development. Such an approach drives pigment research toward increasingly sophisticated solutions aimed at achieving new and ever-improving functionalities [1,2]. In this context, novel core-shell thermochromic pigments exhibiting reversible color change were developed. Selected triarylmethane dyes were employed as the coloring component, subsequently protonated and emulsified using environmentally friendly and non-toxic surfactants with hydrophilic-lipophilic balance values ranging from 3 to 6. The resulting water-in-oil emulsions were encapsulated with an organosilicon polymer capable of self-organization via hydrolytic cross-linking at the polymer-water interface. Aqueous solutions, emulsions, and the final pigment product in the form of polymer-shelled capsules were characterized using selected spectroscopic, thermal, and microscopic methods (conducted in up to 5 cycles). Colorimetric analysis performed for both solutions (20 °C vs. −18 °C) and capsules (20 °C vs. −80 °C) confirmed their ability to undergo reversible color transitions with $\Delta E \geq 5$. Characteristic temperatures, such as the melting and crystallization of the core material and the glass transition of cross-linked capsules, were determined. Laser diffraction measurements revealed particle-size distributions with d50 < 10 µm. To enhance the functional performance of the pigments, attempts were made to incorporate them into polymer matrices, including UV varnishes and bio-derived epoxy systems. The results obtained thus far suggest that future work should focus on silicone-based matrices, which are expected to improve the compatibility and stability of the pigments within formulations. Although the described procedure enables the synthesis of reversible thermochromic pigments suitable for use as standalone indicators for monitoring deep-freeze conditions, there remains a clear need for continued research on the formulation of pigmented coatings or composites.

Acknowledgments

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Development of high solid alkyd resins from hemp oil: Low-VOC and bio-based sustainable approach

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Alkyd resins are widely used in the coatings industry due to their excellent film properties, ease of application, good adhesion, biodegradability. They are environmentally attractive binders because they can be produced from biologically renewable raw materials (fatty acids, glycerol). Bio-based oils, fatty acids (soybean, sunflower, linseed and hemp) enable sustainable formulations that reduce dependence on fossil resources and the carbon footprint while maintaining resin performance. Hemp is a renewable resource that absorbs carbon dioxide as it grows and reduces the heavy metal and toxin content of the soil. By contrast, conventional alkyd resins contain organic solvents such as xylene, toluene, and mineral spirits, which contribute to high levels of volatile organic compound (VOC) emissions. This cause serious damage to air quality, the ozone layer and human health. So strict regulations (EU Directive 2004/42/EC and U.S. EPA) have been implemented to limit VOC and hazardous air pollutant (HAP) emissions, driving the coating industry towards environmentally friendly, sustainable alternatives.

High-solids alkyd resins have a low molecular weight, resulting in low viscosity. This means they can be formulated with minimal or no solvent, making them attractive for reducing VOC emissions in coatings. However, their low molecular weights may result in slow drying properties and reduced film durability. Increasing double bond density in the formulation can accelerate curing and improve durability.

In this study, bio-based high-solids alkyd resins were synthesized using hemp oil combined with various vegetable fatty acids, and characterized by FT-IR. Paints formulated with synthesized high-solids alkyd resins were investigated for yellowing behavior, outdoor durability and anticorrosive properties. The synthesized high-solids alkyd resins demonstrated medium hardness and high gloss, satisfying the mechanical and aesthetic criteria required for exterior, decorative, and wood-protective coatings. Consequently, bio-based high-solids alkyd resins constitute a promising sustainable alternative for low-VOC and HAP-free coating systems.

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Synthesis and characterization of anionic aliphatic waterborne polyurethane dispersions: Influence of soft segment chemistry on anti-corrosive performance

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Traditional polyurethane (PU) application systems typically contain high levels of volatile organic compounds (VOCs) and, in certain instances, residual free isocyanates. Due to their associated toxicity and environmental impact, waterborne polyurethane dispersion (PUD) systems were introduced in the late 1960s as a sustainable alternative. Today, PUDs represent a major class of polyurethanes extensively utilized across diverse sectors, including coatings, adhesives, ink binders, glass fibers, paper, synthetic leather, biomaterials, membranes, packaging, and the textile industry (1). Polyurethane coatings are characterized by their excellent gloss, hardness, flexibility, abrasion resistance, chemical resistance, and ultraviolet (UV) durability. Moreover, high-solids polyurethane coatings meet stringent contemporary regulations for VOC emissions without compromising film performance. Due to these multifaceted advantages, they serve as the market leaders for coating various substrates in demanding end-use markets, such as automotive refinishing, aerospace, and chemical agent resistant coatings (CARC) (2). Currently, the corrosion of metallic structures remains a significant global concern. Mitigating corrosion-related losses is a primary challenge for industrialized nations, as the economic impact is projected to be extremely high. One of the most effective prevention strategies is the protection of metal surfaces using specialized paint and polymer coatings, which continue to be the standard for the anti-corrosion protection of metallic infrastructures (3). In this study, four distinct anionic aliphatic waterborne polyurethane dispersions were synthesized via the prepolymer mixing method. Four different polyols – PTMEG (Polytetramethylene ether glycol), Polyester, HTPB (Hydroxyl-terminated polybutadiene), and hydroxyl-terminated PDMS (Polydimethylsiloxane) – were incorporated into the soft segments of the polyurethane chains. The resulting film properties were systematically characterized through tensile-elongation tests, water swelling capacity measurements, and thermal yellowing resistance. Structural and thermal transitions were analyzed using Fourier Transform Infrared Spectroscopy (FTIR), Differential Scanning Calorimetry (DSC), and Thermogravimetric Analysis (TGA). For the coating performance evaluation, the four synthesized products were applied to carbon steel substrates with a wet film thickness of 90 microns and allowed to dry. The coated surfaces were subsequently subjected to cross-cut adhesion tests, contact angle measurements, and salt spray testing. Through these analyses, the effects of chemical variations in the soft segment polyols on the final film and coating performance were investigated.

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A latent iron catalyst strategy for photo-induced crosslinking of acrylic coating

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Acrylic coatings are widely applied to protect substrates and extend their service lifetime, thereby contributing to material efficiency and sustainability [1]. To achieve optimal mechanical strength and chemical resistance, these coatings require effective crosslinking of the polymer matrix. Currently, crosslinking is typically achieved through reactions between the alcohol group of acrylic polymers and melamine resins or isocyanates in the presence of tin-based catalysts, often requiring elevated temperatures for rapid curing. However, melamine resins, isocyanates, and organotin catalysts are increasingly subject to legislative pressure, creating an urgent need for alternative crosslinking strategies [2].

In response, light-activated systems have emerged as promising alternatives. De Bruin et al. [3] demonstrated that bis-diazo compounds can serve as photo-activatable crosslinkers for acrylic coatings. Upon irradiation, these compounds generate reactive carbene intermediates capable of forming covalent crosslinks within the polymer matrix, resulting in mechanically robust films. Despite these promising results, the system exhibits important limitations: each diazo group reacts with an efficiency of approximately 65%, corresponding to an overall crosslinking efficiency of only ~42% per bifunctional molecule. Furthermore, the bis-diazo crosslinkers display limited solubility and a tendency to crystallize from solution, compromising formulation stability. These shortcomings highlight the need for a more efficient and formulation- compatible approach.

Building on these developments, this work investigates a novel iron-mediated strategy based on a light-activatable iron complex previously developed for alkyd paint systems [4,5]. In this approach, a light trigged latent iron source activates diazo compounds in-situ, enabling crosslinking of acrylic coatings. By opening a new library of bis/tris-diazo crosslinkers, this system aims to improve both crosslinking efficiency and formulation stability compared to previously reported methods.

The poster first focuses on model reactions to optimize the catalytic system and elucidate the reaction kinetics and activation pathways. Subsequently, the optimized iron-mediated approach is applied to acrylic resin formulations to evaluate its performance in practical coating systems.

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Using of ionic liquids to improve the anticorrosive properties of zinc-reduced primers

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In the field of anticorrosive coatings, new solutions are being sought that take into account environmental protection and sustainable development strategies. Commonly used zinc-rich primers require a high zinc content to ensure contact between metal particles, which enables the sacrificial protection. Due to the environmental impact of zinc, research is underway to reduce the zinc content in zinc primers. In previous projects CORNET solvent-based and water-based paints with reduced zinc content, containing organically modified zinc dust and flakes, have been developed. The aim of the current project is to use ionic liquids to improve the anticorrosive effectiveness of zinc-reduced primers or even to eliminate zinc from coatings used for corrosion protection. Ionic liquids adsorb onto metal surfaces and block active sites, slowing the corrosion process (Fig. 1).

Seven ionic liquids were selected for this project. They have been incorporated to primers with or without organic treated zinc pigments, as well as immobilized on ZnO. Successful immobilization is illustrated in Fig. 2 with an example 1-hexyl-3-methylimidazolium hexafluorophosphate.

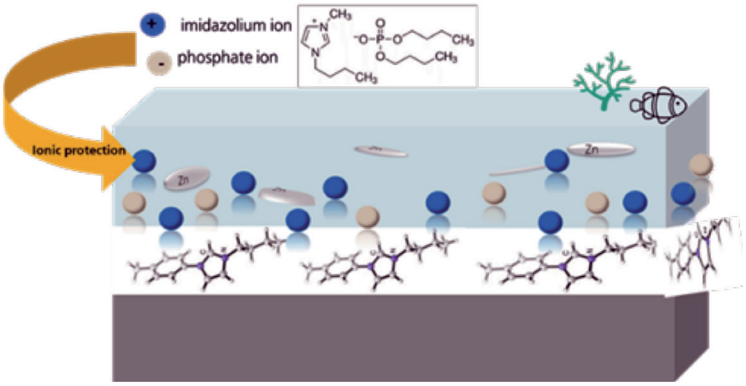

Fig. 1. Scheme of corrosion protection by ionic liquids (Katarzyna Krawczyk, IPA)

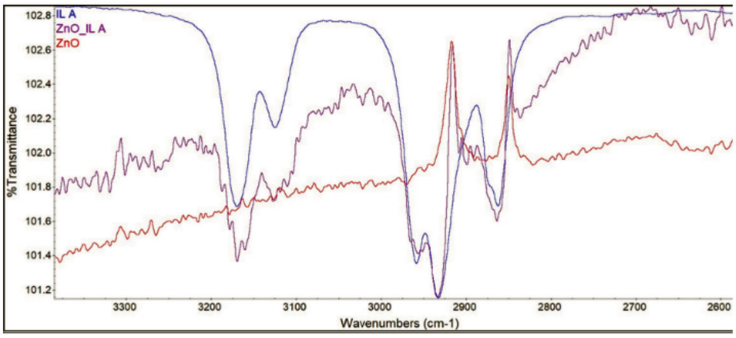

Fig. 2. FTIR spectra: blue line – ionic liquid, red line – ZnO, purple line – ionic liquid deposited on ZnO

Acknowledgments

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Practical aspects of CORNET projects carried by Polish-German research centers

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The results of research completed and ongoing projects carried out as part of the CORNET Initiative were presented. From 2014 to 2025, 6 projects were implemented:

- BioCoat – Cost-Effective Biopolymer Interior Coatings (2014–2016);
- DuraCoat – Criteria and Guidelines for Evaluation and Selection of Paint Anticorrosive Systems for Steel Structures (2015–2017);
- ZincPower – New Generation of Zinc Primers with Improved Anticorrosion, Application and Ecological Properties (2017–2019);
- EcoWaterZinc – Waterbased, Environmental Friendly Zinc Rich Primer Systems (2021–2023);
- ColourTune – Tuning the Colour of Topcoats: Method for Selection of Pigments and Safeguarding Colour Stability (2022–2024);
- MicroSafeCoatings – Novel Antimicrobial Protection in Powder Coating for Composite Materials (2023–2025).

Two projects are currently being carrying out:

- BiBACoM – Bio-based UV-curable Anti-Corrosion Coatings for Metal Substrates (2024–2026);
- EcoFZILProt – Advanced Eco-Friendly Water-Based Primers with Reduced Zinc Content Containing Ionic Liquids for Long-Term Steel Protection (2025–2027).

CORNET projects have both scientific and practical aspects. The results obtained contribute to understanding the role of the mechanisms of anticorrosive coatings. In practice, they provide the opportunity to learn about new, ecological solutions in the field of corrosion protection, as well as guidelines on designing and testing of coatings to obtain the best anticorrosive and decorative properties.

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The impact of various corrosive environments on the durability of selected paint systems

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Coating systems used in transport infrastructure, including railways, are operated in conditions where they are exposed to various corrosive environments, which initiate and intensify degradation processes to varying degrees. The assessment of the durability of the coating systems used covers a wide range of properties, such as coating adhesion, corrosion resistance, weather resistance, and chemical resistance. Variable humidity, the presence of chloride ions, cyclic water vapor condensation, UV radiation, and temperature fluctuations contribute to the gradual loss of barrier properties and thus to the service life of coatings [1–3].

Laboratory tests are the basic tool for verifying the effectiveness of the painting systems used and their ability to maintain the required protective and aesthetic properties during operation [4–5]. For a reliable assessment of durability, it is essential to comply with industry norms and standards that enable the determination of the level of corrosion protection of metal components and structures used in railway infrastructure. An example of a document setting requirements for paint systems in the railway industry is the Alstom DTRF 150608 rev G standard.

The aim of the study was to compare the corrosion resistance of selected single-, double- and triple-layer systems based on epoxy and polyurethane binders and with varying coating thicknesses, subjected to two different laboratory environments in accordance with Alstom DTRF 150608 rev G: neutral salt spray (PN-EN ISO 9227) and humid poultice – cataplasm test (PN-EN 13523-27), simulating long-term exposure to high humidity and elevated temperature. The changes in the appearance of the coatings after exposure to both test conditions were analyzed.

In the humid poultice test (168 h), a significant reduction in the durability of all analyzed systems was observed, manifested by the numerous occurrence of blisters with diameters of 0.5–5 mm. Exposure in a salt chamber (960 h) resulted in a significantly lower degree of degradation – only a few small blisters were observed in single-layer systems, while no blisters were observed in two- and three-layer systems. In both tests, no rusting was found or only trace rusting at the Ri1 level was observed. The results obtained indicate the varying sensitivity of coating systems to the effects of moisture and neutral salt spray, emphasizing the importance of the proper selection of test methods in the process of qualifying paint systems.

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Evaluation of the effect of measurement geometry on the color parameters of coatings with different gloss levels

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Coatings play a crucial role in many industrial applications, combining the protective functions of the substrate with decorative functions. While protective properties determine the durability of the material under specific operating conditions, the color and appearance of the surface largely determine the visual perception of the product. Color is one of the most important parameters determining the aesthetic qualities of a surface. In many cases, color conformity with design specifications or customer requirements is one of the fundamental criteria for coating acceptance. Even slight deviations in this regard can result in the product being rejected, despite meeting other technical requirements. For this reason, a reliable and repeatable assessment of coating color is of significant importance in quality control processes and in ensuring product compliance with customer expectations. [1–3]

The aim of this study was to analyze the effect of spectrophotometer measurement geometry on the values of the L* a* b* color coordinates in the CIELAB color space for coatings of various colors and gloss levels. Spectrophotometers operating in 45/0, 0/45, and d/8 geometries were used for the study. In the case of the spherical geometry, measurements were performed both with the specular component included (SCI) and with its exclusion (SCE). Color coordinates were determined using D65 illumination and a 10° observer. A set of protective and decorative coatings of various colors and characterized by different degrees of gloss—ranging from matte to high-gloss surfaces—was analyzed.

The study showed that the measurement geometry of the spectrophotometers had a significant impact on the color coordinate values. For the L* parameter, the highest values were recorded for the d/8 spherical geometry with the specular component included (SCI), while the lowest values were mainly observed for the 0/45 geometry. It was also found that the magnitude of the differences in L* values between the geometries used depended on the coating color—for light-colored coatings (white and beige), the differences were small (1.29–2.01), while for dark-colored coatings, the differences reached higher values (3.36–8.36). With regard to the a* and b* coordinates, no clear relationship was observed indicating a geometry yielding extreme min-max values; however, the greatest discrepancies in the values of these parameters were obtained for red coatings, specifically for the a* parameter (11.27 and 12.17) and for the b* parameter (17.64 and 22.05). The results obtained indicate that the measurement geometry has a significant impact on the assessment of coating color; therefore, it is particularly important to interpret the results taking into account the specifics of the geometry used, which ensures the comparability and repeatability of the measurement data.

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How a weak polyelectrolyte can affect the anti-corrosion properties of coatings

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Corrosion is a common phenomenon accompanied by a series of physicochemical reactions that alter the composition and properties of both the metal surface and its local environment. This process involves, among others, oxide formation, diffusion of metal cations into the coating matrix, and local changes in pH and electrochemical potential. Numerous factors affect corrosion, including atmospheric conditions (precipitation and humidity), environmental factors (pollutants, inappropriate pH, and contact with soil), as well as physical and biological factors (material stresses and the presence of bioorganisms).To prevent corrosion, protective coatings are most often applied to metal surfaces in order to create a passive barrier between the metal and the aggressive environment [1, 2].

In the present study, the use of a star-shaped polymer (a methacrylate-based polyelectrolyte containing a tertiary amine) as a corrosion inhibitor in protective coatings was investigated. A product based on an alkyd binder was selected for the tests due to the low barrier coatings it creates, which made it possible to observe corrosion changes in a shorter time. The polymer was added to the paint at the production stage, instead of a conventional corrosion inhibitor, which allowed the elimination of the stepwise electrostatic deposition stage (layer-by-layer, LbL, technique) [3]. The scope of the study included, among others, evaluation of resistance to coating delamination from the substrate by the cross-cut test, determination of the surface free energy of solid surfaces, assessment of resistance to neutral salt spray and humidity, as well as evaluation of the durability of coatings exposed to UV radiation.

The results demonstrated that the coating containing the star-shaped polymer exhibits good adhesion to the substrate. Furthermore, despite blister formation during prolonged exposure to moisture and neutral salt spray, the steel substrate remained largely unaffected, which may indicate enhanced barrier properties of the coating. In addition, the paint formulated with the polymer showed a smaller colour change under UV irradiation.

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Influence of the synergy of rheological additives on the application and performance properties of Low-VOC dispersion paints

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Dispersion paints are one of the most important groups of coating materials used in the construction industry, particularly in decorative systems intended for interior walls and ceilings. Current market requirements include achieving high coating performance, good application properties, and reduced volatile organic compound (VOC) content. Meeting these requirements largely depends on the proper selection of formulation components, particularly rheological additives responsible for regulating viscosity, thixotropy, and formulation stability [1,2].

The aim of this study was to investigate the effect of various types of rheological additives and the synergistic effects of their interactions on the application and performance properties of model low-VOC dispersion paints intended for interior use. A series of formulations were prepared, differing in their rheology modification systems, including selected polymeric and associative thickeners, as well as natural and mineral ingredients. All tested systems were based on an aqueous polymer dispersion combined with a conventional system of pigments and mineral fillers, commonly used in decorative coatings.

The study assessed selected physicochemical properties of liquid paints and the performance characteristics of the resulting coatings. Parameters such as viscosity, density, hiding power, wet scrub resistance, water vapor permeability, and VOC content were examined. The results showed that the rheological additive system significantly impacts performance properties, including flowability, sag resistance, and overall formulation stability. At the same time, appropriately designed thickener systems enabled the production of coatings with favorable performance properties while maintaining very low VOC levels.

The obtained results indicate that the synergy between different types of rheological modifiers enables effective tuning of dispersion paint properties and represents a promising direction for further research and development of environmentally friendly coating materials for construction applications.

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Intumescent paints as functional protective coatings for polymeric materials

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Intumescent coatings constitute an important group of functional protective systems used in passive fire protection, for example in piping installations in the construction and industrial sectors. When exposed to high temperatures, these coatings undergo controlled thermochemical transformations, resulting in the formation of an expanded, charred layer with low thermal conductivity. This thermally insulating barrier effectively limits heat transfer to the protected substrate and delays its degradation under fire conditions1–2).

A fire-retardant coating based on a modified vinyl resin was characterized; the formulation contains 20 wt.% of active flame-retardant fillers derived from polyphosphate compounds and polyhydric alcohols. The coating is distinguished by a high content of non-volatile matter (>75%), very good adhesion to the substrate, a short drying time (<30 min), and resistance to direct flame exposure exceeding 15 minutes 2–3).

The paper presents issues related to the application of intumescent coatings as protective systems for piping elements, with particular emphasis on polyethylene pipes characterized by high flammability and low thermal resistance. Key parameters determining the effectiveness of fire protection were discussed, including the swelling mechanism and kinetics, structural stability of the char layer, coating adhesion to the substrate, coating thickness, and the thermal exposure scenario. The results of flammability tests conducted on polyethylene pipes protected with an intumescent coating, in comparison with unprotected samples, are also presented, indicating delayed ignition, reduced combustion intensity, and limited degradation of the pipe material.

The obtained results confirm that properly designed intumescent coatings can provide an effective and flexible solution for passive fire protection of piping installations, in line with current development trends in specialized protective coating systems 2).

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Influence of abrasive pad type on coatings' wet-scrub resistance

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Scrub resistance is a specific type of abrasion resistance, which is usually applied to wall paints, mainly for interior and exterior use.

The principle of the test consists of subjecting the coating obtained in a specific way to wet abrasion called wet--scrub resistance, in a strictly standardised manner which are described in ISO 11998 standard. The result of the wet-scrub resistance test, i.e. volumetric coating erosion, depends on various parameters beginning from coatings preparation, their conditioning and finally their testing, where significant parameters are scrubbing medium, weight of the handle in which the scrubbing pad is, as well as the type of abrasive pad.

This study aimed to investigate the effect of abrasive pad type on the wet-scrub resistance of water-based paint coatings used for interior applications. Three paints differing in their binder types were used in this study. For each paint, three series of coatings with different coating thicknesses were prepared. Each of the prepared coating series was subjected to wet-scrub resistance testing according to PN-EN ISO 11998:2007 [1] using various abrasive pads. The following parameters were determined for all obtained coatings: dry film density, average coating mass loss per unit area, and average coating thickness loss. This last parameter was used to classify the tested coating variant in accordance with PN-EN 13300:2023-04 [2].

The results showed that the type of abrasive pad used affects the test result and can directly impact the final classification of the coating product.

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Effect of parameters used to determine non-volatile matter on the VOC values

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The analysis of non-volatile content is a critical analytical process that involves determining the proportion of solid components in a product relative to its total mass. Non-volatile substances are crucial because the physical and chemical properties of materials depend on their content, and monitoring their levels enables the optimization of production processes and quality control.

This study aimed to investigate the effect of parameters such as drying temperature, drying time, the presence of a solvent, and the time between applying the sample to the dish and drying it, which affect the measured content of non-volatile substances and, consequently, the content of volatile organic compounds. The study utilized solvent-based products, for which series of analysis using various combinations of the parameters listed were prepared. The selection of parameters sets for the analyses was based on the PN-EN ISO 3251:2019-07 [1], PN-EN ISO 11890-1:2008 [2] and PN-EN ISO 11890-1:2024-10 [3]. Based on the measured content of non-volatile matters, the value of volatile organic compounds was calculated. This procedure made it possible to determine the effect of individual analytical parameters on obtained VOC value [2,3].

The results showed that the parameters of the analysis affect determined content of non-volatile matters to varying degrees and highlights how important their selection is in terms of VOC content limits in paints and coating products.

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Vacuum tunnel coating protection for hyperloop high-speed rail transport

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The aim of the project is to develop an innovative, sustainable coating system for underground and above-ground concrete infrastructure, meeting the requirements of vacuum transport systems, particularly the Hyperloop tunnel. Based on advanced coating materials and incorporating bio-based materials, the coating will improve the durability and tightness of concrete and, in the case of pipelines, reduce the risk of leaks.

The developed coating products will be applied using advanced robotics for precise application, control, and autonomous maintenance. The coatings will be tested for resistance to increased concrete shrinkage during vacuum curing, adhesion to concrete under vacuum conditions, and the ability to provide long-term substrate protection under tunnel operating conditions.

Research on the vacuum performance of bio-based coating systems is currently lacking. The project fills this gap by developing and validating renewable coatings optimized for robotic application and protective properties under operating conditions.

Initial formulation work identified binders for concrete substrate coatings with a renewable raw material content of at least 40%. The coatings were characterized for their application, rheological, and performance properties.

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Bio-based UV-curable anticorrosive coatings for metal substrates

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Providing adequate corrosion protection for metal substrates is a challenge, particularly due to ecological and environmental concerns. UV-cured products offer an alternative to traditionally used organic coatings. Advantages of UV-curing technology include low energy consumption, the absence of volatile organic compounds, and high production speed. Well-crosslinked, tight coatings provide good corrosion protection, but the use of adhesion promoters is essential to ensure adequate adhesion to the substrate.

As a result of research conducted as part of the CORNET/36/67/2024 project, acronym BiBACoM, special adhesion promoters based on biologically derived raw materials – phytic acid and glycidyl methacrylate – were developed. The synthesized adhesion promoters were used in coating compositions based on a mixture of highly reactive epoxyacrylate in a solution of dipropylene glycol diacrylate and an amine-modified polyetheracrylate oligomer, as well as in a formulation with a high content of biobased raw materials based on a mixture of epoxidized soy oil acrylate and isobornyl methacrylate. The adhesion promoter used did not negatively affect the UV cross-linking process, which was confirmed by infrared spectroscopy analysis performed in situ during the cross-linking of the coating. Adhesion to the steel substrate was determined. The anti-corrosion properties of the obtained coatings were tested using the EIS method.

Based on the test results, the adhesion promoter with the highest effectiveness was selected. Coatings obtained with this promoter exhibited very good adhesion to the substrate and were the most promising in terms of corrosion resistance due to their high impedance modulus.

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Modern surface modifiers in eco-friendly wood lacquers surface energy engineering as a tool for industrial performance optimization

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The growing demand for environmentally responsible coating technologies has accelerated the development of high-performance waterborne wood lacquers with reduced volatile organic compound (VOC) emissions. Despite significant progress in binder chemistry, improving stain resistance in eco-friendly systems remains a critical industrial challenge. Surface contamination of wooden elements such as furniture, flooring, and joinery is strongly governed by surface free energy and interfacial interactions.

This paper investigates the use of modern surface modifiers for the design of low surface energy coatings in a water-borne polyurethane-acrylic paint system. Four classes of additives were evaluated: modified wax emulsions, fluoropolymer additives, reactive hydro-/oleophobic agents, and polysiloxane modifiers. The coatings were characterized in terms of surface free energy (Owens–Wendt method), contact angle, gloss, hardness, abrasion resistance, and resistance to common staining agents including coffee, red wine, oily soot, and permanent marker.

The results demonstrate that fluoropolymer and reactive hydro-/oleophobic modifiers significantly reduced surface free energy (down to 22.7 mN/m), leading to improved cleanability and reduced contaminant adhesion. Polysiloxane additives provided strong water repellency but introduced subtle surface microtexture affecting optical and mechanical properties. A measurable correlation between decreasing surface energy and reduced surface hardness was observed, attributed to migration of low-surface-tension species toward the coating–air interface and localized modification of crosslink density.

The findings confirm that surface energy engineering is an effective strategy for tailoring the functional performance of eco-friendly wood lacquers. Proper selection of modern surface modifiers enables balancing hydrophobicity, mechanical durability, and aesthetic properties, offering practical guidance for industrial-scale formulation of sustainable, high-performance coatings.

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VOC-exempt solvent integration in 2K OEM clearcoat

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The integration of VOC-exempt solvents into coating formulations has emerged as a critical approach for achieving regulatory compliance while preserving application and performance characteristics, particularly in OEM clearcoat systems. However, incorporating such solvents into two-component (2K) OEM clearcoats presents significant formulation challenges due to their potential impact on film formation, rheology, appearance, and long-term durability.

In this study, a solvent integration strategy was developed for a commercially relevant 2K OEM clearcoat system by systematically modifying the existing solvent package with selected VOC-exempt solvents. The solvents were selected in compliance with European legislation, as defined by the Committee established under Article 75(1) of Directive 2010/75/EU. The physicochemical properties of these solvents, including boiling point, evaporation rate, solubility parameter, and compatibility with resin and additive systems, were evaluated prior to formulation studies.

Formulation optimization studies were conducted to ensure smooth integration of the VOC-exempt solvents while maintaining the established balance of the clearcoat system such as application sag resistance and flow behavior, as well as curing profile and final film mechanical durability. Homogeneous incorporation and stable performance across different processing conditions were achieved through an iterative solvent integration and formulation optimization process. Maintaining OEM-level quality standards and meeting approval criteria associated with the reference formulation represented a key challenge. Comprehensive performance and compatibility tests including sagging performance, appearance evaluation, stone-chipping resistance, water and humidity resistance, gloss retention, film hardness, and storage stability were therefore conducted in direct comparison with the standard clearcoat formulation.

The results demonstrated that the integrated VOC-exempt solvent system did not compromise the mechanical or appearance properties of the clearcoat when the solvent package is selected in line with clearcoat performance requirements. These findings confirm that with careful selection and optimization, VOC-exempt solvents can be successfully incorporated into 2K OEM clearcoat formulations to achieve regulatory compliance while maintaining high-performance. Further validation and assessment through repeated testing and long-term exposure studies is planned to confirm durability and robustness under extended service conditions.

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PTFE-free sandpaper-like texture powder coatings for exterior aluminum protection

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This work focused on obtaining of polytetrafluoroethylene (PTFE) free powder coating with sandpaper-like texture surface. During the processing of PTFE for powder coatings, PFAS (perfluoroalkyl compounds) are also formed. PTFE and PFAS are extremely persistent (they belong to the group of so-called "forever chemicals") and have the potential to bioaccumulate in the environment and living organisms. They accumulate in the liver, kidneys, and circulatory system, among other places, and can contribute to the development of cancer, disrupt hormonal balance, particularly the thyroid, damage certain organs, including the liver, weaken the immune system, promote obesity, cause infertility, birth defects, and even perinatal deaths. Since July 2020, the European Union has banned the marketing of products containing PFAS at concentrations equal to or higher than 25 ppb [1].

For this purpose, polyester resin and hydroxyalkydamide curing agent were used as a binder. The sandpaper-like textured surface of powder coatings was achieved by incorporating additives composed of hydrophobic organic and inorganic particles containing strong bonds with bond energies comparable to those of PTFE (C-F 485 kJ/mol). The use of particles with a similar hydrophobic nature to PTFE migrates to the surface and provides the coating with appropriate hydrophobicity, similar to PTFE. In turn, particles containing strong chemical bonds provide the coating abrasion and scratch resistance. Their appropriate combination creates a sandpaper-like texture on the surface.

The obtained results demonstrate a sustainable development strategy for architectural texture powder coatings based on organic and inorganic components that are harmless to health and the environment.

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Transparent and permanent antistatic finish

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Most polymers are inherently insulating materials. When non-conductive polymer surfaces come into contact with other non-conductive materials and are subsequently separated, they can accumulate electrostatic charge. This electrostatic charging is not permanent but gradually dissipates over time. The rate of discharge depends on both the material properties and the surrounding environmental conditions. However, if the critical dielectric breakdown voltage is reached, a sudden discharge can occur in the form of spark formation. Such sparks may have catastrophic consequences when they occur under explosive conditions. Moreover, the discharge energy can be sufficient to damage electronic components.

Typical polymer-coated materials that pose a potential hazard include, for example, floor coverings, upholstery materials, and protective clothing. For applications in environments where a defined level of electrical dissipation is required, these materials must therefore be equipped with antistatic functionality. This can be achieved through finishes with internal antistatic additives, such as carbon- or metal-based particles; however, these inevitably result in grey to black surfaces. Alternatively, external antistatic agents, such as quaternary ammonium ions, can be used. While these are colourless and transparent, their effectiveness strongly depends on ambient humidity and is not permanent.

In this study, we present the results on the development of a transparent coating with permanent antistatic functionality for flexible polymer-coated materials using the intrinsically conductive polymer PEDOT:PSS. We investigated the dependence of surface resistance on formulation composition, the substrate to be coated, and the coating parameters. The results show that the surface resistance of finishes with PEDOT:PSS are not dependent on humidity. In addition, the influence of PEDOT:PSS on the colour and transparency of the substrates was investigated. Determining an appropriate PEDOT:PSS concentration is essential to ensure the antistatic performance without significantly affecting the colour of the substrate.

Pneumatic rehabilitation equipment with silver-free antibacterial powder coatings

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This work presents the concept of applying silver-free antibacterial powder coatings to selected surfaces of pneumatic rehabilitation equipment intended for passive lower-limb exercises. The rehabilitation device uses microprocessor-based control and a pneumatic drive system to generate alternating and reciprocal movements of both limbs, allowing the exercise parameters to be adjusted to individual patient needs [1,2]. The proposed solution is based on two patents related to the rehabilitation device and its control system [3,4].

A key issue in this context is meeting the hygienic and functional requirements of surfaces exposed to frequent handling and regular cleaning. A promising solution is offered by silver-free antibacterial powder coatings based on polyester systems modified with halloysite/polylysine (HAL/PLY) additives. Previous studies demonstrated their high antibacterial effectiveness against Escherichia coli and Staphylococcus aureus (>99.99%), as well as favorable mechanical properties and good water resistance [5,6].

These coating formulations were developed within the CORNET/34/101/MicroSafeCoatings/2023 project entitled Novel Antimicrobial Protection in Powder Coating for Composite Materials [7]. Their properties suggest that they are suitable for application on selected components of pneumatic rehabilitation equipment, thereby contributing to improved hygiene, durability, and operational safety.

The proposed concept combines mechanical engineering, pneumatic drive systems, rehabilitation technology, and functional surface protection.

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Antibacterial properties of garlic-modified paints in the context of rehabilitation devices

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In this work, the concept of applying antibacterial epoxy paints modified with plant-derived additives to selected surfaces of a pneumatic rehabilitation device intended for passive lower-limb exercises is presented. Particular attention was paid to paints containing garlic-based additives, which, among the analyzed modifiers, exhibited the highest antibacterial activity against Staphylococcus aureus, achieving a bacterial reduction of 99.998%. This high effectiveness indicates the strong potential of these bio-modified systems as an alternative to coatings containing silver and other synthetic biocides [1].

The proposed solution relates to selected components of a rehabilitation device based on pneumatic actuation and microprocessor control [2,3], which enables alternating and counter-phase lower-limb movements as well as precise adjustment of therapy parameters to individual patient needs [4,5]. In this application, the paint serves not only as a protective coating but also as a functional surface layer that reduces the risk of microbiological contamination during use.

The presented concept combines materials engineering, coating technology, pneumatics, and rehabilitation engineering. The use of garlic-modified epoxy paints may therefore represent a promising direction in the development of hygienically enhanced surfaces for rehabilitation and medical equipment.

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Biomodified epoxy coatings with plant based fillers cured under UV radiation and their antibacterial and functional properties

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This study presents the development of UV-curable epoxy coatings modified with natural plant-based fillers such as garlic (Allium sativum), turmeric (Curcuma longa), nettle (Urtica dioica), and privet (Ligustrum vulgare) [1,2]. The coatings were formulated using Epidian® 5 epoxy resin and cured using a cationic photoinitiator under UV radiation [2].

The influence of plant modifiers on the functional properties of the coatings was evaluated, including surface roughness, scratch resistance, hardness, gloss, wettability, and antibacterial performance [3,4,5]. Structural characterization was performed using FT-IR spectroscopy, while surface properties were investigated using profilometry and contact angle measurements.

The results demonstrated that plant-based fillers significantly affect the surface and mechanical properties of epoxy coatings. The addition of natural modifiers slightly reduced hardness and scratch resistance but improved the functional characteristics of the coatings [5].

The most significant antibacterial effect was observed for coatings containing garlic, which showed nearly complete inhibition of Staphylococcus aureus growth with a bacterial reduction of approximately 99.998%. These findings indicate that plant-derived modifiers can serve as effective bio-based functional additives in polymer coatings, offering a promising alternative to traditional antimicrobial agents such as silver compounds [5].

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Radical processes induced by UV radiation in polymer coatings containing natural dyes

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Natural plant dyes are increasingly investigated as sustainable colorants and functional additives in polymer coatings, while their stability under ultraviolet radiation remains an important challenge.In this study, the photochemical behavior of coatings containing natural dyes derived from turmeric (Curcuma longa) and madder (Rubia tinctorum) was investigated using electron paramagnetic resonance (EPR) and FT-IR spectroscopy [1–2].

Model coating formulations were prepared using two polymer matrices: epoxy resin (Epidian® 5) and unsaturated polyester resin (Polimal® 109). The systems were cured using cationic and radical photoinitiators and exposed to controlled UV irradiation (β= 320 nm). The formation and evolution of paramagnetic centers during irradiation were monitored using EPR spectroscopy, while structural changes in the polymer matrix were analyzed by FT-IR. The results revealed the generation of stable organic radicals with characteristic g-values around 2.001, corresponding to semiquinone and phenoxyl radicals formed during photochemical transformations of the dyes [3–4].

Additionally, signals attributed to transition metal ions such as Fe^{3+} and Cu^{2+} were observed, indicating their involvement in redox processes during UV exposure, with the Cu^{2+} assignment supported by literature data on EPR characterization of copper centers [5].

The study demonstrates that EPR spectroscopy is a powerful tool for understanding radical processes responsible for color changes in polymer coatings containing natural dyes and provides insight into their photochemical stability [1,2].

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Assessment of the effect of paint coatings on the mechanical properties of the PZL M-20 Mewa aircraft skin

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Paint coatings applied to aircraft skin perform a protective function during service and may significantly affect both the surface condition and the mechanical response of the material [1–3].

This study evaluates the influence of paint coating presence on the mechanical properties of specimens taken from the skin of a PZL M-20 Mewa aircraft. Three types of specimens were analyzed: a specimen without a paint coating, a specimen with an intact paint layer taken from an undamaged area, and a specimen with a coating collected from the rivet-adjacent region [4–5]. All specimens were subjected to static tensile testing. The experimental program was supplemented by a macroscopic assessment of the surface condition, identification of visible forms of degradation, and an analysis of the condition of the preserved protective layer. The basic mechanical parameters were determined, including ultimate tensile strength, yield strength, and elongation at break, and the failure characteristics after testing were also evaluated.

A comparative analysis of the results made it possible to assess the effect of paint coating presence and local surface condition on the mechanical response of the aircraft skin material [6]. The obtained results indicate that both the presence of the paint coating and the local character of its in-service degradation may influence the mechanical performance of thin-walled aircraft skin components.

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Modal and harmonic analysis of thin-walled steel plates with paint coatings using the finite element method for vibration damping assessment

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This study presents the results of a numerical investigation of the dynamic response of thin-walled steel plates coated with paint layers, with particular emphasis on modal and harmonic analyses performed using the finite element method in the ANSYS environment.

The developed numerical model complemented the experimental research and enabled the separation of the effects of coating mass increase and coating damping properties on the dynamic characteristics of the system. The analysis included coatings based on zinc paint, white camouflage paint, and red rubber paint, modeled as surface layers with material properties estimated from experimental measurements and literature data [1–2]. Modal analysis and harmonic response analysis were performed in the frequency range up to 500 Hz under boundary conditions corresponding to the experimental arrangement. The simulation results showed a systematic decrease in natural frequencies with increasing coating mass, with the most pronounced effect observed for the white camouflage paint. In contrast, the zinc paint and rubber paint produced only slight shifts in the resonance frequencies [3–5]. The harmonic analysis demonstrated a significant reduction in vibration amplitude in the resonance region for all analyzed variants, confirming their damping effectiveness.

The numerical model successfully reproduced the principal trends observed in the experimental study, particularly the reduction in amplitude near resonance and the dependence of the dynamic response on the type and number of coating layers. The obtained results indicate that simplified FEM modeling incorporating structural damping constitutes an effective tool for supporting the analysis of the influence of paint coatings on the dynamic properties of thin-walled structures and may be applied in the design of passive vibration reduction methods.

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The ghost of fireplaces and stoves

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Have you considered whether fire in a fireplace impacts more than just the wood? A freezing, winter evening should be the perfect time to put your new fireplace/stove to the proof. The coating on fireplaces/stoves undergoes a transformation during the first ignition, which can generate unpleasant odours and smoke. Are these unpleasant effects evitable?

Achieving low smoke and odour levels requires careful selection of raw materials in coating formulations. However, combining visually unchanged, non-smellable degradation with high mechanical robustness while maintaining economical (<100°C) and ecological aspects (VOC-free and preferably water-dilutable) presents a significant challenge for paint producers.

To address this, detailed assessments of degrading mechanisms have proven essential in understanding what happens during the heating-up process of a coated fireplace. By fine-tuning raw materials, production processes, and measurement techniques, it is possible to meet all the requirements of the 21st century.

This poster shows the formulation strategy and unique characterisation techniques (TGA, DTG, FTIR, and Laser-Assisted Machine Vision) that enable the development of advanced heat-resistant coatings.

Development of a new cobalt-free drier based on manganese and 2,4,6-tris(2-pyridyl)-1,3,5-triazine ligand

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Drying of alkyd resins in paints and coatings is based on a radical autoxidation process. Organic hydroperoxides are formed and subsequently decomposed into reactive radicals, which are responsible for cross-linking of the double bonds of the alkyd resin, resulting in the hardening of the system [1]. Traditionally, cobalt-based driers have been the primary drying catalysts; however, their salts are currently classified, or under evaluation, as repro-toxic category 1B and, in some cases, potentially carcinogenic 1B [2].

Co-free driers' performance strongly depends on the system, making it necessary to evaluate different alternatives to identify the most suitable one. Dura has developed several series of catalysts based on activated metals specifically engineered to optimize both catalytic activity and final film properties.

Dura DriCAT 2800 series is based on the coordination of manganese with 2,4,6-tris(2-pyridyl)-1,3,5-triazine (TPTZ), a hexadentate ligand featuring three active sites capable of coordinating up to three metal centres [3] (Figure1). This ligand features an open meridional pincer architecture that facilitates manganese coordination and substrate accessibility, leveraging its extended aromatic ϖ-system to provide the electronic stability and oxidative robustness required for efficient catalysis. This results in reduced undesired side reactions and improved active radical formation, promoting a more controlled and efficient cross-linking process, leading to good drying, hardness, exceptional whiteness and high yellowing resistance.

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POSTER #P-31

Microbiological risks and control strategies of water-based paints

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Water-based paints are highly susceptible to microbial growth because the aquatic environment creates favorable conditions for their rapid multiplication. Therefore, they require effective protection against microbial growth in packaging. To assess the effectiveness of their preservation, microbiological analysis is necessary. For this purpose, various commercially produced paints containing biocides and laboratory samples without biocides were tested. Aerobic bacteria and their spore forms were detected in the highest numbers in water-based paints. Bacteria that grow at room temperature (20 °C) predominated. These bacteria may originate from environmental microflora, for example, during the production process, raw material contamination, or contamination during packaging. Therefore, maintaining sterile conditions during production is crucial. The detected presence of anaerobic bacteria in the paint samples could potentially accelerate paint spoilage during fermentation processes. Although the paints contained biocides, a small number of pathogenic bacteria (*Coli* forms and *Pseudomonas aeruginosa*) were detected, which may pose a health risk to users. Mold and fungal cells were also present in the paints, including a selective strain of Candida yeast, which may also pose a health risk. Spore forms of bacteria were also detected, which form during bacterial cell stress (sporulation) – for example, during paint production. These bacterial forms are much more resistant to physical and chemical processes. Based on the conducted research, it can be concluded that the presence of a typical biocide limits the growth of microorganisms, but does not completely disinfect the paint. Therefore, it is necessary to develop of alternative methods their preservation.

Acknowledgments

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Development of T-type silsesquioxane resins as functional additives in protective coatings

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Silicone-based additives are widely used in protective coatings to improve surface properties such as hydrophobicity and scratch resistance; however, conventional linear silicone oils often suffer from limited durability due to migration and poor long-term integration into the coating matrix. In this context, silicone-based silsesquioxane additives have attracted increasing interest, as they have been shown to enhance mechanical properties such as hardness and scratch resistance in polymer films [1], and hybrid silsesquioxane/POSS systems exhibit improved thermal and surface performance in transparent and protective coatings [2,3].

In this study, three industrially relevant T-type silsesquioxane silicone resins, methyl (MSQ), phenyl (PSQ), and methyl-phenyl (MPSQ), were developed and evaluated as functional additives for protective coating applications. MSQ was synthesized as a 100% active solvent-free resin, while PSQ and MPSQ were produced as 50% active solutions in xylene, enabling direct incorporation into solvent-based coating formulations. The resins were designed to enhance key coating performance parameters including hydrophobicity, scratch resistance, and thermal stability, targeting both topcoat and primer systems.

The chemical structure and thermal behavior of the synthesized resins were characterized by FTIR, TGA, DSC, and GPC, providing insight into functional group evolution, molecular weight distribution, and thermal degradation profiles. Coating performance was assessed through static contact angle measurements, scratch/mar resistance testing, and AFM surface analysis to evaluate surface morphology and mechanical durability.

The results demonstrated that silsesquioxane resin incorporation significantly improved coating surface properties, increasing water contact angles by 20–35° and providing enhanced resistance against surface damage. In addition, improved thermal stability was observed, with phenyl-containing resins (PSQ and MPSQ) exhibiting superior performance due to their increased aromatic content. MSQ-based formulations showed improved leveling and anti-blocking behavior, contributing to smoother coating surfaces. AFM analysis confirmed changes in surface topography, indicating a more uniform microstructure consistent with improved mechanical performance.

Overall, this work demonstrates the potential of 3D network silsesquioxane resin additives as high-performance coating modifiers, offering a scalable approach to improve durability and functionality in industrial protective coatings.

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Nanofiller-modified waterborne polyurethane coatings for improved scratch resistance

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Waterborne polyurethane (WPU) suspensions are used to produce coatings for various applications and are attracting increasing attention thanks to their environmentally friendly properties. However, the scratch resistance and mechanical properties of the resulting coatings often remain inferior to those based on traditional solvent-based formulations, which limits their application [1]. Therefore, we investigated the addition of different nanofillers in WPU suspensions to improve the scratch resistance and mechanical properties of the coatings while preserving transparency. For this, bio-based cellulose nanofibers (NFC), tyrosine (Tyr), and inorganic silica nanoparticles (SiO_2) were selected as nano-additives to distribute into commercial WPU systems along with an appropriate amount of butyl diglycol (BDG) co-solvent for film formation at room temperature. The coating properties, including transparency, surface morphology, roughness, micro-scratch and abrasion resistance, hardness and mechanical properties, were evaluated. Micro-scratch resistance was evaluated with AFM by monitoring the Wenzel roughness resulting from scanning the tip on the surface under increasing loads. The results show that an appropriate amount of co-solvent promotes a more homogeneous distribution of hard and soft PU phases, resulting in improved film uniformity. However, the addition of Tyr significantly increases surface roughness and reduces transparency due to the formation of long fibrous crystals during solvent evaporation. SiO_2 nanoparticles induce a relatively limited effect on transparency but higher surface roughness, even cracks. In contrast, NFC not only obviously improves micro-scratch resistance and mechanical properties but also has minimal effects on surface roughness and almost no effect on transparency. For all the fillers, irrespective of their nature, a clear correlation was observed when plotting micro-scratch resistance versus Young's modulus (Figure 1): the lower the scratch-induced roughness, the higher the Young's modulus, until a plateau is reached in the high-modulus region. This shows that increasing the stiffness of the system helps inhibit surface damage. However, in the high modulus region, other film performance indicators depend strongly on additive morphology, dispersion state, and their influence on the coating microstructure. Overall, NFC appears as a promising nanofiller for achieving the synergistic optimization of mechanical reinforcement, surface smoothness, optical properties, and film-forming stability. This study provides experimental guidance for filler selection and additive-strategy optimization in transparent functional coating applications.

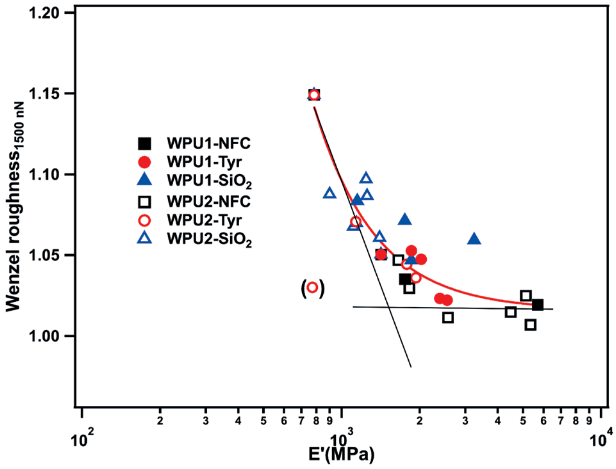

Figure 1. Relationship between surface damage (i.e., Wenzel roughness resulting from micro-scratches performed at a force loading of 1500 nN) and Young's modulus (measured at room temperature), for coatings incorporating Tyr, SiO_2 or NFC.

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Biocompatibility assessment of silver – Modified titanium dioxide nanoparticles for surface coating applications

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Our work focuses on the synthesis of innovative modified titanium-based nanoparticles exhibiting enhanced antipollutant and antimicrobial activity under visible light. Although titanium and its alloys are characterized by adequate stability and biocompatibility, these materials lack intrinsic antibacterial properties [1]. Titanium dioxide (TiO_2, titania) has attracted significant scientific interest due to its ability to generate reactive oxygen species (ROS) under UV light (photoactivity), leading to cell death [2]. Considerable efforts have been devoted to conjugating metal nanoparticles with enhanced antibacterial activity to titanium.

Among the photocatalytic nanoparticles synthesized in our lab, TiO_2@Ag are considered the most prominent. Their morphology and particle size were examined by TEM, whilst their hydrodynamic size and surface charge was evaluated through DLS analysis. This study focuses on the biological evaluation of these nanoparticles, since they are intended for incorporation into hospital wall coatings to reduce microbial contamination and inhibit the formation of potentially infected surfaces. All experiments were conducted using the HaCaT cell line, a human epidermal keratinocyte model. Initially, cytotoxicity was assessed using the MTT assay. Subsequently, the mechanism of nanoparticle-cell interactions was further investigated. Specifically, we evaluated the effect on the cell cycle and after that the extent of apoptosis and necrosis induced by nanoparticle exposure, as well as the proportion of ROS generated. In addition to the TiO_2@Ag NPs, bare AgNPs were also synthesized for comparison. These NPs were characterized using pXRD, TEM, and DLS measurements, allowing for a comprehensive evaluation of their structural and physicochemical properties.

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Photoredox polymerization: A promising route toward lubricant and coating additives

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The scarcity of resources and the growing environmental awareness in an increasingly technology-driven society require the development of new sustainable synthetic strategies in chemical research for the efficient production of complex organic intermediates and specialty chemicals. In this context, particular emphasis is placed on the integration of renewable energy sources and the reduction of potential hazards within chemical processes [1].

This work investigates the targeted synthesis of lubricants based on poly(βolefins) through photoredox catalysis under visible light irradiation. The study examined whether βolefins can be polymerized via photoredox-catalyzed methods and which reaction conditions are decisive. Photoregulated atom transfer radical polymerization (photo-ATRP) [2] and cationic photoinduced electron/energy transfer-reversible-addition-fragmentation chain-transfer (PET-RAFT) [3] strategies were explored.

A simplified scheme of a photoredox-catalyzed polymerization is presented in Figure 1. Polymerizations of model monomers such as methyl methacrylate, styrene, and isobutyl vinyl ether confirmed that controlled reactions are achievable under optimized conditions. Photoredox-catalyzed polymerization was investigated for both linear and branched βolefins, including 1-octene, 1-decene, and 2-methyl-2-pentene. While no polymerization could be achieved for the linear substrates under the applied conditions, initial results indicate that branched βolefins such as 2-methyl-2-pentene are accessible via photo-ATRP under white light irradiation. Preliminary findings further suggest that cationic PET-RAFT polymerization may represent a viable complementary approach. The results demonstrate the fundamental suitability of photoredox-catalyzed methods for the synthesis of technical polymers and identify influencing factors for their future implementation in sustainable processes for lubricant or coating additive production.

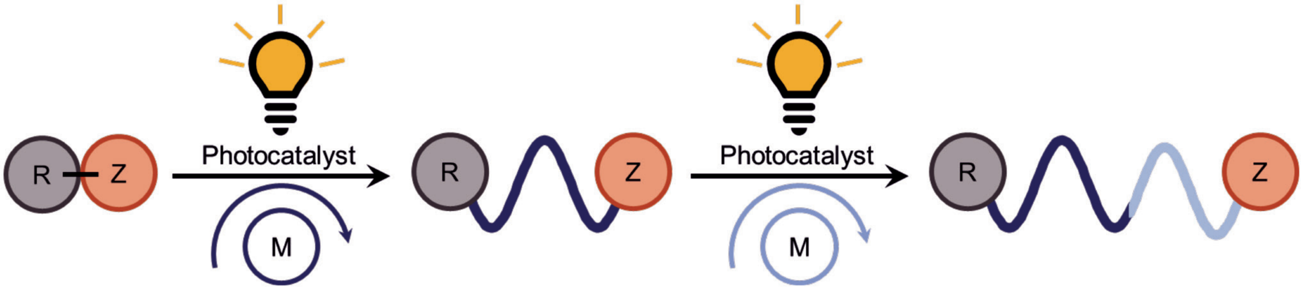

Figure 1: Simplified photoredox polymerization under visible light. M = monomer; R = organic rest; Z = initiator (halogen atom in photo-ATRP or chain transfer agent in PET-RAFT polymerization).

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New concept of corrosion protection in the presence of water: Hydrojetting application

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This study presents laboratory test results obtained using a newly developed organic inhibitor: V-active VCIs. The findings demonstrate that it is possible to eliminate or significantly reduce the oxidizing effect of water, thereby extending the permissible interval before painting after hydrojetting. Importantly, the new corrosion inhibitor technology does not compromise the final quality of paint adhesion.

Metallic specimens were treated and washed under standardized laboratory conditions. A 2 to 5% solution of V-active VCI SPH 1712 was prepared by diluting the inhibitor in industrial water. Metal sample plates were analyzed after blasting and subsequent drying, and subjected to paint adhesion tests, cathodic disbondment, total soluble salts measurement, flash rust formation timing, and cyclic corrosion testing (type III, 20 cycles) to evaluate temporary protection duration, oxidation prevention, and influence on paint adherence.

The proposed V-active VCI technology effectively minimizes or eliminates the oxidizing action of water when metal is exposed to saline moisture in enclosed environments, extending the allowable time before painting without affecting the final quality of the coating.

This technology enables larger areas of wet-blasted steel surfaces to be cleaned and prepared, reducing labor and product costs, and decreasing water consumption during surface preparation. Practical applications include shipbuilding, ship maintenance, oil and gas production, preservation of internal tubes and pipes, protection during hydrostatic testing, and corrosion prevention in diesel tanks contaminated with water.

This paper presents results for a novel formulation of organic chemical inhibitors applied via aqueous medium. In addition to this property, these organic inhibitors retain the characteristics of volatile inhibitors, and are collectively referred to as V-active VCIs.

Keywords

Inhibitors, VCI, corrosion, green/environmental, development, ship maintenance, oil and gas

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High performance additive package for waterborne DTM coatings

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Modern corrosion-protection systems are increasingly moving from multi-layer solventborne technologies toward waterborne direct-to-metal (DTM) coatings. While waterborne DTM systems offer environmental benefits and simplified application, achieving fast rust inhibition, corrosion resistance, durability, and good film appearance within a single coating layer remains challenging.

This work evaluates a high-performance additive package developed for waterborne DTM coatings. The package consists of PAT-ADD DA 817 wetting & dispersing additive, PAT-ADD LE 1023 leveling additive, RHEOL 117 rheology modifier, PAT-ADD AF 39 defoamer, and RU 02 corrosion inhibitor.

The additives were assessed for their contribution to pigment wetting, film appearance, rheology control, foam reduction, flash-rust protection, and corrosion resistance. DA 817 improved pigment wetting and stabilization, enabling smooth film formation and stronger overall corrosion resistance in waterborne systems. LE 1023 enhanced gloss, DOI, RIQ, and leveling performance. RHEOL 117 provided balanced KU and ICI viscosity with stable Newtonian-like flow and good leveling. AF 39 minimized foam during processing and application while improving film uniformity. RU 02 provided strong flash-rust suppression and reinforced long-term corrosion protection.

Performance was evaluated using flash-rust testing, ASTM D870 water immersion testing, ASTM B117 salt spray exposure, and mechanical testing including adhesion, pencil hardness, scratch resistance, and flexibility. Compared with a commercial waterborne DTM formulation, the additive package demonstrated improved corrosion resistance while maintaining mechanical performance.

The results show that a carefully selected additive package can provide robust stability, enhanced water and humidity resistance, and improved corrosion protection across multiple waterborne DTM resin chemistries.

Keywords

Waterborne DTM coatings, corrosion protection, flash rust, dispersants, rheology modifiers, additives.

Redefining Surface Dynamics – PFAS-Free

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Increasing regulatory pressure, including the EU REACH proposal and the European Chemicals Agency (ECHA) PFAS Restriction Proposal, is driving the coatings industry toward PFAS-free alternatives. Traditional silicone and fluorinated additives have historically provided strong wetting, leveling, slip, and defoaming performance in both solventborne and waterborne coatings. However, concerns regarding persistence, bioaccumulation, and environmental impact are accelerating the transition to PFAS-free technologies.

This work presents a PFAS-free additive approach designed to provide surface control and defoaming performance in coatings while maintaining compatibility across different resin systems and substrates. The study evaluates leveling additives LE 1777, LE 1078, and LE 1025, together with defoamers AF 174 and AF 183.

Performance was assessed in both solventborne and waterborne coating systems. LE 1777 demonstrated gloss, DOI, and RIQ values comparable to PFAS-based leveling agents while providing lower coefficient of friction and eliminating haze at all dosage levels. LE 1078 delivered instantaneous wetting, improved substrate coverage on metals, plastics, wood, glass, and polycarbonate, and significantly reduced gloss, DOI, RIQ, and coefficient of friction. LE 1025 matched PFAS-reference performance in gloss, DOI, RIQ, and slip, while maintaining excellent inter-coat adhesion and substrate wettability without increasing haze.

For defoaming performance, AF 174 provided foam suppression comparable to PFAS-based defoamers while maintaining clarity and coating appearance. AF 183 demonstrated improved defoaming during mixing, superior performance in SF epoxy and polyaspartic clear-coat systems, and produced clear films without haze or yellowing.

The results demonstrate that the evaluated PFAS-free additives can achieve performance comparable to conventional PFAS-containing technologies in key application areas including wetting, leveling, slip, and foam control. These solutions provide practical alternatives for both waterborne and solventborne coatings while supporting the industry‘s transition toward PFAS-free formulations.

Keywords

PFAS-free additives, surface control, wetting, leveling, defoaming, coatings..