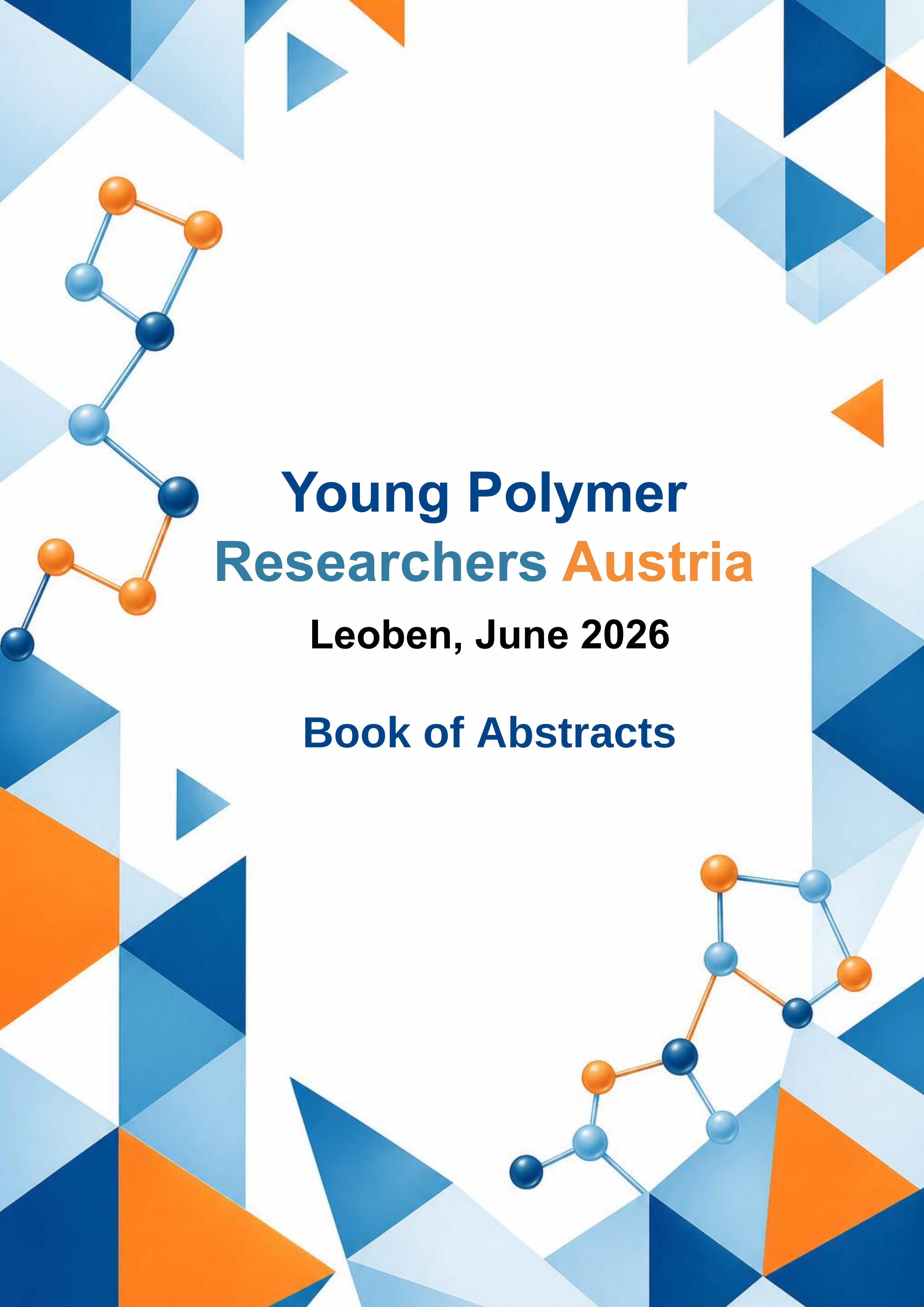


Young Polymer Researchers Austria

Leoben, June 2026

Book of Abstracts

Acknowledgement

Gold Sponsor

isovolta
GROUP

Silver Sponsor

Anton Paar

AT&S

Bronze Sponsor

CHASE

Award Sponsors

Chemistry Open

Chem Plus Chem

Chemistry Europe

ROYAL SOCIETY
OF CHEMISTRY

Sponsorships for refreshments

TERRA
CERVISIAE
SCHÜTZING

MAKAvA
delighted ice tea

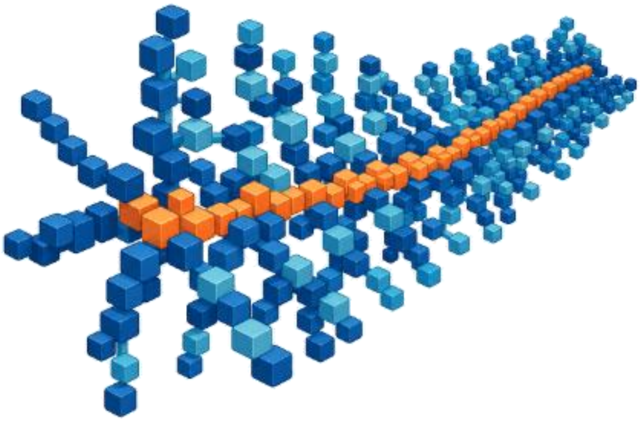
Red Bull

Programme

MONDAY 29.06.2026	
12:00-13:00	**Registration**
13:00-13:15	**Opening**
Chair: C. Slugovc	
13:15-13:30	**OP1:** G. Winkler - Lossless shear mixing of milligrams for the rapid screening of amorphous solid dispersion
13:30-13:45	**OP2:** I. Cicco - High-Resolution Microscopy of Epoxy–Thiol Thermosets: Microscopic Insights into Morphology and Toughness
13:45-14:00	**OP3:** D. Pint - 3D Printing Complex Anisotropic Cellulose Hydrogel Structures Using Sacrificial Support Systems
14:00-14:15	**Break**
Chair: S. Schlögl	
14:15-14:45	**P1:** Dr. H. Houck
14:45-15:00	**OP4:** D. Wielend - Circular biopolymer economy: Simulation-assisted modelling of chemical recycling towards a green BIOCYCLE
15:00-15:15	**OP5:** J. Dale - Atmospheric Water Harvesting: Can Sulfur be the Solution?
15:15-15:30	**Break**
Chair: T. Grießer	
15:30-15:45	**OP6:** J. Maier - Wavelength-Orthogonal Control of Thiol–Ene Reactions: Inhibition and Reactivation
15:45-16:00	**OP7:** P. Weiss - Active Ester Curing of Epoxides Producing Low-Dielectric Thermosets
16:00-16:15	**OP8:** M. Puzhakkalakath - Functional Poly(amidoamine)s from Tulipalin A
16:15-16:30	**OP9:** A. Kruglhuber - Investigating sustainable functional polyester materials
16:30-18:30	**Poster session & Break**
18:30-22:00	**Pubquiz**

TUESDAY 30.06.2026	
Chair: C. Paulik	
09:00-09:15	**OP10:** S. Salehi-Siouki - Surface Engineering of Photopolymers for Nucleic Acid Biosensing Applications
09:15-09:30	**OP11:** J. Lang - Opportunities and Challenges of Acrylates and Methacrylates in Epoxy-Amine Covalent Adaptable Networks
09:30-09:45	**OP12:** S. Hummer - Robust, Air-Stable, and Reusable: An Ir2(i,iii) Hydride Catalyst for Homogeneous Alkane Dehydrogenation
09:45-10:00	**OP13:** V. Musil - From commodity to high-performance: Next-generation hyperbranched polyethylene materials for additive manufacturing
10:00-10:30	**Break**
Chair: E. Rossegger	
10:30-11:00	**P2:** Dr. G. Rosetto
11:15-11:30	**OP14:** M. Mostofizadeh - 3D-printed APA-based photopolymers with tunable mechanical properties and surface erosion degradation
11:30-11:45	**OP15:** J. Jüstel - PES-Membrane Meets polyHIPE
11:45-12:00	**OP16:** M. Augustin - Development and Synthesis scale-up of Template Monomers for AB-alternating Polyacrylamides
12:00-13:30	**Lunch**
Chair: A. Pfeil	
13:30-13:45	**OP17:** H. V. Kien - Development of Thermo-Responsive Polythiourethane–Urethane Coatings for Enhanced Battery Safety
13:45-14:00	**OP18:** F. Guerrero-Ruiz - Towards Circular Optoelectronics: Sustainable and Reversible Unsaturated Polyester Adhesives Via Photochemical Curing
14:00-14:15	**OP19:** B. Schneider - All about that Base: Lewis Base Photobase Generators for Oxa-Michael based Photopolyme
14:15-14:30	**OP20:** L. Vevere - Sustainable Rigid Polyurethane Foams from Tall Oil Fatty Acids for High-Performance Cryogenic Insulation
14:30-15:00	**Break**
Chair: G. Trimmel	
15:00-15:15	**OP21:** C. Normand - Structural composite battery: Reinforced carbon fibre electrodes within a porous polyethersulfone matrix
15:15-15:30	**OP22:** A. Hellmayr - Strategies for Printed Electronics on Rubber
15:30-15:45	**OP23:** L. Hofbauer - The role of phenolic Mannich bases in isocyanate self-reaction pathways
15:45-16:00	**OP24:** A. Markovič - Ionic π-conjugated porous polymer frameworks for synergistic adsorption–photocatalysis in water
16:00-16:30	**Break**
Chair: S. Schlögl	
16:30-17:30	**Panel discussion** From Pitch to Practice: Startup Success Stories
17:30-22:00	**Dinner & Social programme**

WEDNESDAY 01.07.2026	
Chair: R. Kargl	
09:00-09:15	**OP25:** I. Draxler - Insights into the Development of Sustainable Automotive Compounds
09:15-09:30	**OP26:** A. Naryshkina - Upcycling Waste Aromatic Polymers as Adsorbents for Atmospheric Water Harvesting
09:30-09:45	**OP27:** A. Bauer - Advancing 3D Lithography with Vitamin-Based Photoinitiators in Aqueous Systems
09:45-10:00	**OP28:** M. Haslinger - Polarisation Resistance of Individual Carbon Fibre Current Collectors for Structural Composite Batteries
10:00-10:15	**Break**
Chair: K. Ehrmann	
10:15-10:30	**OP29:** C. Angerer - Raman Spectroscopy Across Disciplines: From Classical Polymers to Functional Materials and Biomolecules
10:30-10:45	**OP30:** A. Alem - Carbon Felt Electrodes in Redox Flow Batteries: Mechanistic Insights into Performance and Degradation
10:45-11:00	**OP31:** P. Schweng - A hydrochromic porous aromatic polymer for self-reporting, high-capacity atmospheric water harvesting
11:00-11:15	**OP32:** S. Renner - MOFs as new catalytic platform for covalent adaptable networks: catalysis meets reinforcement
11:15-11:30	**Break**
11:30-12:00	**Award ceremony & Closing**
12:00-13:00	**Lunch**



Oral Presentations

OP 1: Lossless shear mixing of milligrams for the rapid screening of amorphous solid dispersion

Gabriel Winkler[1]; Julia Nikolaus[1]; Andreas Bramböck[1], Lizbeth Siegmann[1], Daniel Treffer[1]
[1]*MeltPrep GmbH, Graz Austria, daniel.treffer@meltprep.com*

Even the smallest commercially available twin-screw extruders require gram-scale quantities to produce amorphous solid dispersions (ASDs). In early drug development, this material demand is often impractical, as only a few hundred milligrams of a new compound may be available from synthesis. This creates a need for near-lossless, small-scale mixing methods that can process limited material quantities while still generating representative ASD samples.

During twin-screw extrusion, screw elements apply shear forces and repeated material reorientation, resulting in dispersive and distributive mixing. Existing small-scale mixers use various approaches to reproduce these effects but are often limited by material loss during processing and recovery[1]. This work presents a lossless (LM) mixing device where mixing is performed on a swappable, heatable glass plate. The process consists of two alternating steps. First, a defined-gap tool applies shear to the material, forming a thin film on the heated surface. Second, a sharp blade collects[2] and reorients the material in segments, following a baker's transformation approach. These steps are repeated until the material appears optically homogeneous.

The LM approach was evaluated using three pharmaceutical model systems: 10%

Mannitol/ Kollidon VA64, 20% Butylparaben/ HPMCAS, and 30% Butylparaben/ HPMCAS. Powder mixtures (PM), LM -processed samples, and solvent-cast (SC) samples were compared. For LM processing, ten mixing cycles were applied. The PM discs showed clear heterogeneity, with distinct phases of model compound and polymer carrier. In contrast, the LM discs were transparent for all formulations, indicating improved homogeneity and successful incorporation of the model compounds into the polymer matrices. Solvent-cast samples prepared on the LM discs underwent multiple heating cycles and showed more pronounced coloration. In the Mannitol/ Kollidon VA64 formulation, rapid recrystallization was observed in the solvent-cast sample, suggesting that residual solvent promoted early recrystallization.

Overall, the LM device provides a promising small-scale mixing technique for early formulation screening. Its near-lossless setup enables rapid evaluation of multiple formulations using minimal material quantities and can be integrated into the vacuum compression molding workflow.

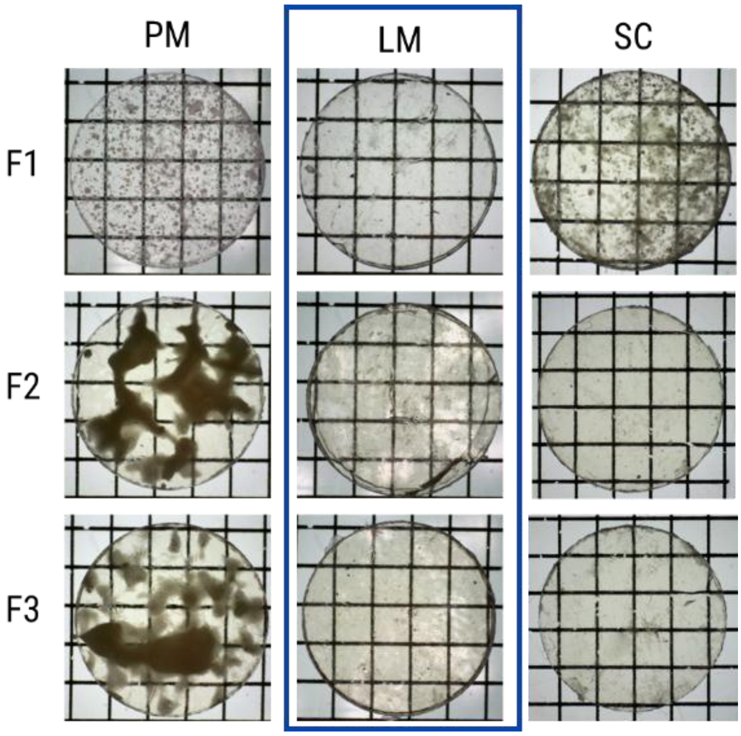


Figure 1: VCM discs (100 mg, 10 mm) obtained from Physical Powder Mixtures (PM), Lossless Mixing (LM), and Solvent Casting (SC) on a 2 mm grid background. F1: 10% Mannitol/ Kollidon VA64; F2: 20% Butylparaben/ HPMCAS; F3: 30% Butylparaben/ HPMCAS

References

(1) Pluntze, A; Beecher, S.; Wright, D.; Mudie, D. Material-sparing Feasilbility Screening for Hot Melt Extrusion, MDPI Pharmaceutics, 76, (2024)

(2) Treffer DF, Khinast JG. Why Hot Melts Do Not Stick to Cold Surfaces. Polym Eng Sci. 2017;57(10):1083-1089. doi:10.1002/pen.24483.

OP 2: High-Resolution Microscopy of Epoxy–Thiol Thermosets: Microscopic Insights into Morphology and Toughness

I. Cicco[1], A. C. Seitlinger[2], M. A. Tunes[2], K. Resch-Fauster[3], T. Griesser[1]

[1]*Chair of Chemistry of Polymeric Materials, Technical University of Leoben, Leoben, Austria.*
[2]*Chair of Nonferrous Metallurgy, Technical University of Leoben, Leoben, Austria.*
[3]*Chair of Materials Science and Testing of Polymers, Technical University of Leoben, Leoben, Austria.*

Thiol–epoxy systems are an emerging area of research within the field of thermosetting materials. In particular, polythiol-based hardeners have attracted increasing attention as they offer a promising, sustainable way to produce high-performance epoxy thermosets with enhanced toughness[1]. Although epoxy systems have been extensively studied[2,3], the morphology of epoxy–thiol networks has received comparatively less attention—particularly with regard to stoichiometry, processing conditions, and their thermomechanical properties. This study used transmission electron microscopy (TEM) to conduct an in-depth morphological characterisation of stoichiometric and off-stoichiometric epoxy–thiol thermosetting systems. Furthermore, dynamic mechanical analysis (DMA) and tensile testing were employed to systematically investigate the thermomechanical behaviour of these systems, thereby providing deeper insight into the correlations between their morphological structure and resulting material properties. Particular emphasis was placed on the influence of polythiol content, as variations in this parameter can induce the formation of distinct nanostructured morphologies. Interestingly, offstoichiometric formulations, defined by reduced polythiol content and concurrent epoxy homopolymerisation, exhibit elevated glass-transition temperatures and enhanced toughness[4], as corroborated by the corresponding morphological analysis.

This work presents a comprehensive microscopic characterisation of epoxy–thiol thermosets, elucidating the interplay between network morphology, macroscopic properties, and processing conditions, and thereby providing a basis for the rational design of optimised formulations.

References

(1) S. B. Acar & M. A. Tasdelen Thiol-epoxy click chemistry in polymer science. *Journal of Macromolecular Science*, Part A, **2026**, 63:2, 91-100. DOI: 10.1080/10601325.2025.2598333

(2) F. Meng et Al. Nanostructured Thermosetting Blends of Epoxy Resin and Amphiphilic Poly(ε-caprolactone)-block-polybutadiene-block-poly(ε-caprolactone) Triblock Copolymer. *Macromolecules*, **2006**, 39, 711-719. DOI: 10.1021/ma0518499

(3) R. Mezzenga et Al. Morphology build-up in dendritic hyperbranched polymer modified epoxy resins: modelling and characterization. *Polymer*, **2001**, 42 305-317. DOI: 10.1016/S0032-3861(00)00307-4

(4) Xavier Fernández-Francos et Al. Sequential curing of off-stoichiometric thiol–epoxy thermosets with a custom-tailored structure. Polymer Chemistry, **2016**, 7, 2280–2290. DOI: 10.1039/C6PY00099A

OP 3: 3D Printing Complex Anisotropic Cellulose Hydrogel Structures Using Sacrificial Support Systems

Daniel Pint, **Tobias Steindorfer, Florian Lackner, Tamilselvan Mohan, Rupert Kargl, and Karin Stana Kleinschek**

Institute of Chemistry and Technology of Biobased Systems (IBioSys), Graz University of Technology, Stremayrgasse 9, 8010 Graz, Austria; e-mail: pint@tugraz.at

Three-dimensional (3D) printing of hydrogels has enabled new directions in biomedical engineering, soft material design, and biofabrication. However, unsupported hydrogel inks often collapse under their own weight or deform during printing, limiting achievable geometries.[1,2] We present a reproducible, standardized support system combining a nanofibrillated cellulose/sodium alginate (NFC/ALG) structural ink with a cellulose-based sacrificial support ink composed of NFC, hydroxyethylcellulose (HEC) and $CaCl_2$, building on established NFC-based hydrogel systems and support-assisted printing concepts, shown in Figure 1.[3,4] Quantitative validation using tubular models shows that unsupported tubes collapse before 50 mm height, whereas supported tubes remain upright and stable. Surface fidelity is substantially improved by reducing layer height, yielding watertight prints. Demonstrations of complex geometries, including an anatomical aorta, confirm the method's capability. Support dissolution in 30 mM $CaCl_2$ occurs over approximately 3 days, ensuring stability during crosslinking and handling. Compared with other sacrificial strategies, this approach is inexpensive, cellulose-based, and relies on mild ionic crosslinking compatible with future cell-laden systems. This work provides a robust and accessible hydrogel engineering system, supporting stable and high-fidelity DIW of complex anisotropic structures.

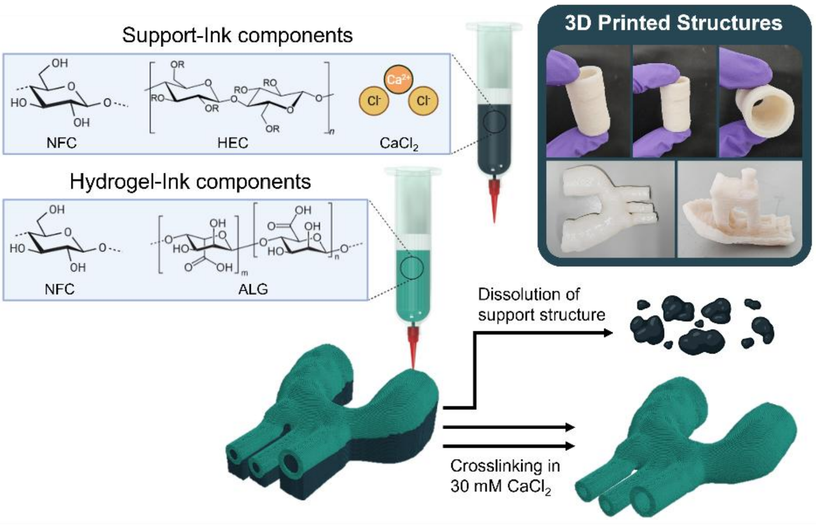


Figure 1: Cellulose-based sacrificial support enables stable printing of complex hydrogel architectures.

Acknowledgement

This research project (grant number: 911658) was funded by COMET – Competence Centers for Excellent Technologies – through BMIMI, BMWET, and the co-financing federal provinces (Styria through SFG, Upper Austria, Vorarlberg) and carried out with the participation of scientific and company partners. The COMET program is managed by FFG.

References

(1) F. Lackner, et al., Advanced Materials Technologies, 2023, 8, 2201708. DOI: 10.1002/admt.202201708

(2) Skylar-Scott et al., *Science Advances,* 2019, 5, eaaw2459. DOI: 10.1126/sciadv.aaw2459

(3) T. J. Hinton, et al., *Science Advances,* 2015, 1, e1500758. DOI: 10.1126/sciadv.1500758

(4) K. Markstedt, et al., *Biomacromolecules* 2015, 16, 1489. DOI: 10.1021/acs.biomac.5b00188

OP 4: Circular biopolymer economy: Simulation-assisted modelling of chemical recycling towards a green BIOCYCLE

Dominik Wielend*[1], Katharina Kelderer[1,2,3], Norbert Hohenauer[1,2,4], Michael Egermeier[5], Markus Wierer[3], Gunnar Spiegel[1], Markus Himmelsbach[3], Christian Paulik[1,2]

[1]Competence Center CHASE GmbH, 4020, Linz, Austria
[2]Institute for Chemical Technology of Organic Materials, Johannes Kepler University, 4040, Linz, Austria
[3]Institute of Analytical and General Chemistry, Johannes Kepler University, 4040, Linz, Austria
[4]New address: Department of Chemistry, Ludwig-Maximilians-University Munich, 81377, Munich, Germany
[5]Wood K plus – Kompetenzzentrum Holz GmbH, 4040 Linz, Austria
** dominik.wielend@chasecenter.at*

Polymers are a key material class nowadays in industry, construction, medicine and packaging. However, they also possess drawbacks regarding microplastics, single-usage and low biodegradability. Bio-polyester like polyhydroxyalkanoates (PHA) are a promising class of biooriginated and bio-degradable polymers, which could address these problems of commodity polymers.[1]

Understanding the mechanism and kinetics of biopolymer degradation is the key-step within chemical recycling. Using polyhydroxybutyrate (PHB) as a case study, we developed a new probability mass function for modelling the kinetic of a random scission process of PHB hydrolysis. A validated key-assumption is, that oligomers with six or fewer repeating units are water-soluble and represent the effective depolymerization yield. Using our model, which combines a function for conversion and pseudo second order kinetics, we are able to accurately predict the yield of our PHB hydrolysis experiments.[2] Furthermore, the decarboxylation side reaction was studied, yielding results in accordance with literature by Li & Strathmann.[3]

In addition to the simulation-based yields of each oligomer fraction, we developed a fractionation method to experimentally separate and analyze the hydrolysate. Based on this innovative approach, we were able to quantify the hydrolysate composition of oligomers and monomers and directly compare it to our simulation results.

Closing the loop towards a full life circle of biopolymers, the water-soluble hydrolysates were successfully investigated as carbon source for microbial fermentation of PHB. This connection between deep understanding of depolymerisation with microbial polymerisation approaches is a key aspect within the project partners of the Biocycle UA-II project.

Acknowledgement

This work was conducted within the cooperative research project “BIOCYCLE-UA II | Kreislaufwirtschaft am Beispiel von ausgewählten Biopolymeren (Herstellung-Verarbeitung-Recycling)”, co-funded by the European Union and the Federal Province of Upper Austria within the IBW/EFRE & JTF 2021-2027 program „Investitionen in Beschäftigung & Wachstum/EFRE & JTF 2021-2027", https://www.efre.gv.at/

References

(1) Clarke, R. W.; Rosetto, G.; Uekert, T.; Curley, J. B.; Moon, H.; Knott, B. C.; McGeehan, J. E.; Knauer, K. M. Polyhydroxyalkanoates in Emerging Recycling Technologies for a Cir-cular Materials Economy. Mater. Adv. 2024, 5 (17), 6690–6701. https://doi.org/10.1039/D4MA00411F.

(2) Hohenauer, N.; Wielend, D.; Kelderer, K.; Holzinger, J.-M.; Spiegel, G.; Schwarzinger, C.; Paulik, C. From Simulation to Distribution: A Novel Approach to Depolymerization Kinetics Using PHB Hydrolysis as a Case Study. Polymer Degradation and Stability 2026, 246, 111949. https://doi.org/10.1016/j.polymdegradstab.2026.111949.

(3) Li, Y.; Strathmann, T. J. Kinetics and Mechanism for Hydrothermal Conversion of Polyhydroxybutyrate (PHB) for Wastewater Valorization. Green Chem. 2019, 21 (20), 5586– 5597. https://doi.org/10.1039/c9gc02507c.

OP 5: Atmospheric Water Harvesting: Can Sulfur be the Solution?

Joseph J. Dale[1]

Institute of Materials Chemistry and Research, Faculty of Chemistry, University of Vienna, Währinger Straße 42, 1090, Vienna, Austria

A lack of access to global clean water is leading to a water crisis.[1] United Nations Sustainable Development Goal 6 states that we must "…achieve universal and equitable access…" to clean drinking water by the year 2030.[2] The atmosphere contains 6x the liquid volume of water as all the freshwater sources on Earth combined.[3] Tapping the natural water reserves of the atmosphere is the next step to provide clean water to all. **Atmospheric water harvesting (AWH)** materials are hydrophilic structures, capable of adsorbing moisture from the atmosphere for collection and consumption.[4]

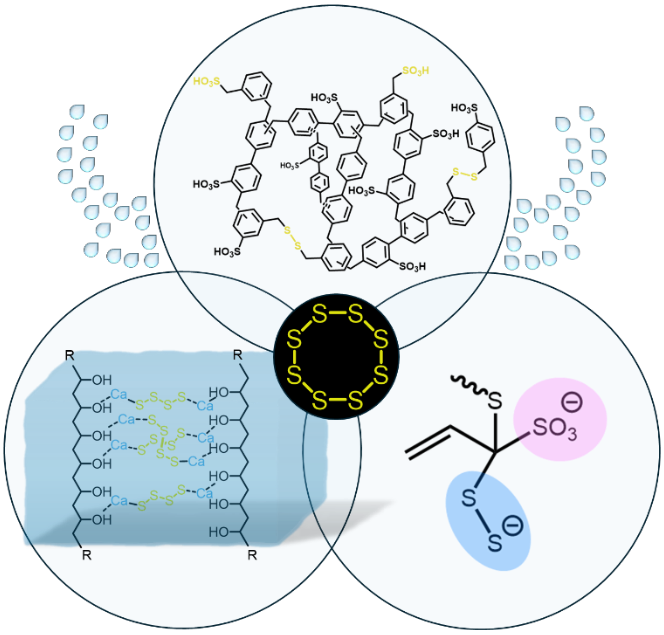


Figure 1. A collection of materials, prepared from elemental sulfur waste or using sulfur chemistry, for AWH.

Sulfur, extracted from the desulfurisation of crude oil, collects in quantities in excess of 7 tonnes per annum as waste.[5] The chemistry of sulfur can introduce interesting new properties and characteristics to AWH materials. Disulfide cleavage drives reversible structural rearrangement upon water sorption.[6] Base-stimulated sulfur ring-opening converts hydrophobic sulfur to hydrophilic metal polysulfides, used to synthesise AWH polymers[7] and hydrogels.[8] Thiol self-condensation can prepare polymer scaffolds for hydrophilic metal moieties at room temperature in minutes. Here, we blend sulfur - a hydrophobic material - with the field of AWH, to design and enhance materials for the future of water harvesting. We present a catalogue of sulfur-containing polymer and hydrogel materials (**Figure 1**) with impressive AWH properties. Sulfur chemistry proves capable of introducing new characteristics and properties to materials to address problems such as waste and water management.

Acknowledgement

Mathilde Gerbaud, Paul Schweng, Martin W. Smith, Tom Hasell, Robert T. Woodward

References

(1) J. Lee et al., Progress in Disaster Science, 2020, 8, 100123.

(2) Sustainable Development Goals, United Nations, https://www.un.org/sustainabledevelopment/water-and-sanitation/, Accessed 19/06/2025.

(3) P. Gleick, In Water in Crisis: A Guide to the World’s Fresh Water resources, Oxford University Press, Oxford, 1993, pp. 13–24.

(4) X. Zhou et al., ACS Materials Lett., 2020, 2, 671−684.

(5) W. J. Chung et al., Nat. Chem. 2013, 5, 518.

(6) J. J. Dale et al., Small, 2026, e73271

(7) J. J. Dale et al., Adv. Func. Mater., 2024, 34 (24), 2314567.

(8) J. J. Dale et al., Small Methods, 2025, 9 (12), e01244.

OP 6: Wavelength-Orthogonal Control of Thiol–Ene Reactions: Inhibition and Reactivation

Julian Maier[1], Rita Höller[1], Thomas Grießer[1]

[1]Chair of Chemistry of Polymeric Materials, Technical University of Leoben.

Corresponding author: Julian.maier@unileoben.ac.at

The growing demand for precise and efficient fabrication techniques has led to increased interest in light-induced reactions in polymer science due to their good spatial and temporal control. Light as stimulus also provides an additional layer of control through wavelength selective activation of chemical reactions, allowing different processes to be triggered depending on the applied wavelength. Wavelength selectivity can generally be classified into three categories: synergistic, antagonistic and orthogonal systems.[1]

In antagonistic interactions, one wavelength initiates a reaction while the other wavelength quenches the reaction initiated by the first wavelength. In a previous study, antagonistic photochemical control is successfully applied to thiol-ene polymerization. In the investigated resin system, consisting of pentaerythritol-tetrakis(3-mercaptopropionat) and triallyl-triazine-2,4,6(1H,3H,5H)-trione, radical curing is activated by a type II photoinitiator at 450 nm, while light at 365 nm is used to photorelease a base, resulting in an inhibition of the curing reaction.[2]

In this contribution, two strategies are introduced to overcome this inhibition enabling reactivation of the suppressed thiol-ene reaction. In the first approach, the reaction is reinitiated by irradiation with UV light at 254 nm, which directly generates thiyl radicals from mercapto monomers and thereby restores radical propagation. The second pathway relies on the neutralization of the photogenerated base by vapours of acid. Reaction kinetics were monitored by infrared spectroscopy, demonstrating successful reactivation of the previously inhibited reaction pathways.

References

(1) Eren, T. N.; Feist, F.; Ehrmann, K.; Barner-Kowollik, C. Kooperative Netzwerkbildung mittels zweifarben Aktivierung von λ-orthogonalen Chromophoren. Angew. Chem. 2023, 135 (36), e202307535. DOI: 10.1002/ange.202307535.

(2) Höller, R. J.; Sivun, D.; Gvindzhiliia, G.; Müller, S. M.; Haiden, L.; Klar, T. A.; Jacak, J.; Schlögl, S.; Griesser, T. Spatial control of curing kinetics in thiol-ene-systems through antagonistic photoreactions. Nature Communications 2025, 16 (1), 8487. DOI: 10.1038/s41467-025-63407-0.

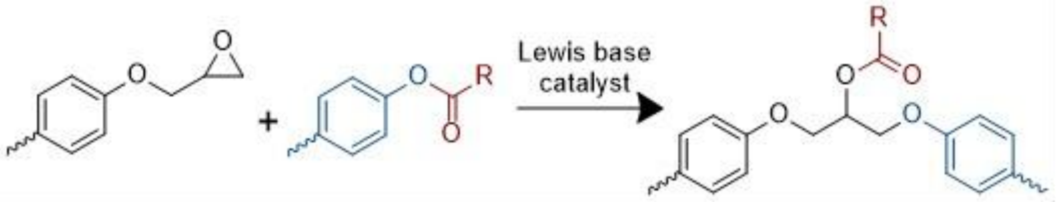
OP 7: Active Ester Curing of Epoxides Producing Low-Dielectric Thermosets

Peter Weiss[1,2], David Schuster[1,2], Christian Slugovc[1,2]*

[1] *Institute for Chemistry and Technology of Materials, Technische Universität Graz,*
Stremayrgasse 9, 8010 Graz, Austria

[2] *Christian Doppler Laboratory for Organocatalysis in Polymerization,*
Stremayrgasse 9, 8010 Graz, Austria

Epoxy resins are important materials used in a variety of applications due to their excellent mechanical, thermal, and electrical properties. The curing process, whereby the resin is transformed into a solid material, is an important processing step in which curing agents react with the epoxides and influence their properties. For use in castings and encapsulations, good thermal properties, stability for mechanical processing and electrical properties, enabling insulation, are needed. The most commonly used curing agents for this purpose are anhydrides, bearing some ecological drawbacks, such as long curing cycles at high temperatures. [1] Additionally, anhydrides entail certain hazards, making them the focus of potential prohibition measures and regulatory provisions. To overcome these issues active esters can be used as curing agents to produce epoxy thermosets. Model reactions to determine the mechanism of these reactions delivered promising results, particularly with regard to the modification of the polymer backbone by the type of active ester used. [2]



Picture 1: Scheme for the epoxy ester curing reaction.

In this work we present results that contribute to identifying influences on dielectric and thermal properties of epoxy materials, focusing on DGEBA, the most commonly used epoxide in industry. The selection of curing agents significantly influences the curing kinetics and final properties of the epoxy resin. Additionally, varying the ratio of epoxide to curing agent results in different products obtained from the same starting materials. Comparing the two organic Lewis base catalysts, 1-methylimidazole (1-MI) and 4-dimethylaminopyridine (DMAP), we observed an influence on the effectiveness of the curing process and the dielectric properties of the products. These properties are also influenced by the amount of catalyst used in the reaction.

References

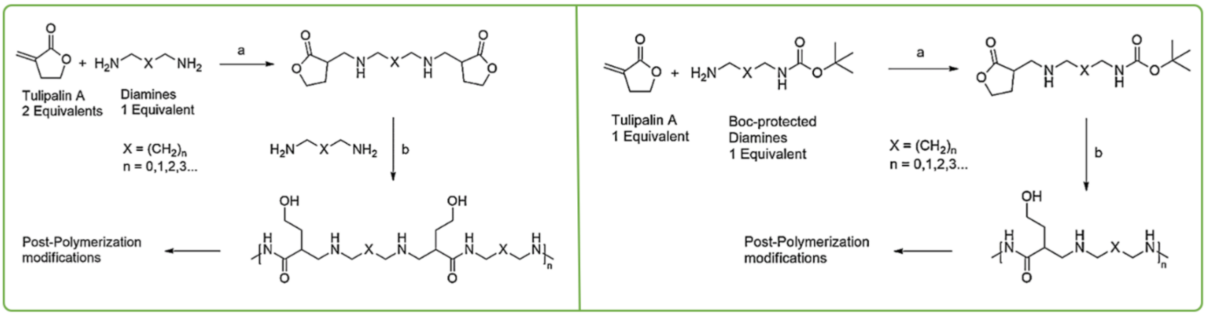
(1) Pham, H. Q.; Marks, M. J., Epoxy Resins, Ullmann's Encyclopedia of Industrial Chemistry 2005, 13, 155-244. DOI: 10.1002/14356007.a09_547.pub2.

(2) Chen, C. H.; Gu, Z. C.; Tsai, Y. L.; Jeng, R. J.; Lin, C. H. Identification of the reaction mechanism between phenyl methacrylate and epoxy and its application in preparing low-dielectric epoxy thermosets with flexibility. Polymer 2018, 140, 225-232 -. DOI: 10.1016/j.polymer.2018.02.045.

OP 8: Functional Poly(amidoamine)s from Tulipalin A

Muhammed Muhsin Puzhakkalakath[1], **Sambit Kumar Lenka**[1], **Jaroslav Mosnacek**[1]
[1]*Polymer Institute SAS, Bratislava, Slovakia*

Poly(amidoamine) polymers, particularly linear poly(amidoamine)s (PAAs) and poly(amidoamine) dendrimers (PAMAM), are an important class of polymers with significant demand due to their extraordinary applications in biomedical and materials science.1 However, their synthesis has traditionally relied on petrochemical-based monomers, raising concerns regarding sustainability and long-term environmental impact. This work explores the design and synthesis of functional linear poly(amidoamine)s with well-defined repeating units by replacing petrochemical monomers with biobased Tulipalin A (α-methylene-γ-butyrolactone, MBL) and diamines. Tulipalin A, a naturally occurring α,β-unsaturated lactone found in tulip species, offers a promising renewable alternative to conventional vinyl and acrylate monomers.2 A combinatorial library of poly(amidoamine)s was synthesized by varying diamines. The resulting polymers bear pendant hydroxyl groups and backbone secondary amine functional groups, providing rich potential for post-polymerization modifications. The effects of chemical structure and molecular characteristics on thermomechanical properties were investigated.



Picture 1: Synthesis of poly(amidoamine)s via head-to-head and head-to-tail approaches.

Acknowledgement

The authors thank the financial support through the project APVV-23-534.

References

(1) Ferruti, P. Poly(Amidoamine)s: Past, Present, and Perspectives. *J. Polym. Sci. Part A: Polym. Chem.* **2013**, *51* (11), 2319–2353. https://doi.org/10.1002/pola.26632.

(2) Kollár, J.; Danko, M.; Pippig, F.; Mosnáček, J. Functional Polymers and Polymeric Materials From Renewable Alpha-Unsaturated Gamma-Butyrolactones. *Front. Chem.* **2019**, *7*, 845. https://doi.org/10.3389/fchem.2019.00845.

OP 9: Investigating sustainable functional polyester materials

Anna Kruglhuber*, **Klara M. Saller, Clemens Schwarzinger**

Institute for Chemical Technology of Organic Materials, Johannes Kepler University Linz

Altenberger Straße 69, 4040 Linz, Austria

**anna.kruglhuber@jku.at*

Functional polymers are vastly important to a broad range of product categories, yet they are often based on petrochemical resources. As climate change and pollution pose ever-increasing problems for society, a transition to more sustainable solutions is essential. Polyesters are promising alternatives to current materials as many bio-based and renewable educts can be implemented. Further, especially for aliphatic polyesters, biodegradability is a viable characteristic[1]. The current research project focuses on the development of functional polyesters using citric acid (CA), malic acid (MA), and tartaric acid (TA)[2].

All three acids are easily available renewable resources that are characterized by their multifunctionality, as illustrated in Figure 1. This allows synthesizing polyesters with free carboxy or hydroxy groups that provide options for functionalization and tuning of polyester properties. However, depending on the specific monomers and reaction conditions, gelation of the reaction mass is a frequently occurring behaviour after a certain reaction time. Therefore, optimized synthesis strategies are required to achieve high molecular weights without inducing too much crosslinking[3]. The polyesters are characterized *via* (quantitative) ^{1}H and ^{13}C nuclear magnetic resonance spectroscopy (NMR), whereby the conversion can be determined (Figure 1). Size exclusion chromatography (SEC) is employed to monitor molecular weights, and structures are elucidated with mass spectrometry.

The currently investigated materials show promising characteristics concerning hydrophilicity, that must be investigated in more depth. Both the synthesis procedure as well as characterization methods for polyesters and polyester networks are continuously being optimized, to hopefully yield a basis for functional materials in the near future.

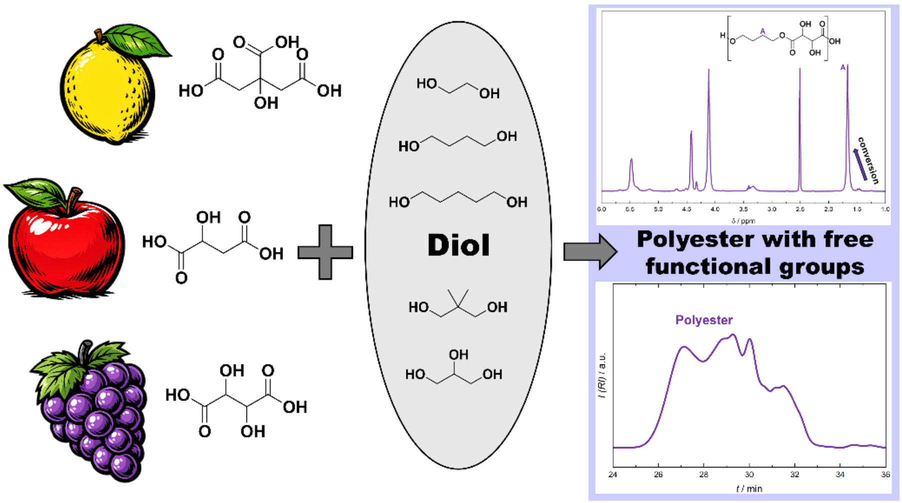


Figure 1: Schematic representation of functional polyester synthesis based on citric acid, malic acid, and tartaric acid.

References

(1) Zhang, Q.; Song, M.; Xu, Y.; Wang, W.; Wang, Z.; Zhang, L. Bio-based polyesters: Recent progress and future prospects. *Progress in Polymer Science* **2021**, *120*, 101430. DOI: 10.1016/j.progpolymsci.2021.101430.

(2) Kruglhuber, A.; Bernhard, C.; Boye, S.; Wierer, M.; Lederer, A.; Schwarzinger, C.; Saller, K. M. Synthesis of Functional Water-Soluble Polyesters Based on Citric Acid and Dimethylolpropionic Acid. *ACS polymers Au* **2026**, *6* (2), 610–621. DOI: 10.1021/acspolymersau.5c00196.

(3) Shan, P.; Lian, X.; Lu, W.; Yin, X.; Lu, Y.; Zhang, M.; Wen, X.; Xin, G.; Li, Z.; Li, Z. Direct Synthesis of Aliphatic Polyesters with Pendant Hydroxyl Groups from Bio-Renewable Monomers: A Reactive Precursor for Functionalized Biomaterials. *Biomacromolecules* **2023**, *24* (6), 2563–2574. DOI: 10.1021/acs.biomac.3c00064.

OP 10: Surface Engineering of Photopolymers for Nucleic Acid Biosensing Applications

Sara Salehi Siouki[1], Jan Hesse[2], Jinhong Wang[1], Michael Haas[3], Sandra Schloegl[1], Thomas Griesser[1]

[1]Institute of Chemistry of Polymeric Materials. Technical University of Leoben, Austria,
[2]Institute for Sensors, Photonics and Manufacturing Technologies, Joanneum Research Forschungsgesellschaft-mbH, Austria,
[3]Institute of Inorganic Chemistry, Graz University of Technology, Austria.

DNA-based biosensors can function as lab-on-a-chip devices for rapid point-of-care analysis, but their performance depends on stable and controlled immobilization of DNA probes on polymer surfaces.[1]

In this study, physical and covalent strategies for attaching short DNA probes to photocurable polymer substrates were investigated, with emphasis on thiol-based chemistry and polyethyleneimine-mediated surface activation. Resin formulations and processing conditions were optimized to preserve reactive surface functionality and maximize probe density. Polycation modification enabled electrostatic adsorption of nucleic acids. Alternatively, covalent attachment was achieved through thiol–ene reactions between model thiols and surface vinyl groups. Thiol-ended DNA was then used for stable biofunctionalization of the photopolymer surface. DNA immobilization was confirmed by X-ray photoelectron spectroscopy and fluorescence microscopy, which showed probe coverage and surface binding.

Acknowledgement

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the granting authority European Union's Horizon Europe research and innovation programme. Neither the European Union nor the granting authority can be held responsible for them. The DECIPHER project has received funding under the Horizon Europe research and innovation programme, (the grant agreement No.101137242).

References

(1) Shepherd, S.; Tibbs, J.; Bhaskar, S.; Bala, Z.; Ayupova, T.; Akin, L. D.; Liu, W.; Monaco, M. H.; Donovan, S. M.; Cunningham, B. T. Oligonucleotide surface attachment by tosylation for digital detection of microRNA using photonic resonator absorption microscopy. APL Bioeng. 2025, 9 (4), 46108. DOI: 10.1063/5.0290900.

OP 11: Opportunities and Challenges of Acrylates and Methacrylates in Epoxy-Amine Covalent Adaptable Networks

Johanna Lang[1], Christian Slugovc[1]

[1] *Institute for Chemistry and Technology of Materials, Graz University of Technology, Stremayrg. 9, 8010 Graz, Austria*

Epoxy thermosets are essential for high-demand composite applications due to their outstanding thermal and mechanical performance. However, their structural stability leads to problems concerning recycling. The incorporation of dynamic covalent bonds into the network facilitates reprocessing, making the materials more sustainable.[1] A recently introduced way to make epoxy-amine based thermosets reprocessable, is the addition of (meth)acrylates, which form β-amino ester bonds within the network via the aza-Michael reaction. The dynamic potential of β-amino esters has been reported by du Prez et al.[2]

Since methacrylates are less toxic than acrylates, it is advantageous to substitute the latter whenever possible.[3] However, they are also less reactive in aza-Michael reactions, so the methacrylate under study has an additional hydroxyl group to increase the amount of proton donors in the system, which could potentially increase the reactivity. Therefore, this research combines the epoxy-amine, Aza-Michael and epoxy-alcohol reactions to obtain a low viscous formulation with covalent adaptable network (CAN) properties once cured.

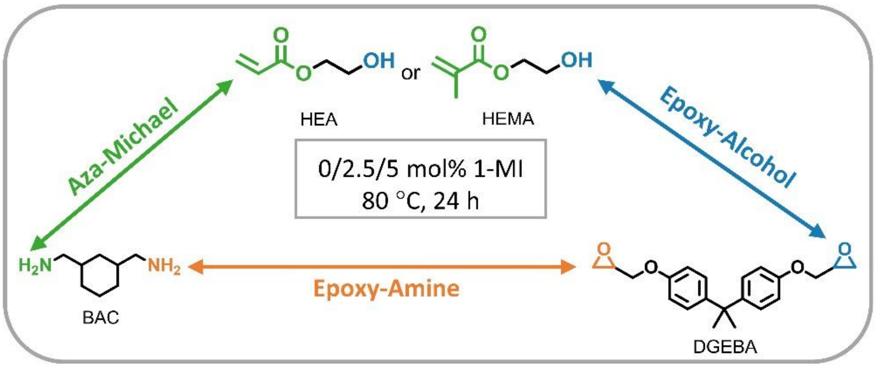


Figure 1: Monomers and curing conditions for epoxy-amine-(meth)acrylate CANs.

The importance of 1-methylimidazole (1-MI) as a catalyst for the epoxy-alcohol reaction is demonstrated. ATR-IR reaction monitoring of the Aza-Michael reaction between 1,3-Bis(aminomethyl)cyclohexan (BAC) and 2-hydroxyethyl acrylate (HEA) and 2-hydroxyethyl methacrylate (HEMA) confirmed that the methacrylate reacted more slowly than its acrylic counterpart. This resulted in a lack of reworkability because the methacrylate groups did not contribute significantly to the network formation. In contrast, acrylate-based networks were remouldable, with glass transition temperatures above 75 °C. The stress relaxation behaviour and changes in the material during rheological investigations were examined. Finally, the thermal stability and decomposition products showed potential limitations of the material.

References

(1) S. M. Fischer, I. De Baere, L. T. Nguyen, H. Stecher, W. Van Paepegem, F. E. Du Prez, *Macromolecules* **2025**, 58, 7948. DOI: 10.1021/acs.macromol.5c00958

(2) C. Taplan, M. Guerre, F. E. Du Prez, *J. Am. Chem. Soc.* **2021**, 143, 9140. DOI: 10.1021/jacs.1c03316

(3) C. Ivaldi, E. Laguzzi, V. M. Ospina, D. Antonioli, R. Chiarcos, F. Campo, N. Cuminetti, J. de Buck, M. Laus, *Polymer* **2024**, 293, 126636. DOI: 10.1016/j.polymer.2023.126636

OP 12: Robust, Air-Stable, and Reusable: An Ir_2(i,iii) Hydride Catalyst for Homogeneous Alkane Dehydrogenation

Sebastian Hummer,[1] **Robert T. Woodward**,[1] **Alexander Bismarck**,[1,2] **Philip Verdross**[1]

[1]*Institute of Material Chemistry and Research, Faculty of Chemistry, University of Vienna, Währinger Strasse 42, 1090 Vienna, Austria*
[2]*Department of Chemical Engineering, Imperial College London, South Kensington Campus, London, SW7 2AZ, United Kingdom*

The efficient homogeneous dehydrogenation of alkanes is challenging, due to a lack of stable, recoverable, and yet reactive catalytic compounds.[1,2] We report a binuclear iridium-hydride catalyst for acceptorless and transfer dehydrogenation reactions of alkanes (**Figure 1**). The title compound was obtained in 69% yield over two synthetic steps, is air stable, and can be reused upon precipitation from a reaction mixture. Turnover numbers (TONs) for the dehydrogenation of cyclododecane and n-hexadecane at 220 °C in an acceptorless approach are 9 ± 0.8 and 4 ± 0.5, respectively, while in transfer dehydrogenation, TONs of 80 ± 6 and 13 ± 2, and turnover frequencies (TOFs) of 3.3 and 0.6 h^{-1} were determined at the same temperature.

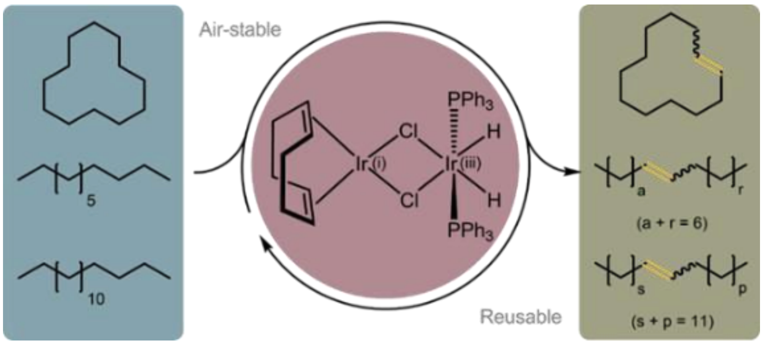


Figure 1: Possible substrates for dehydrogenation reaction

Acknowledgement

This work received funding from the European Union under the DCDYNAMIC project (Grant no. 101172817). Views and opinions expressed are, however, those of the author(s) only and do not necessarily reflect those of the granting authorities. Neither the European Union nor any granting authority can be held responsible for them.

References

(1) Wiebus, E.; Cornils, B. Die Großtechnische Oxosynthese Mit Immobilisiertem Katalysator. Chemie Ingenieur Technik 1994, 66 (7), 916–923. https://doi.org/10.1002/cite.330660704.

(2) Keim, W. Oligomerization of Ethylene to α-Olefins: Discovery and Development of the Shell Higher Olefin Process (SHOP). Angew Chem Int Ed 2013, 52 (48), 12492–12496. https://doi.org/10.1002/anie.201305308.

OP 13: From commodity to high-performance: Next-generation hyperbranched polyethylene materials for additive manufacturing

Vojtěch Musil[1], Dominik Laa[2], Jürgen Stampfl[2], Jan Merna[3], Robert Liska[1], Katharina Ehrmann[1]

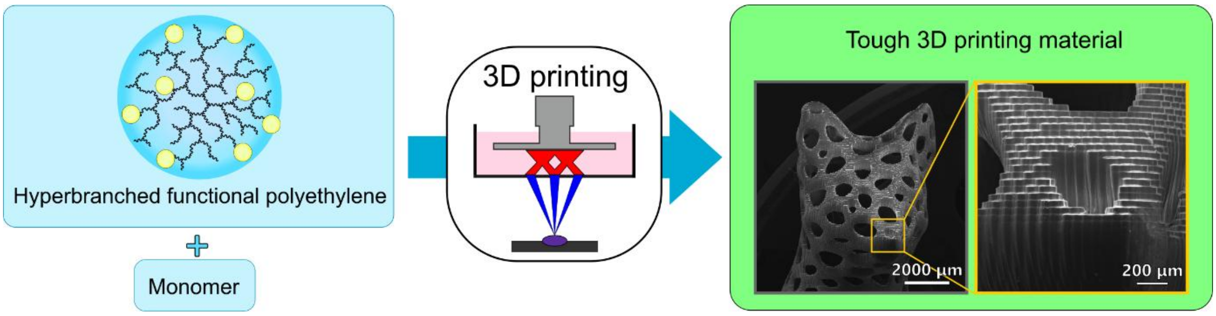
[1]Institute of Applied Synthetic Chemistry, Technische Universität Wien, Vienna, Getreidemarkt 9BE, Vienna 1060, Austria

[2]Institute of Materials Science and Technology, Technische Universität Wien, Getreidemarkt 9BE, Vienna 1060, Austria

[3]Department of Polymers, University of Chemistry and Technology, Prague, Technická 5, Prague 6, 166 28, Czech Republic

Additive manufacturing remains constrained by material limitations in performance, processability, and functional versatility. This work introduces hyperbranched polyethylene-based performance modifiers synthesized via *α*-diimine chain-walking catalysis, where the chain-walking mechanism enables precise control over branching architecture while the catalysts' exceptional polar group tolerance facilitates functionalization and reactivity tuning through copolymerization with polar monomers.[1]

The resulting modifiers deliver significant thermomechanical enhancements while introducing multiple functional capabilities. These include photoinitiation for rapid curing processes, in-situ crosslinking for improved mechanical properties, reactive dilution for optimized viscosity control, and shrinkage reduction to minimize warping effects. When incorporated into conventional polymer matrices, these hyperbranched modifiers transform conventional photopolymers into high-performance 3D printing materials that approach the properties of specialized engineering resins. This work establishes a catalyst-driven approach to molecular engineering that provides a scalable pathway for developing next-generation 3D printing materials with tailored properties for demanding applications.



Picture 1: Additive manufacturing of hyperbranched polyethylene formulation and example of a tough 3D printed object.

References

(1) Chen, Z.; Brookhart, M. Exploring Ethylene/Polar Vinyl Monomer Copolymerizations Using Ni and Pd α-Diimine Catalysts. *Accounts of Chemical Research* 2018, 51, 1831−1839. DOI: 10.1021/acs.accounts.8b00225

OP 14: 3D-printed APA-based photopolymers with tunable mechanical properties and surface erosion degradation

Mahsa Mostofizadeh[1], Ian Teasdale[2]
[1]Institute of Polymer Chemistry, Johannes Kepler University, Linz 4040, Austria

Additive manufacturing (AM) enables the fabrication of complex 3D biomaterials for applications such as drug delivery and tissue engineering. However, conventional acrylate-based photopolymers often generate cytotoxic residual monomers and form non-degradable backbones. In contrast, biodegradable polymers such as PLGA undergo bulk degradation, limiting precise control over drug release kinetics.

Amino acid phosphoramidate (APA) photomonomers provide a promising alternative, as they contain hydrolytically cleavable phosphorus–nitrogen bonds that degrade under physiological conditions into biocompatible phosphates and amino acids [1]. Notably, these systems exhibit surface erosion behavior, enabling predictable material degradation and improved control over release profiles.

In this work, APA-based photopolymers were developed with tunable mechanical properties, controlled degradation, and programmable drug release for photochemical 3D printing. APA monomers were synthesized by coupling selected amino acids to a phosphorus core and functionalized with photocurable groups such as vinyl esters, vinyl carbonates, or alkynes [2]. Polymer networks were formulated by varying amino acid substituents, comonomer composition, and thiol content to tailor crosslink density, hydrophilicity, and network architecture [3]. The materials were photopolymerized via UV curing and processed using 3D printing techniques (Figure 1a).

The resulting systems exhibited a broad range of mechanical properties, from stiff to soft elastic materials (Figure 1b). Degradation studies under physiological conditions (pH 7.4, 37 °C) revealed pronounced and tunable mass loss compared to PLGA (Figure 1c). Several formulations showed near-linear degradation profiles, indicating a surface erosion–dominated mechanism. The degradation rate was governed by amino acid structure, hydrophilicity, and crosslink density, while vinyl carbonate-based systems degraded more slowly than vinyl ester analogues due to their increased hydrophobicity. Time-dependent morphological changes further confirmed progressive surface erosion without bulk fragmentation (Figure 1c).

The combination of surface erosion, tunable network structure, and adjustable hydrophilicity enables precise control over drug release kinetics. In these systems, degradation directly governs release behavior, allowing sustained and predictable drug delivery while maintaining mechanical integrity (Figure 1d).

Overall, APA-based photopolymers represent a versatile platform for biodegradable, 3D-printable drug delivery systems. Their properties can be systematically tailored to achieve controlled mechanical performance, degradation, and release behavior, making them highly promising for advanced biomedical applications.

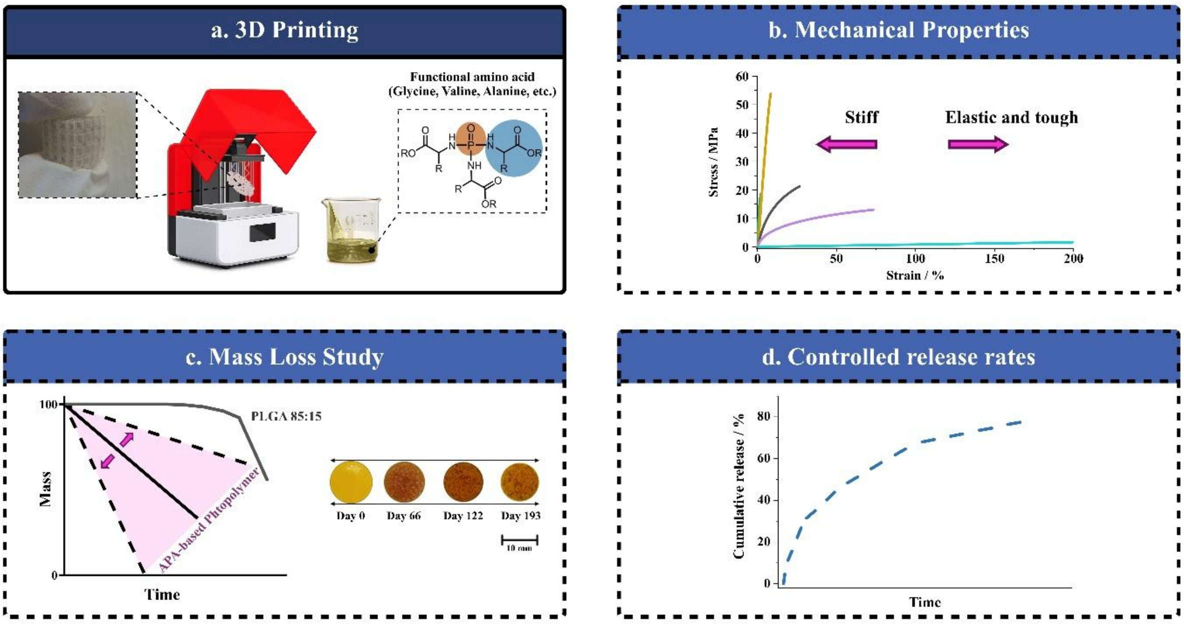


Figure 1: Overview of APA-based photopolymers: (a) Photochemical 3D printing of APA-based resins derived from amino acid phosphoramidates. (b) Tunable mechanical properties ranging from stiff to elastic and tough materials. (c) Mass loss profiles demonstrating surface erosion–dominated degradation behavior compared to bulk-degrading PLGA, supported by time-dependent morphological changes. (d) Controlled and sustained drug release enabled by near-linear degradation kinetics.

Acknowledgement

This work was supported by the ACCURE project, funded by the European Regional Development Fund (ERDF), Project ID ATCZ00083.

References

(1) Haudum, S; Lenhart, S.; Müller, S. M.; Tupe, D.; Naderer, C.; et al. Amino Acid-Based Polyphosphorodiamidates with Hydrolytically Labile Bonds for Degradation-Tuned Photopolymers. *ACS Macro Letters* **2023**, *12* (6), 673–678. DOI: 10.1021/acsmacrolett.3c00173

(2) Mostofizadeh, M; Kainz, M.; Alihosseini, F.; Haudum, S.; Youssefi, M.; Bauer, P.; et al. Phosphoramide Hydrogels as Biodegradable Matrices for Inkjet Printing and Their Nano-Hydroxyapatite Composites. *ACS Applied Material & Interfaces* **2024**, *16* (39), 52902–52910. DOI: 10.1021/acsami.4c10532

(3) Haudum, S; Demirdögen, B.; Müller-Müchler, L.; Döttl, S. C.; Müller, S. M.; Naderer, C.; et al. *European Polymer Journal* **2024**, *211*, 113037. DOI: 10.1016/j.eurpolymj.2024.113037

OP 15: PES-Membrane Meets polyHIPE

J. Jüstel [1,2], **A. Menner**[1] **& A. Bismarck** [1,3*]

[1]*Institute of Materials Chemistry and Research, Polymer and Composite Engineering (PaCE) Group, Faculty of Chemistry, University of Vienna, Währinger Straße 42, 1090, Vienna, Austria*

[2]*University of Vienna, Vienna Doctoral School in Chemistry (DoSChem), Währinger Str. 42, 1090 Vienna, Austria.*

[3]*Department of Chemical Engineering, Imperial College London, South Kensington Campus, London SW7 2AZ, U.K.*

**alexander.bismarck@univie.ac.at*

Membrane technology plays a vital role in filtration and separation processes, with polyethersulfone (PES) being one of the most used materials. PES membranes are valued for their excellent chemical stability and robustness, making them suitable for a range of filtration applications. However, their relatively low permeability and limited flexibility can restrict performance in more demanding conditions.[1] To address these limitations, polymerised High Internal Phase Emulsions (polyHIPEs) were used as support materials for PES membranes, offering a promising strategy for enhancing their properties.[2,3] PolyHIPEs based on polyurethane diacrylate (PUDA) provide high porosity, structural stability, and tunable mechanical properties, making them suitable for membrane applications.[4] Additionally, incorporating silica nanoparticles enables precise control of pore architecture, resulting in optimised polyHIPEs with high permeability, improved mechanical strength, and enhanced resistance to deformation.[5] This makes them a potential ideal membrane support. Therefore, we developed a flow cell which operates under dynamic flow conditions.

References

(1) Corvilain, M.; Klaysom, C.; Szymczyk, A.; Vankelecom, I. F. J. Formation Mechanism of sPEEK Hydrophilized PES Supports for Forward Osmosis. *Desalination* 2017, *419*, 29–38. https://doi.org/10.1016/j.desal.2017.05.037.

(2) Foudazi, R. HIPEs to PolyHIPEs. *React. Funct. Polym.* 2021, *164*, 104917. https://doi.org/10.1016/j.reactfunctpolym.2021.104917.

(3) Barkan-Öztürk, H.; Menner, A.; Bismarck, A. Emulsion-Templated Macroporous Polymer Micromixers. *Ind. Eng. Chem. Res.* 2021, *60* (39), 14013–14025. https://doi.org/10.1021/acs.iecr.1c01949.

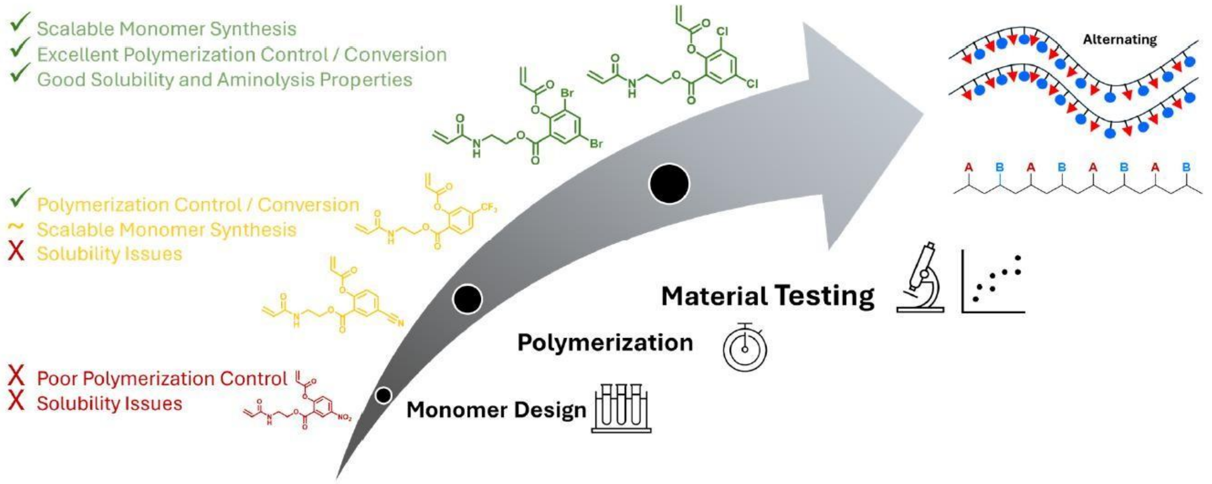
(4) Jiang, Q.; Menner, A.; Bismarck, A. Robust Macroporous Polymers: Using Polyurethane Diacrylate as Property Defining Crosslinker. *Polymer* 2016, *97*, 598–603. https://doi.org/10.1016/j.polymer.2016.05.071.

(5) Ikem, V. O.; Menner, A.; Horozov, T. S.; Bismarck, A. Highly Permeable Macroporous Polymers Synthesized from 7Pickering Medium and High Internal Phase Emulsion Templates. *Adv. Mater. Deerfield Beach Fla* 2010, *22* (32), 3588–3592. https://doi.org/10.1002/adma.201000729.

OP 16: Development and Synthesis scale-up of Template Monomers for AB-alternating Polyacrylamides

Maximilian Augustin, Klaus Bretterbauer
Johannes Kepler Universität Linz / Institut für Chemische Technologie Organischer Stoffe,
Altenberger Straße 69 4040 Linz, Österreich

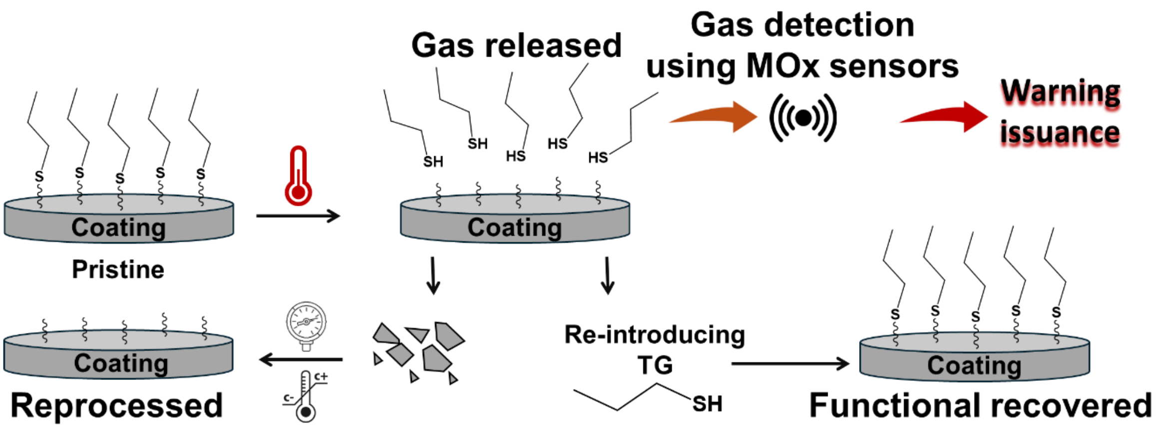
Sequence-controlled polymers hold great promise as functional materials, yet scalable synthetic routes remain a key challenge. Here, we present a versatile cyclopolymerization strategy for the synthesis of strictly AB-alternating polyacrylamides from divinyl monomers based on salicylic acid derivatives. Initial studies with a nitro-functionalized monomer revealed critical limitations: low conversion, poor solubility, and radical quenching — all of which compromised sequence fidelity. Guided by these findings, we designed a new generation of dichloro- and dibromo-substituted divinyl monomers, which exhibited superior stability, higher isolated yields, and minimal side reactions compared to previously reported analogues. Free-radical polymerization in 1,4-dioxane achieved conversions exceeding 90% within two hours, with balanced acrylate/acrylamide incorporation and no evidence of ester cleavage or residual vinyl groups — hallmarks of well-controlled cyclopolymer formation. Subsequent aminolysis delivered the target AB-alternating polyacrylamides, confirmed by ^{1}H-NMR, MALDI-TOF MS, DSC, and polarized optical microscopy. Characteristic mesomorphic transitions and distinct mass spectral distributions validate the strict alternating architecture. The halogenated monomers offer reliable scalability and robust control over polymer architecture. This work establishes an efficient synthetic platform for sequence-defined polyacrylamides with potential applications as functional binder materials in energy storage systems.



OP 17: Development of Thermo-Responsive Polythiourethane–Urethane Coatings for Enhanced Battery Safety

Van-Kien Hoang[1,2], Daniel Bautista[1,2], Gabriel Ferdigg[3], Sandra Schlögl[1,2]
[1]Polymer Competence Center Leoben GmbH, Sauraugasse 1, 8700 Leoben, Austria
[2]Chair of Chemistry of Polymeric Materials, Technical University of Leoben, Otto Glöckel-Straße 2, 8700 Leoben, Austria
[3]Virtual Vehicle Research GmbH, Inffeldgasse 21a, 8010 Graz, Austria

Enhancing safety measurements in battery systems remains critical due to accidents caused by hazardous failures such as overcharging, mechanical stress, short circuits, or external heat, which can lead to overheating and fire events. While recent research has been deeply focused on preventive measures[1], this study proposes a complementary precautionary approach by developing a thermo-responsive polythiourethane-urethane coating capable of releasing a tracer gas (TG) at well-defined temperatures (90–95 °C)[2]. The polymer matrix incorporates a thiol component that is cleaved and emitted in the gas phase during overheating events, enabling detection by metal oxide (MOx) sensors that trigger an alarm to signal a hazardous battery condition. To improve sustainability, the process is developed so that the coating can be functionally recovered by reintroducing the thiol compound into the polymer matrix. Afterwards, the obtained coatings showed gas release behavior comparable to the pristine one, as evaluated using quantitative methods such as thermogravimetric analysis and MOx sensor measurements, and qualitative characterization such as evolved gas analysis–mass spectrometry. Following gas release, the coatings can additionally be reprocessed and subsequently reused for further applications due to their network architecture based on dynamic covalent disulfide bonds. The reprocessed coatings were characterized using rheological techniques, including stress relaxation to demonstrate the effective exchange of disulfide bonds, and dynamic mechanical analysis for a better understanding of property evolution during the process.



Picture 1: Precautionary safety mechanisms in batteries and pathways for sustainable treatment, including reprocessing and functional recovery of coatings after gas release

Acknowledgement

This study was conducted as part of the following cooperative R&D projects.

COMET-Module Project BattLab (project no.: 904924), with contributions by Technical University of Leoben (Austria), Virtual Vehicle Research GmbH (Austria), hofer powertrain GmbH (Austria), Isovolta AG (Austria) and Resch GmbH (Austria) and the Polymer Competence Center Leoben GmbH (Austria). BattLab is funded within the COMET Competence Centers for Excellent Technologies Programme by the Austrian Federal Ministry for Innovation, Mobility and Infrastructure, the Austrian Federal Ministry for Economy, Energy and Tourism, and the province Styria and SFG. The COMET Programme is managed by FFG founded by the national funding institution for industry-related research and development (FFG) in Austria.

References

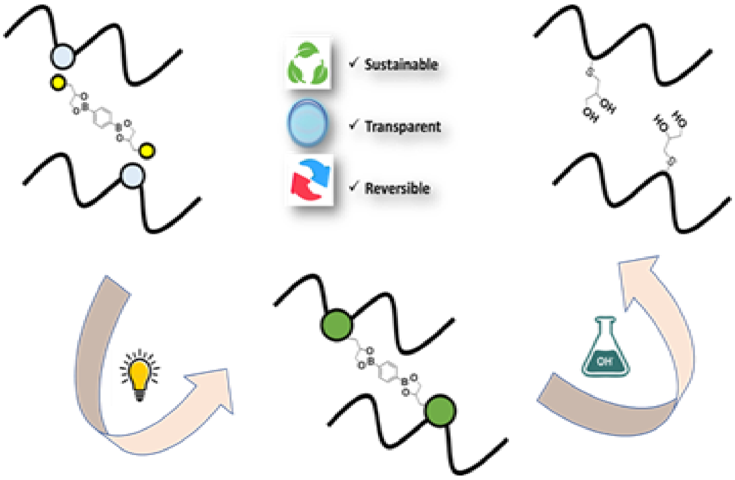
(1) Srinivasan, R.; Demirev, P. A.; Carkhuff, B. G.; Santhanagopalan, S.; Jeevarajan, J. A.; Barrera, T. P. Review—Thermal Safety Management in Li-Ion Batteries: Current Issues and Perspectives. J. Electrochem. Soc. 2020, 167 (14), 140516. DOI: 10.1149/1945-7111/abc0a5.

(2) Hoang, V.-K.; Bautista-Anguís, D.; Ferdigg, G.; Schlögl, S. Dynamic thermo-responsive polythiourethane–urethane coatings for enhanced energy storage safety. Polymer 2026, 349, 129758. DOI: 10.1016/j.polymer.2026.129758.

OP 18: Towards Circular Optoelectronics: Sustainable and Reversible Unsaturated Polyester Adhesives Via Photochemical Curing

Federico Guerrero-Ruiz[1], Anton Kirch[2], Ludvig Edman[2], Minna Hakkarainen[1]
1 KTH Royal Institute of Technology, Wallenberg Initiative Materials Science for Sustainability & Department of Fibre and Polymer Technology, 11428 Stockholm (Sweden)
2 Umeå University, Wallenberg Initiative Materials Science for Sustainability & Department of Physics,90187 Umeå (Sweden)

Light-emitting electrochemical cells (LECs) have emerged as key candidates for the next generation of optoelectronic devices. Due to their cost-effectiveness, high efficiency, air stability, and the absence of critical raw materials in their fabrication, they are positioned as a viable future alternative to traditional light-emitting diodes (LEDs) (1). Nevertheless, their current lack of recyclability remains a significant drawback. The urgent need for sustainable, transparent, and reversible adhesive has driven this work, in which an unsaturated polyester was synthesized and photocrosslinked with a dithiol via thiol-ene reaction. The resulting adhesive is transparent, fast-curing, and provides and effective oxygen barrier. In addition, by leveraging the dynamic nature of the boronic ester bonds within the dithiol structure, the LECs components were successfully recovered by immersing the device in a basic medium.



Acknowledgement

This work was supported by Wallenberg Initiative Materials Science for Sustainability (WISE) funded by the Knut and Alice Wallenberg Foundation.

References

(1) Kirch, A., Park, SR., Ràfols-Ribé, J., Kassel, JA., Zhang, X., Tang, S., Larsen, C., & Edman, L. Impact of the Electrode Material on the Performance of Light-Emitting Electrochemical Cells. ACS Applied Materials & Interfaces, 2025, 17 (3), 5184-5192

OP 19: All about that Base: Lewis Base Photobase Generators for Oxa-Michael based Photopolymers

Björn Schneider[1], **Klaus Ableidinger**[2], **Robert Liska**[1]

[1]*Institute of Applied Synthetic Chemistry, TU Wien, Getreidemarkt 9/163 1060 Vienna*

Photobase generators (PBGs) are compounds capable of releasing a free base upon irradiation. Their oxygen tolerance and non-corrosive nature make them a promising alternative to conventional radical photoinitiators and photoacid generators. However, the limited number of studies to date has constrained the development and broader application of PBGs.[1]

PBGs enable the light-induced polymerization of a wide range of monomers that were previously inaccessible to photochemical initiation, including certain step-growth polymerizations. These reactions yield homogeneous and mechanically robust photopolymers, which are particularly attractive for additive manufacturing technologies such as Stereolithography and Digital Light Processing.[1] In particular, the oxa-Michael polyaddition, initiated by highly active Lewis base catalysts released from PBGs (Figure 1), demonstrates strong potential as an alternative to established thiol-ene systems. Replacing thiols with alcohols in combination with electrophilic double bonds not only broadens the range of accessible monomer systems and enhances formulation storage stability, but also avoids the unpleasant odor typically associated with thiols.[2]

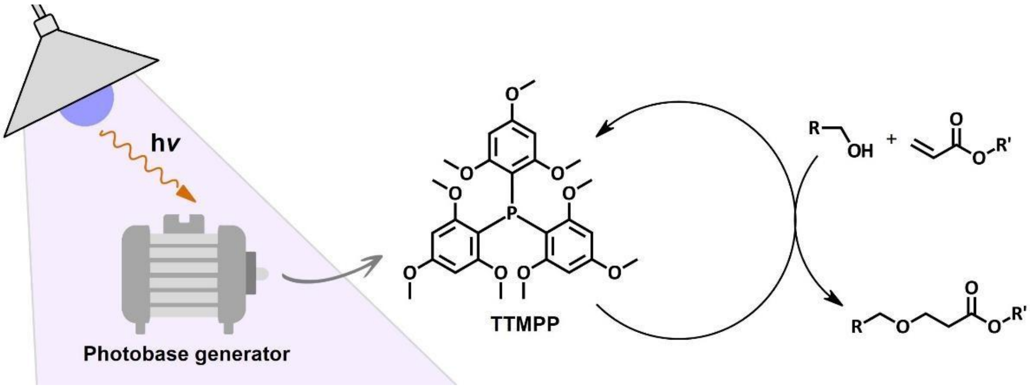


Figure 1. Schematic illustration of the working principle of the Lewis base PBG and the subsequent catalyzed oxa-Michael polyaddition.

Application of this system in heated vat polymerization (hot lithography) produces transparent, nearly colorless specimens with high resolution. Furthermore, adding suitable photosensitizers to the formulations enables their use in Two-Photon Polymerization (2PP), allowing the fabrication of microstructures.[3]

References

(1) Zivic, N.; Kuroishi, P. K.; Dumur, F.; Gigmes, D.; Dove, A. P.; Sardon, H. Recent Advances and Challenges in the Design of Organic Photoacid and Photobase Generators for Polymerizations. *Angewandte Chemie International Edition* **2019**, *58* (31), 10410-10422. DOI: https://doi.org/10.1002/anie.201810118.

(2) Ratzenböck, K.; Fischer, S. M.; Slugovc, C. Poly(ether)s derived from oxa-Michael polymerization: a comprehensive review. *Monatshefte für Chemie - Chemical Monthly* **2023**, *154* (5), 443-458. DOI: 10.1007/s00706-023-03049-4.

(3) Ableidinger, K.; Laa, D.; Chalupa-Gantner, F.; Gjata, E.; Knaack, P.; Ovsianikov, A.; Stampfl, J.; Slugovc, C.; Liska, R. Investigation of Lewis photobase-catalysed oxa-Michael addition for hot lithography. *Materials Horizons* **2025**, *12* (23), 10103-10111, 10.1039/D5MH01050K. DOI: 10.1039/D5MH01050K.

OP 20: Sustainable Rigid Polyurethane Foams from Tall Oil Fatty Acids for High-Performance Cryogenic Insulation

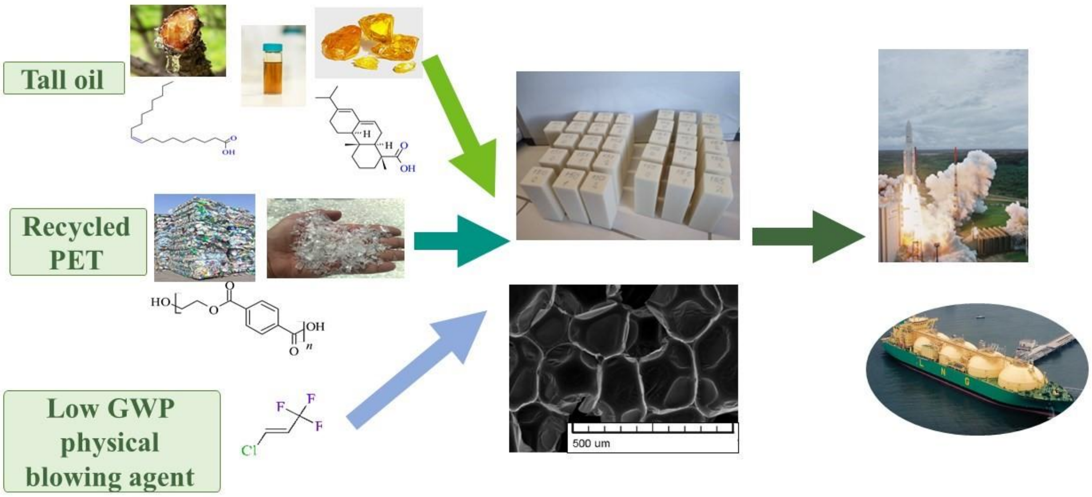
Laima Vevere, Vanesa Dhalivala, Beatrise Sture-Skela, Vladimir Yakushin, Ugis Cabulis

Latvian State Institute of Wood Chemistry, Dzerbenes street 27, Riga, Latvia

Cryogenic insulation is an essential and effective means of preventing unwanted heat gain and conserving energy. It's employed on liquefied natural gas carriers, on both internal and external surfaces of cryogenic propellant tanks for space launchers, and in various ground-based applications. It also shows promise for use in liquid-hydrogen aircraft. Polyurethane (PU) foams are among the preferred cryogenic insulators because they are lightweight, mechanically robust, and have low thermal conductivity.

Beyond established applications, cryogenic insulation could play a key role in hydrogen-powered aviation. As the industry investigates hydrogen as a sustainable fuel, efficient storage and transport of liquid hydrogen become crucial. With a boiling point of −253°C, liquid hydrogen demands advanced insulation to limit heat transfer, curb boil-off, and boost system energy efficiency. High-performance cryogenic insulation in aircraft fuel tanks could increase range, enhance safety, and reduce operational costs by cutting the large energy requirements for maintaining cryogenic temperatures.

Polyols from epoxidized tall oil fatty acids and recycled PET were used to produce rigid PU foams. A low global warming potential physical blowing agent was used. The properties of rigid PU foams at both room temperature and liquid nitrogen temperature were investigated. The apparent density of rigid PU foams is lower than 50 kg/m^3, and thermal conductivity is low, as it doesn't exceed 20 mW/m·K. Adhesion strength to aluminium is up to 0.60 MPa, and the safety coefficient, Ks, is up to 3, indicating the rigid PU foams' capability to maintain adhesion in cryogenic conditions. The developed materials have promising properties as cryogenic insulation for both liquified gas tanks and in aerospace applications.



Picture 1. Schematic overview of rigid PU foam manufacturing

Acknowledgement: This research was funded by the Latvian Council of Science, grant number lzp-2024/1-0652 “Rigid Polyurethane Foams as Cryogenic Insulation for Future ZeroEmission Commercial Aircrafts (PUR4LH2)”.

OP 21: Structural composite battery: Reinforced carbon fibre electrodes within a porous polyethersulfone matrix

Qixiang Jiang [1], Cedric Normand [1], Francois Beauchamp [1], Alexander Beutl [2], Olivier Hubert [1], Alexander Bismarck [1,3]

[1]Polymer & Composite Engineering (PaCE) Group, Institute of Material Chemistry, Faculty of Chemistry, University of Vienna, Währinger Straße 42, 1090, Vienna, Austria
[2]Center for Transport Technologies, Battery Technologies, AIT Austrian Institute of Technology GmbH, Giefinggasse 2, 1210, Vienna, Austria
[3]Department of Chemical Engineering, Imperial College London, South Kensington Campus, SW7 2AZ, London, UK

A method for producing multifunctional structural battery composites is presented, combining carbon fibre–reinforced anodes and cathodes within an electrolyte-filled bicontinuous polymer matrix. Lithium iron phosphate (LFP) and lithium titanate (LTO) were deposited onto carbon fibres via electrophoretic deposition (EPD), enabling uniform coatings with ~30 wt.% active material. The cathode (LFP@CF), separator, and anode (LTO@CF) were stacked and impregnated with a polyethersulfone (PES) solution, which was phase-separated to form a porous polymer matrix. This structure binds the components while allowing efficient electrochemical interaction. The resulting composite exhibited a Young's modulus of 27 ± 10 GPa and a tensile strength of 282 ± 65 MPa. It achieved an energy density of 63 Wh/kg_{LFP} or 2 $Wh/kg_{battery}$ at 0.1C, with stable cycling for over 400 hours.[1]

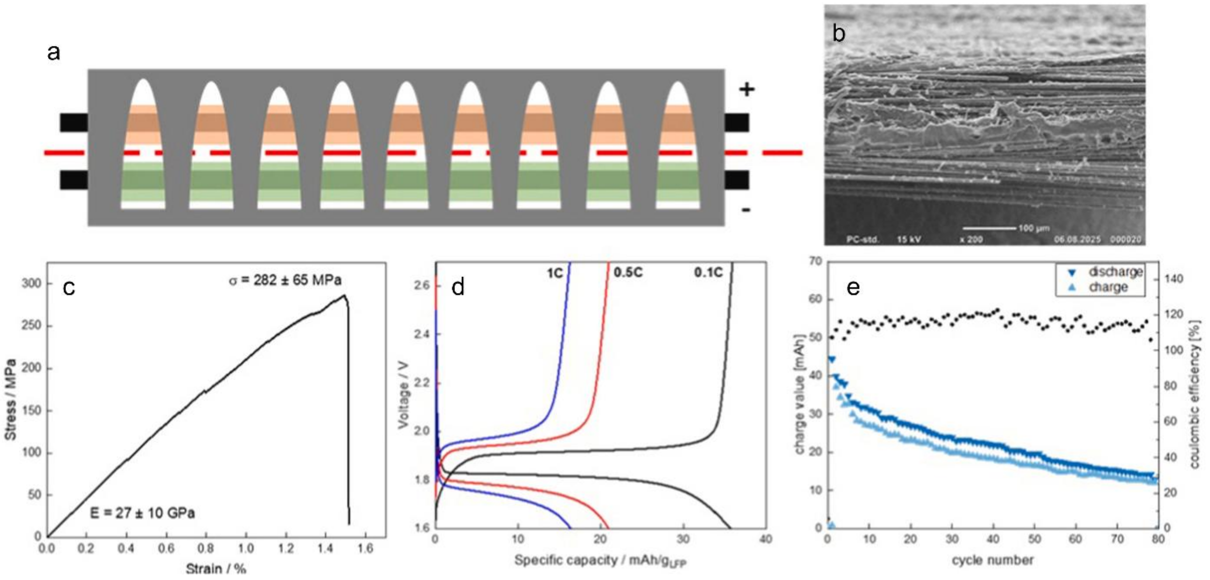


Figure 1: (a) Scheme of the structural composite battery with coated electrodes (orange and red) the separator (red dashed line) and the porous polyethersulfone matrix (grey). (b) Cross-section SEM image of the structural composite battery. (c) Stress-strain curve of the structural composite battery. (d) Cyclic charge-discharge curves at different (dis)charging rates. (e) Steadily reducing capacity during cyclic charge and discharge.

Acknowledgement

The authors thank the Institute of Materials Chemistry, Faculty of Chemistry, University of Vienna (371300) for supporting this project. We also acknowledge Erasmus+ for supporting FB’s stay in Vienna. QJ, ABe, and ABi gratefully acknowledge funding from the European Union’s Horizon 2020 Clean Sky 2 Joint Undertaking under grant agreement No. 101007577 (Solifly). OH acknowledges support from the HyFiSyn project funded by Horizon 2020 under the Marie Skłodowska-Curie Actions grant agreement No. 765881. CN acknowledges funding from the Cluster of Excellence (10.55776/COE17) for PhD studies.

References

(1) Jiang, Q.; Normand, C.; Beauchamp, F.; Beutl, A.; Hubert, O.; Bismarck, A. Structural Composite Battery: Reinforced Carbon Fibre Electrodes within a Porous Polyethersulfone Matrix. *Compos. Sci. Technol.* **2026**, *278*, 111555. https://doi.org/10.1016/j.compscitech.2026.111555.

OP 22: Strategies for Printed Electronics on Rubber

Alexander Hellmayr, Lukas Heindler, Jakob Müller, Alice Lassnig

Printed electronics (PE) have become more widespread in applications such as in-mold electronics, smart textiles, and health care monitoring. In most cases, the widely used substrates are thermoplastic, such as PET, PC, or TPU. Crosslinked substrates, which are far less common, are typically polyurethane- or silicone-based. For stretchable applications, elastomers offer superior stretchability and wear resistance, especially over many cycles. However, raw rubber as a substrate is mostly unexplored due to its difficult processing. In this work, the challenges of using rubber as a substrate were explored and compared with conventional substrates. Additionally, different strategies to improve PE on rubber were investigated and compared with TPU as a stretchable reference material. One strategy employed a multi-layer architecture of carbon and silver inks, in which the carbon ink encapsulates the silver ink, which has far higher conductivity but is chemically less reactive. The second strategy was a protective layer of cross-linked polyurethanes with additional zinc oxide as a sulfur-catching filler, which provides both chemical and mechanical stability to the structure. Both long-term stability and the electromechanical performance in tensile testing of the material combinations were tested and compared with the reference material combination.

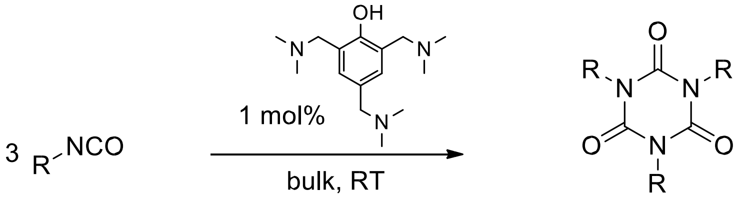
OP 23: The role of phenolic Mannich bases in isocyanate self-reaction pathways

Lena M. Hofbauer[1,2], Valentin J. Siegmund[1,2], Larissa Donner[1,2] and Christian Slugovc[1,2]

[1]Christian Doppler Laboratory for Organocatalysis in Polymerization, Stremayrgasse 9, 8010 Graz, Austria
[2]Institute for Chemistry and Technology of Materials, Graz University of Technology, Stremayrgasse 9, 8010 Graz, Austria.

Isocyanates are primarily recognised for their role in the synthesis of polyurethanes through polyaddition with diols. Besides that, the self-trimerisation of isocyanates to form isocyanurates has been extensively studied as a side reaction in relation to many different types of catalyst. In industrial processes, the formation of isocyanurates can be desirable as it enables the trimerisation of difunctional isocyanates, a process that is widely favoured for hardening polyurethane coatings.[1,2]

In our current study, we found that the Mannich base 2,4,6-tris(dimethylaminomethyl)phenol (better known in industry as K54) is a highly efficient catalyst for the homocyclisation of phenyl isocyanate, leading to complete conversion within seconds. The corresponding reaction equation can be found in Picture 1.



Picture 1: Typical reaction under investigation: Trimerisation of phenyl isocyanate using 1 mol% of K54, at room temperature and bulk conditions.

This enhanced reactivity has been reported in the past.[3] However, to gain a deeper understanding of the reaction mechanism and why K54 converts the reaction so quickly, further Mannich bases and catalytic systems were tested in order to clarify the influence of each of K54's catalytic features. Namely, the influence of the hydroxyl and amine groups, as well as the aromatic ring, was investigated, as these lead to a highly acidic alcohol. The influence of different catalytic systems, solvents and temperatures was investigated in model reactions involving phenyl isocyanate and aliphatic hexyl isocyanate. The reactions were monitored using thermal imaging, ^{1}H-NMR and IR spectroscopy. Furthermore, the synthesis of polyisocyanurates was investigated.

References

(1) Golling, F.E., Pires, R., Hecking, A., Weikard, J., Richter, F., Danielmeier, K. and Dijkstra, D. Polyurethanes for coatings and adhesives – chemistry and applications. Polymer International 2018, 68(5), 848-855. DOI: 10.1002/pi.5665.

(2) Guo, Y., Muuronen, M., Lucas, F., Sijbesma, R. P. and Tomović, Ž., Catalysts for Isocya-nate Cyclotrimerization. ChemCatChem 2023, 15(10), 1867-3899. DOI: 10.1002/cctc.202201362

(3) Imai, Y., Hidai, T., Inukai, T. and Nakanishi, T., Study on Isocyanurate-Modified MDI. 1 — Preparation. Cellular Polymers 1986. 5(1): 13–23. DOI: 10.1177/026248938600500102

OP 24: Ionic π-conjugated porous polymer frameworks for synergistic adsorption–photocatalysis in water

Aleksander Saša Markovič, [a, b] **Sebastijan Kovačič** [a, b, *]

[a] *National Institute of Chemistry, Hajdrihova 19, 1000 Ljubljana, Slovenia*

[b] *Faculty of Chemistry and Chemical Engineering, University of Maribor, Smetanova ulica 17, 2000 Maribor, Slovenia; email: sebastijan.kovacic@um.si*

Ionic π-conjugated polymer networks are a promising class of organic photocatalysts that combine semiconducting properties, water compatibility, and tunable adsorption capacity within a single material platform. In this work, we present two complementary synthetic approaches to ionic π-conjugated porous polymer frameworks designed for the synergistic adsorption and photocatalytic removal of organic pollutants from water.

The first system is based on vinylene-linked ion-in-conjugation porous polymer networks (IIC-PPNs) synthesised via Knoevenagel polycondensation of predesigned zwitterionic monomers and aromatic aldehydes. The resulting networks exhibit permanent porosity (SBET up to ~263 $m^2 \cdot g^{-1}$), enhanced water uptake, visible-light absorption, and semiconducting properties, enabling efficient heterogeneous photocatalytic oxidation of bisphenol A (BPA) in aqueous media [1].

The second system comprises high-porosity conjugated polyelectrolyte hydrogels (CPE-PHs) prepared via Sonogashira–Hagihara coupling in high internal phase emulsions (HIPEs). These materials combine ionic side-chain functionality, hierarchical porosity (surface area up to approximately 350 $m^2 \cdot g^{-1}$), and high water uptake (up to approximately 25 $g \cdot g^{-1}$), enabling dual-function removal of BPA through synergistic adsorption and visible-light-driven photocatalysis, with removal efficiencies exceeding 90% [2].

Together, these results demonstrate that the placement of ionic functionality (backbone versus side chain), combined with controlled porous architecture, governs water compatibility, adsorption capacity, and photocatalytic performance.

References

(1) Markovič, A. S.; Kotnik, T.; Kovačič, S. Zwitterionic, Ion-in-Conjugation Porous Polymer Networks: Synthesis and Photooxidation of Bisphenol A in Water. *Polymer* **2025**, *332*, 128574. https://doi.org/10.1016/j.polymer.2025.128574.

(2) Markovič, A. S.; Lievens, S.; Hanozin, E.; Velimirovic, M.; Pintar, A.; Kovačič, S. High-Porosity Conjugated Polyelectrolytes Synthesized via Sonogashira–Hagihara Coupling in Concentrated Emulsions: Robust Adsorptive–Photocatalytic Hydrogels for Water Pollutant Removal. *Macromolecules* **2026**, acs.macromol.5c02304. https://doi.org/10.1021/acs.macromol.5c02304.

OP 25: Insights into the Development of Sustainable Automotive Compounds

Ines Traxler[1], **Daniela Mileva[1]**, **Markus Gall[1]**, **Georg Grestenberger[1]**, **Patrik Rohrer[1]**

[1] *Borealis Polyolefine GmbH, St. Peter-Straße 25, 4021 Linz, Austria*

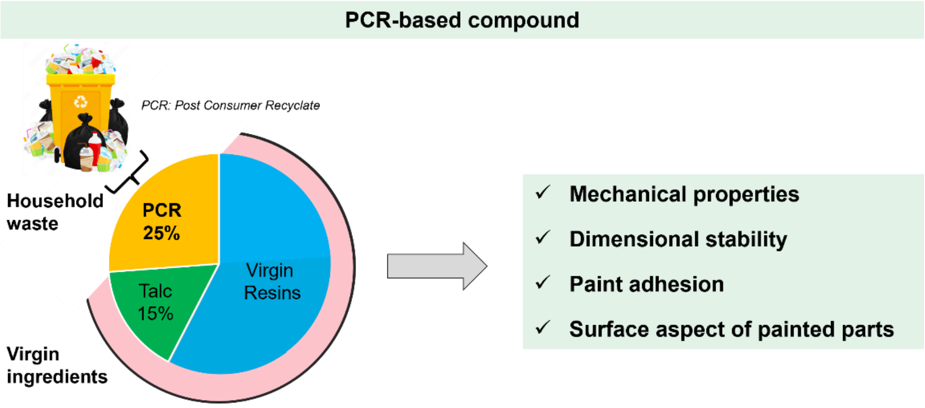
With respect to the currently defined End-of-Life Vehicles (ELV) regulation, compound development for automotive applications faces new challenges. By 2036, a recycled plastics content of 25% will be required, including a 20% share from closed-loop ELV. The recycled plastic is intended to originate from post-consumer waste [1].

The development of automotive compounds for interior and exterior applications require fulfilment of stringent OEM specifications (original equipment manufacturer). Typical selected properties (see Figure 1) which need to be fulfilled are

- Mechanical property profile (e.g., stiffness, ductility at low temperature)
- Dimensional stability
- Surface requirements (e.g., paint adhesion, flow mark free surface, scratch resistance)
- Low odor and emissions.

Only complex systems consisting of virgin and/or recycled polypropylene base polymers, mineral fillers and elastomers can reach the required material properties. Especially in the development of recycled compounds, the question of batch-to-batch consistency and recyclability of these compounds arises. Measurements of the melt flow rate and the stiffness/impact balance over several produced batches showed good consistency of these compounds.

As in the ELV regulation a required amount of closed loop material is demanded, the impact of re-processing of such compounds was investigated. While the MFR was kept stable after a maximum of five cycles, the mechanical properties and emissions were even improved due to better dispersion and degassing.



Picture 1: Schematic representation of polypropylene based compound with 25 wt.% of post-consumer recycylate (PCR) and 15 wt.% of talc for bumper applications.

References

(1) European Union; Council of the European Union. Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on circularity requirements for vehicle design and on management of end-of-life vehicles, amending Regulations (EU) 2018/858 and 2019/1020 and repealing Directives 2000/53/EC and 2005/64/EC. 2026.

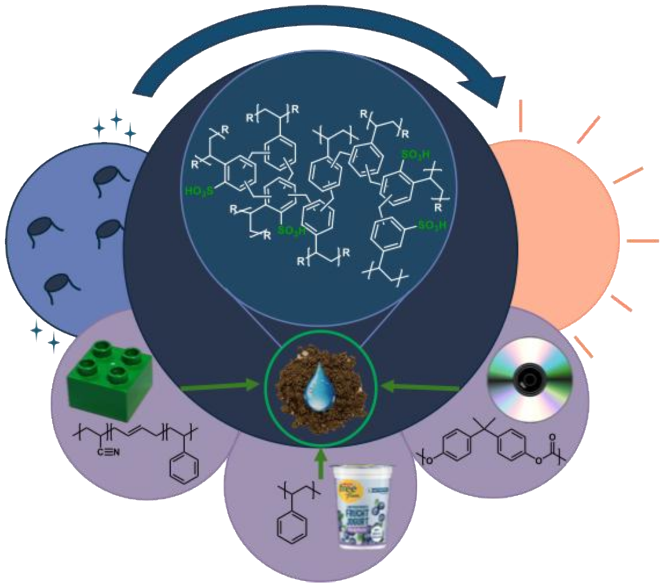
https://www.europarl.europa.eu/meetdocs/2024_2029/plmrep/COMMITTEES/ENVI/DV/2026/02-25/ELV-Provisionalagreement-consolidatedtext-FINAL_EN.pdf (accessed 03.02.2026)

OP 26: Upcycling Waste Aromatic Polymers as Adsorbents for Atmospheric Water Harvesting

Anastasiia Naryshkina[1], Robert T. Woodward[1]

[1]Institute of Materials Chemistry and Research, Faculty of Chemistry, University of Vienna, Währinger Straße 42, 1090 Vienna, Austria

Plastic pollution and water scarcity are two of the most pressing global challenges of the 21st century. Conventional recycling approaches such as mechanical reprocessing, pyrolysis, and depolymerization often lead to material degradation, high energy demands, or low-value outputs. In contrast, upcycling offers a sustainable pathway by transforming plastic waste directly into high-performance functional materials. Here, we demonstrate an innovative approach to upcycle discarded polymers into hypercrosslinked polymers (HCPs)[1] for atmospheric water harvesting (AWH). HCPs, while traditionally studied for gas adsorption and catalysis, are now gaining recognition as promising candidates for AWH due to their high surface areas, tunable porosity, and facile chemical modification. Recent studies have shown that introducing sulfonated functionalities enhances their ability to capture water even under low relative humidity.[2] In this work, waste plastics were converted into HCPs that exhibited excellent water adsorption capacity, reaching 0.2 $g \cdot g^{-1}$ at 30% and 0.5 $g \cdot g^{-1}$ at 90% relative humidity. This performance underscores the potential of HCPs as scalable, low-cost, and robust materials for sustainable water production, bridging the dual challenges of plastic waste management and water scarcity.



Picture 1: Upcycling of waste polymers into atmospheric water harvesting materials.

References

(1) Blocher, A.; Mayer, F.; Schweng, P.; Tikovits, T. M.; Yousefi, N.; Woodward, R. T. One-Pot Route to Fine-Tuned Hypercrosslinked Polymer Solid Acid Catalysts. *Mater. Adv.* **2022**, *3* (15), 6335–6342. https://doi.org/10.1039/D2MA00379A.

(2) Schweng, P.; Mayer, F.; Galehdari, D.; Weiland, K.; Woodward, R. T. A Robust and Low-Cost Sulfonated Hypercrosslinked Polymer for Atmospheric Water Harvesting. *Small* **2023**, 2304562. https://doi.org/10.1002/smll.202304562.

OP 27: Advancing 3D Lithography with Vitamin-Based Photoinitiators in Aqueous Systems

Anton Bauer[1], Dmitry Sivun[1], Heinrich Krobath[2], Jaroslaw Jacak[1]

[1] *Josef Ressel Centre for Materials Engineering in Soft Tissue Regeneration, Department of Medical Engineering, University of Applied Sciences Upper Austria, Garnisonstraße 21, 4020, Linz, Austria.*

[2] *Institute for Theoretical Physics, Johannes Kepler University, Altenberger Straße 69, 4040 Linz, Austria.*

Three-dimensional nanostructuring via single- and multiphoton lithography is a cornerstone technology for biomedical engineering, enabling the fabrication of cell culture systems and tissue scaffolds with sub-micron precision. Conventional photoinitiators are often limited by cytotoxicity, narrow spectral range, or poor solubility, restricting their use in biologically relevant environments.

This work investigates vitamin-based photoinitiators—riboflavin, nicotinamide, ascorbic acid, and vitamins B_{12} and B_9—as biocompatible alternatives for 3D lithography using 515 nm and 1030 nm excitation. Performance was evaluated in aqueous polyethylene glycol diacrylate and hyaluronic acid–based monomers, with and without manganese co-initiators, focusing on polymerization thresholds, structure fidelity, and processing stability.

All photoinitiators enabled 2D and 3D structuring with feature sizes in the ~200 nm range using two-photon lithography, and the approach shows potential for adaptation to single-photon techniques. These results highlight the promise of vitamin-based photochemistry for sustainable, aqueous lithography and biomedical microfabrication applications.

OP 28: Polarisation Resistance of Individual Carbon Fibre Current Collectors for Structural Composite Batteries

Marlis Haslinger[1], Johannes Theiner[2], Qixiang Jiang[1], Alexander Bismarck[1,3], Günter Trettenhahn[4]

[1]Institute of Materials Chemistry and Research, Polymer and Composite Engineering (PaCE) Group, Faculty of Chemistry, University of Vienna, Währinger Straße 42, Vienna, 1090, Austria

[2]Microanalysis Services, Faculty of Chemistry, University of Vienna, Währinger Straße 42, Vienna, 1090, Austria

[3]Department of Chemical Engineering, Imperial College London, South Kensington Campus, London SW7 2AZ, UK

[4]Institute of Physical Chemistry, Faculty of Chemistry, University of Vienna, Währinger Straße 42, Vienna, 1090, Austria

Structural composite batteries (SCBs) are a promising technology that can store electrical energy and withstand mechanical loads simultaneously. SCBs have the potential to reduce the weight of systems and improve their performance, making them ideal for applications where weight is critical. However, using carbon fibres with higher resistance than metals requires reducing other resistances within the battery system. Galvanostatic pulse measurements were used to investigate the impact of acid treatment in different electrolytes on polarisation resistance.

Acknowledgement

M.H., J.T., and Q.J. acknowledge the funding from the Institute of Material Chemistry (371003), University of Vienna.

OP 29: Raman Spectroscopy Across Disciplines: From Classical Polymers to Functional Materials and Biomolecules

Christian Angerer[1], Ingrid Trofin[1], Sandra Posch[2] Georgii Gvindzhiliia[3], Andreas Horner[2], Thomas A. Klar[3], Sabine Hild[1]

[1] Institute of Polymer Sciences, Johannes Kepler University Linz, Altenbergerstraße 69, 4040, Linz, AT
[2] Institute of Biophysics, Johannes Kepler University Linz - Life Science Center, Gruberstraße 40, 4020 Linz, AT
[3] Institute of Applied Physics, Johannes Kepler University Linz, Altenbergerstraße 69, 4040, Linz AT

Raman spectroscopy (RS) serves as an umbrella technique that unifies and accelerates discoveries across polymers, membrane proteins, and laser-written structures by providing chemically specific, non-destructive readouts of bonding, conformation, and structural changes across scales and different scientific fields. RS enables mechanistic linkage between processing, structure and function. This is achieved through specific Raman bands such as C=O stretching vibrations for hydrogen bonding and crystallinity peaks in poly(lactic acid), aromatic and carboxylate bands for protonation- and conformation-sensitive states in proteins, and the D/G bands for carbon evolution in laser-exposed materials. Combining spectroscopy with confocal mapping or pH-dependent measurements, RS provides operando access to kinetics, structures and heterogeneity that are otherwise difficult to capture with traditional structural biology or materials techniques.

Building on this unifying framework, we first investigate semicrystalline poly(lactic acid) systems, where RS is used to elucidate stereocomplex (SC)-driven crystallization in poly(L-lactic acid) (PLLA) and poly(D,L-lactic acid) (PDLLA) matrices containing low PLA-SC loadings (1 - 5 wt%). PLA-SC (PLLA/PDLA 1:1) melt blending under industrial conditions and post-annealing is introduced to promote phase transition. The stereocomplexation is propelled by the intermolecular interactions between the enantiomers e.g., hydrogen bonds [1]. For further analysis, PLA/PLA-SC crystallization is studied as a function of temperature. Specific Raman bands e.g., carbonyl shifts and stereocomplex-specific signatures allow quantification of crystallinity and domain formation. These spectroscopic readouts correlate with differential scanning calorimetry and rheology measurements, evidencing solvent-free self-reinforcement controlled by stereocomplex integrity.

We apply RS to laser-fabricated functional materials, focusing on poly(3,4-ethylenedioxythiophene) (PEDOT) nanostructures, fabricated via laser writing using 7-diethylamino-3-thenoylcoumarin (DETC) as a photoinitiator. Here, Raman spectroscopy provides direct chemical insight into whether polymerization or carbonization occurs during laser processing. The emergence of D and G Raman bands indicates partial graphitization, which correlates with the electrical conductivity of the nanostructures. Thus, RS establishes a direct link between processing, carbon content, and conductive behavior [2].

Finally, extending this technique to biological systems, we investigate the pH-gating mechanism of the Helicobacter pylori urea channel (*Hp*UreI), which is responsible for the survival of the bacterium even under harsh conditions [3]. Here, Raman spectroscopy of *Hp*UreI in detergent micelles reveals pH-dependent conformational changes under near physiological conditions. The observations agree with complementary functional measurements and demonstrate the capability of Raman spectroscopy to resolve environmentally induced structural dynamics in complex biomolecular assemblies.

Together, these examples demonstrate how Raman spectroscopy serves as a versatile, cross-disciplinary tool to connect molecular-scale interactions with macroscopic function across synthetic and biological systems.

References

(1) Huang, W.; Shi, Y.; Wang, P.; Yang, Q.; et.al. Facile and efficient formation of stereocomplex polylactide fibers drawn at low temperatures. *Polymer* 2022, *246*, doi.org/10.1016/j.polymer.2022.124743.

(2) Gvindzhiliia, G.; Angerer, C.; Schwaiger, C.; Sivun, D.; Hild, S.; Klar, T.A.; Sub-diffraction multiphoton polymerizsation of PEDOT. *ACS Applied Materials & Interfaces.* 2026, manuscript under review

(3) Weeks, D.L.; Sachs, G.; Sites of pH regulation of the urea channel of Helicobacter pylori. *Mol. Microbiol*. 2001, *40* (6). 1249-1259. doi: 10.1046/j.1365-2958.2001.02466.x

OP 30: Carbon Felt Electrodes in Redox Flow Batteries: Mechanistic Insights into Performance and Degradation

Ahmad Alem[1], Dominik Wickenhauser[2], Bernhard Marius[2], Alexa Scheer[3], Max Rauscher[4], Johannes Liebhart[4], Nicole Wechner[5], Matheus A. Tunes[5], Michael Feuchter[6], Christoph Rameshan[7], Oskar Paris[4], Stefan Spirk[2,3], Christine Bandl[1]

[1]Department of Polymer Engineering and Science, Chair of Chemistry of Polymeric Materials, Montanuniversität Leoben, Austria

[2]Ecolyte GmbH, Austria

[3]Institute of Bioproducts and Paper Technology (BPTI), Graz University of Technology, Austria

[4]Department of Physics, Mechanics and Electrical Engineering, Chair of Physics, Montanuniversität Leoben, Austria

[5]Department of Metallurgy, Chair of Nonferrous Metallurgy, Montanuniversität Leoben, Austria

[6]Department of Polymer Engineering and Science, Chair of Materials Science and Testing of Polymers, Montanuniversität Leoben, Austria

[7]Department of General, Analytical and Physical Chemistry, Chair of Physical Chemistry, Montanuniversität Leoben, Austria

Carbon felts are widely used as electrodes in redox flow battery (RFB) systems, yet their long-term performance is limited by surface chemistry changes, fouling, and structural degradation in harsh condition of the electrolytes. In this work, we investigate how pretreatment strategies including O_2 plasma, KOH activation, and CO_2 activation modify the properties of carbon felt electrodes by tuning surface chemistry, defect structure, and porosity. Using X-ray photoelectron spectroscopy (XPS), Raman spectroscopy, scanning electron microscopy (SEM), and inverse gas chromatography (iGC), we establish a structure–property relationship linking these modifications to electrochemical behavior in an organic RFB (ORFB). All treatments improve initial performance by reducing activation losses; however, stability differs markedly. O_2 plasma and KOH increase oxygen functionality and porosity but exhibit strong degradation, including rising charge-transfer resistance and severe sulfur-based fouling. In contrast, CO_2 activated felts, with high surface area and low initial functionalization, maintain superior performance and stability. Post-mortem analysis reveals pronounced anode–cathode asymmetry, with stronger sulfate accumulation and pore blockage at the anode. Pristine and KOH-treated felts suffer significant surface area loss, whereas CO_2 activated electrodes retain open morphology and resist fouling. Notably, CO_2 activation enables a self-activation process during cycling, improving charge-transfer kinetics through enhanced electrolyte accessibility and in situ formation of active sites. Overall, the results show that long-term performance is governed by the interplay of pore structure, transport, and dynamic surface evolution rather than initial surface chemistry alone, identifying CO_2 activation as a robust strategy for durable carbon electrodes in ORFBs.

Acknowledgement

This research has received funding from the European Innovation Council program under the grant agreement No. 101115293 (VanillaFlow).

OP 31: A hydrochromic porous aromatic polymer for self-reporting, high-capacity atmospheric water harvesting

Paul Schweng,[1,2] **Christoph Bendl**,[2,3] **Kai C. Hultzsch**,[3] **Robert T. Woodward**[1]*

[1] Institute of Materials Chemistry and Research, Faculty of Chemistry, University of Vienna,
Währinger Straße 42, 1090, Vienna, Austria

[2] Vienna Doctoral School in Chemistry, University of Vienna, Währinger Straße 42, 1090,
Vienna, Austria

[3] Department of Functional Materials and Catalysis, Faculty of Chemistry, University of Vienna,
Währinger Straße 42, 1090 Vienna, Austria

Despite access to clean drinking water being recognised as a human right by the United Nations, large regions of the world already face significant freshwater scarcity, and the number of affected areas is expected to rise further due to climate change.[1] To tackle this challenge, atmospheric humidity offers a geographically unrestricted supplementary source of water.[2,3] In this talk, I will present a sulfonated porous aromatic framework, PAF-1-S, capable of efficiently harvesting water directly from air. PAF-1-S exhibits exceptional water uptake, reaching 1.87 g·g-1 at 90% relative humidity (RH), while retaining significant capacity below 10% RH, mimicking some of the harshest environments on Earth. Water adsorption is rapid, and desorption occurs at mild temperatures, enabling multiple cycles in short time frames and low-energy operation. Uniquely, PAF-1-S undergoes a reversible colour change upon water uptake, which we exploit to visualise humidity in real time using a custom-built sensor. Post-cycling, the material maintains excellent sorption performance, highlighting its stability and practicality. By combining high water uptake, fast kinetics, and hydrochromic sensing, PAF-1-S provides a versatile platform for low-energy, decentralised water harvesting and humidity sensing.

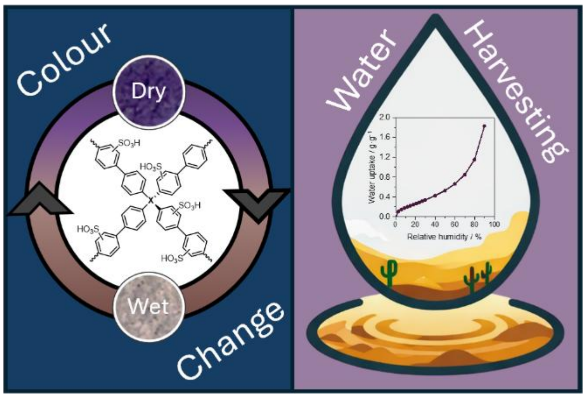


Figure 1: Graphical representation of PAF-1-S, illustrating its reversible colour change with increasing water uptake and the corresponding water sorption isotherm.

References

(1) United Nations, The Sustainable Development Goals Report 2022. https://unstats.un.org/sdgs/report/2022/ (accessed 2026-03-08).

(2) P. Gleick, in Water in Crisis: A Guide to the World's Fresh Water Resources, Oxford University Press, Oxford 1993, pp. 13–24.

(3) Schweng, P.; Woodward, R. T. Challenging POPular Opinion: Porous Organic Polymers for Atmospheric Water Harvesting. Reactive and Functional Polymers 2024, 203, 106014. DOI: 10.1016/j.reactfunctpolym.2024.106014

OP 32: MOFs as new catalytic platform for covalent adaptable networks: catalysis meets reinforcement

Simon Renner[1,2], Roman Korotkov[1,3], Inge Mühlbacher[1,2], Markus Alfreider[4], Daniel Kiener[4], Johannes Liebhart[5], Oskar Paris[5], Christian Slugovc[2], Sandra Schlögl[1,3], Elisabeth Rossegger[1,2]*

[1]Polymer Competence Center Leoben GmbH (PCCL), Sauraugasse 1, 8700 Leoben, Austria

[2]Institute of Chemistry and Technology of Materials, Graz University of Technology, Stremayrg. 9, 8010 Graz, Austria

[3]Department of Materials Science, Montanuniversität Leoben, Franz-Josef-Strasse 18, 8700 Leoben, Austria

[4]Chair of Materials Physics, Department of Materials Science, Montanuniversität Leoben, Jahnstraße 12, 8700 Leoben, Austria

[5]Chair of Physics, Department Physics, Mechanics and Electrical Engineering, Montanuniversität Leoben, Franz Josef Straße 18, 8700 Leoben, Austria

**elisabeth.rossegger@pccl.at*

The polymer type dynamic covalent network is gaining increased interest as these materials bridge the properties of thermoplasts and thermosets[1] enabling the usage of these materials for shape shifting and self-healing.[2] To achieve this effect the covalent bonds in the polymer undergo thiol-thioester exchange processes which can be catalyzed by various types of catalysts.[2,3] These catalysts can be e.g. initiated by heat or light.[4,5] Herein a new type of catalyst is suggested, namely a heterogenous and crystalline one. To achieve this goal, various base catalysts are immobilized on a Zr based metal-organic framework (MOF). This modified MOF was assessed using thermogravimetric analysis (TGA) and nuclear magnetic resonance spectroscopy (NMR) to quantify the efficiency of catalyst immobilisation. Equipped with this information, we successfully incorporated the modified MOF in a thiol-ene click photopolymer. Subsequent stress-relaxation experiments to evaluate the self-healing property of the polymer composite proved the catalytic effect of the MOF catalyst for thiol-thioester exchange. In these measurements the here developed heterogeneous MOF catalyst shows a significant improved thermal stability over the sample with the homogeneous analogon. Supplementary to the self-healing effect the integration of this crystalline catalyst serves to modify the intrinsic properties of the thiol-ene click photopolymer which is generally known for having low toughness.[6] To characterise the beneficial impact of the MOF additive, measurements of the tensile strength, dynamic mechanical analysis (DMA), and X-Ray diffraction analysis (XRD) were conducted. In summary, we can report the first two-in-one additive for vitrimers to catalyse self-healing and reinforce the polymer composite simultaneously in a single step.

Picture 1: combining covalent adaptable network (CAN) with MOF catalysis

References

[1] M. O. Saed, X. Lin, E. M. Terentjew, ACS Appl. Mater. Interfaces, 2021, 13, 35, 42044-42051.

[2] E. Rossegger, R. Höller, D. Reisinger, J. Strasser, M. Fleisch, T. Griesser, S. Schlögl, Polym. Chem., 2021, 12, 639

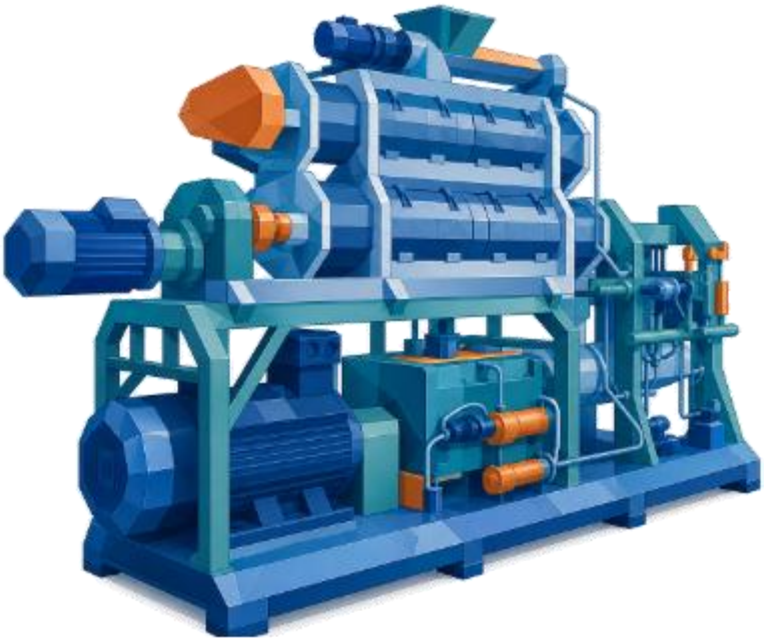
[3] W. Denissen, J. M. Winne, F. E. Du Prez, Chem. Sci., 2016, 7, 30.

[4] D. Reisinger, M. Kriehuber, M. Bender, D. Bautista-Anguis, B. Rieger, S. Schlögl, Adv. Mater, 2023, 35, 2300830.

[5] D. Reisinger, S. Kaiser, E. Rossegger, W. Alabiso, B. Rieger, S. Schlögl, Angew. Chemie – Int. Ed., 2021, 60, 14302-14306.

[6] C. Satheeshkumar, H. J. Yu, H. Park, M. Kim, J. S. Lee, M. Seo, J. Mater. Chem. A, 2018, 6, 21961

Poster Presentations



P 1: Biodegradable, Photocurable Amino Acid Phosphoramidate Resins for Multiphoton Nanolithography

Amelie Krug[1], Ian Teasdale[1]

[1] *Institute of Polymer Chemistry, Johannes Kepler University, Linz 4040, Austria*

Multidisciplinary advances in sensor design, data science, and biotechnology are accelerating the development of polymeric materials for medical engineering. Individualized biodegradable polymers are critical for prosthetics, implants, surgical models, implantable tissues, and in-vitro systems, and they also enable applications in electronics, energy storage, optics, and wearable devices. A key focus is 3D-printable polymers, which must combine functionality, reproducibility, precise 3D structuring, and tunable intrinsic properties (e.g., Young's modulus). However, there is a lack of biodegradable photopolymer resins that balance practical degradation rates with robust mechanics and minimal swelling in aqueous environments.

Current lithography largely relies on (meth)acrylate chemistry to achieve fast curing, but this yields biopersistent aliphatic carbon backbones—even when starting from biodegradable feedstocks—limiting network degradability. To overcome this, we designed amino acid phosphoramidate (APA) photomonomers that undergo hydrolytic degradation under physiological conditions to biocompatible products (phosphates and amino acids). The phosphorus-nitrogen bond provides controlled hydrolysis, while amino acid substituents and backbone functional groups tune hydrophilicity and degradation rates.

We evaluate these APAs in Multiphoton Polymerization Lithography (MPL), which enables rapid prototyping of arbitrary 3D scaffold geometries with minimal photoresist. MPL imposes stringent resist requirements, facilitating translation to other optical lithographies. Using functional synthetic polymers, MPL achieves feature sizes of ~100 nm (lateral) and ~450 nm (axial), supporting high-surface-area 3D scaffolds for compact microfluidic bioassays and organ-on-a-chip models that probe intercellular interactions at cellular resolution.

Acknowledgement

The authors gratefully acknowledge funding by the FWF Grant-DOI 10.55776/PAT4579525

P 2: Thermoplastic RTM of PA6 Mono-Material Pressure Vessels

Çağla Sipahi[1], Zirui Liu[1]
[1]*Chair of Carbon Composites, Technical University of Munich, Boltzmannstr. 15, 85748 Garching, Germany*

Thermoplastic resin transfer molding (T-RTM) is a promising route for recyclable polyamidebased composite pressure vessels (PVs) but remains challenging. In particular, the production of Type IV polyamide 6 (PA6) mono-material PVs requires precise control of impregnation, polymerization, structural integrity, and thermal conditions. Previous studies have shown that T-RTM processing parameters strongly influence polymer conversion with direct consequences for mechanical performance. Furthermore, the coupling between polymerization kinetics and crystallization during T-RTM makes pressure- and temperature-based process monitoring a valuable tool for understanding material evolution during molding.[1, 2]

In parallel, a life cycle analysis (LCA) showed that electricity demand in the T-RTM process has a major effect on the overall environmental impact, underlining the importance of process optimization not only for component performance but also for reducing energy demand. Accordingly, material-process interactions in T-RTM of PA6 PVs were investigated by process monitoring, parameter evaluation, and cross-sectional analysis. Pressure and temperature measurements during production were used to assess resin flow behavior. Cross-sectional analysis revealed local variations in resin distribution and excess resin content, particularly in geometrically complex regions. The polymerization state was evaluated by differential scanning calorimetry (DSC) on failed parts. Endothermic melting transitions were attributed to residual ε-caprolactam in regions with limited impregnation. Heating experiments on reinforcement structures without resin showed geometry-dependent temperature distributions during processing. Together, these findings show how material behavior and process design jointly influence component quality and sustainability in T-RTM-based PA6 PVs.

Figure 1 (Left): Dry carbon fiber wound onto a PA6 liner inside the mold before T-RTM process.

Figure 2 (Right): Cross-section taken from the middle of the vessel.

Acknowledgement

This project is funded under the National Innovation Programme for Hydrogen and Fuel Cell Technology (NIP) by the Federal Ministry for Digital and Transport (BMDV), coordinated by NOW GmbH and implemented by Project Management Jülich (PtJ).

References

(1) Maazouz, A.; Lamnawar, K.; Dkier, M. Chemorheological Study and In-Situ Monitoring of PA6 Anionic Ring Polymerization for RTM Processing Control. Composites Part A: Applied Science and Manufacturing, 2018, 107, 235–247. https://doi.org/10.1016/j.compositesa.2018.01.007.

(2) Semperger, O. V.; Suplicz, A. The Effect of the Parameters of T-RTM on the Properties of Polyamide 6 Prepared by in Situ Polymerization. Materials 2020, 13, 4. DOI: 10.3390/ma13010004.

P 3: Processing Strategies in Dual-Curing Acrylate–Epoxy Systems for High-Performance 3D Printing

**Hani Alzubi , Osman Konuray , Xavier Fernández-Francos , Xavier Ramis ,
Sasan Moradi**

The development of dual-curing polymer systems has emerged as a promising approach to overcome the limitations of conventional photoresins in additive manufacturing, particularly in terms of mechanical performance, thermal stability, and sustainability. In this work, dual-curing acrylate–epoxy resin systems were investigated with the aim of enabling high-precision 3D printing while improving mechanical performance of the printed parts.[1], [2]

Two distinct processing strategies were explored to control the curing behavior and network formation of the materials. In the first approach, the resin was printed immediately after mixing the monomer at room temperature, followed by a thermal cure. In the second approach, the thermal cure preceded 3D-printing, yielding a relatively viscous and partially-cured resin. Using a heated 3D printing system, this resin was printed successfully. Comprehensive characterization was carried out on final materials to understand the relationship between processing conditions, network structure, and material properties. The tests included heological analysis, tensile testing, thermal analysis (DSC and TGA), stress relaxation behavior, and morphological investigation using scanning electron microscopy.

The results demonstrate that both processing routes lead to comparable final polymer network structures, while intermediate stages show significant differences in mechanical and viscoelastic properties. The incorporation of epoxy chemistry within the dual-curing system resulted in improved mechanical performance and enhanced thermal stability compared to conventional acrylate-based resins. Furthermore, the presence of dynamic covalent bonds enables recyclability and reprocessability, addressing key sustainability challenges associated with thermoset materials.

Overall, this study reveals a flexibility in processing of dual-curing systems which can be leveraged for ease of 3D printability. It also permits formulation of dual-curing resin systems with minimally compromised printability even after long storage periods. The findings contribute to the design of next-generation, high-performance, and sustainable materials for advanced additive manufacturing applications.

References

(1) J. Casado, O. Konuray, G. Benet, X. Fernández-Francos, J. M. Morancho, and X. Ramis, “Optimization and Testing of Hybrid 3D Printing Vitrimer Resins,” *Polymers (Basel).*, vol. 14, no. 23, 2022, doi: 10.3390/polym14235102.

(2) J. Casado, O. Konuray, A. Roig, X. Fernández-Francos, and X. Ramis, “3D printable hybrid acrylate-epoxy dynamic networks,” *Eur. Polym. J.*, vol. 173, no. May, 2022, doi: 10.1016/j.eurpolymj.2022.111256.

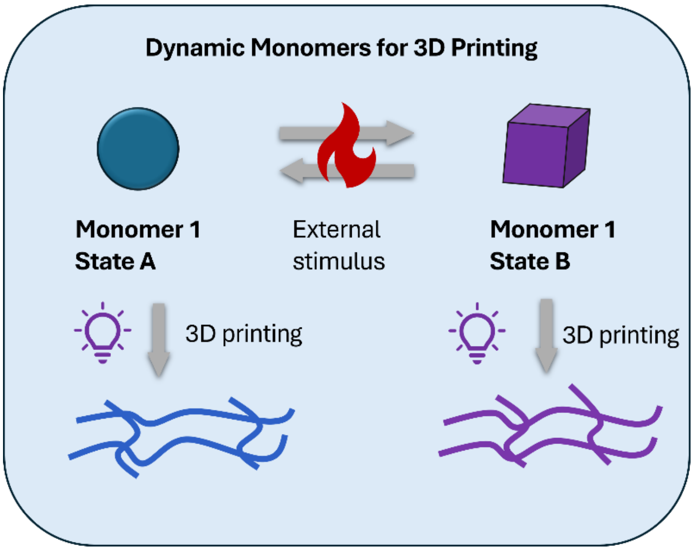
P 4: Switchable monomers for multi-material 3D printing

Hannah Venskutonis[1], Katharina Ehrmann[1]

[1]*Institute for Applied Synthetic Chemistry, TU Wien, Getreidemarkt 9, 1060 Vienna, Austria*

Light-based additive manufacturing represents a powerful strategy for integrating multiple, properties within a single 3D-printed object. This technique provides precise spatio-temporal control and enables the fabrication of complex, highly customizable structures *via* photopolymerization. Nevertheless, the integration of multiple distinct material properties within one object remains challenging, despite advances in grayscale or multi-wavelength printing.[1]

In this context, the concept of “switchable monomers” emerges as a promising alternative. Rather than assigning distinct material properties to separate monomer species, this approach proposes the use of monomers whose functionality can be modulated through variation of printing parameters. Such parameter-dependent switching enables a single formulation to yield a spectrum of material properties, thereby enhancing the versatility of the fabrication process.[2]



Picture 1: Schematic illustration of “switchable monomers”.

In a first example, our group demonstrates control over the crystallinity of polymer networks by systematically “switching” the printing temperature and thus monomer state between liquid crystalline and isotropic liquid. At moderate temperatures (80 °C), stiff and opaque materials are obtained, as the resin is trapped in an ordered state during curing. At higher temperatures (>95 °C), the formulation is polymerized in its isotropic phase, resulting in amorphous polymer networks. This approach enables precise fabrication with pixel-to-pixel resolution and provides an initial demonstration of the potential of such systems for advanced applications.[2]

Currently, we are establishing new thermo-switchable polymerization modes within cationic ring-opening photopolymerization. This is expected to provide precise control over polymer architecture and key properties including crystallinity, birefringence, and degradability.

Acknowledgement

This research project is funded by the Elise Richter Programme of the Austrian Science Fund (FWF) (DOI: 10.55776/RIC9773224).

References

(1) Ehrmann, K. Polymers for 3D Printing. In *Springer Handbook of Functional Polymers*, Chujo, Y. Ed.; Springer Nature Singapore, 2025; pp 557–590.

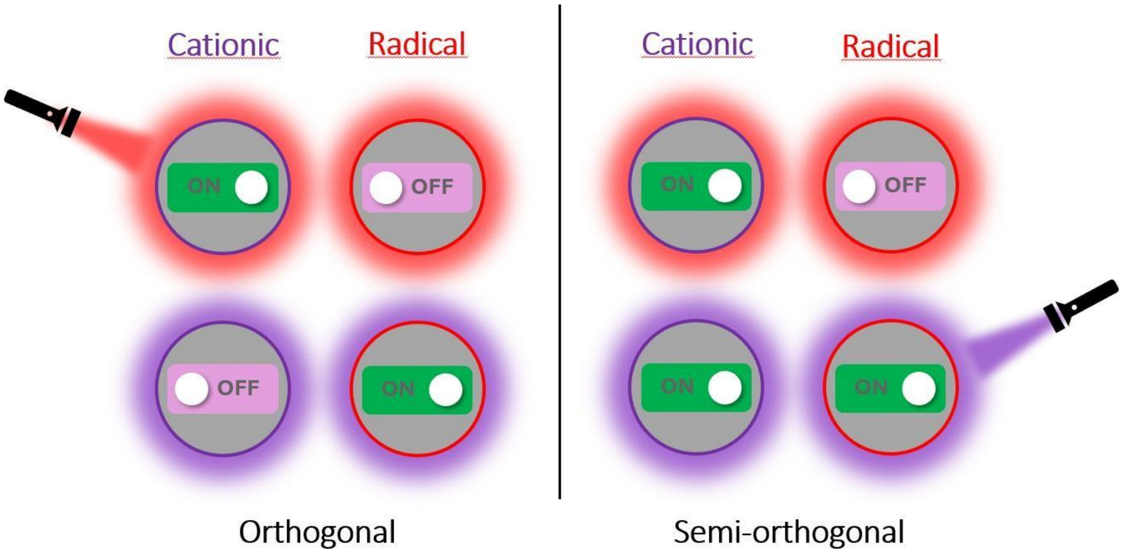
(2) Göschl, M.; Laa, D.; Koch, T.; Constable, E.; Liu, X.; Pimenov, A.; Stampfl, J.; Liska, R.; Ehrmann, K. Semi-crystalline and amorphous materials via multi-temperature 3D printing from one formulation. *Nature Communications* **2025**, *16* (1), 8961. DOI: 10.1038/s41467-025-64092-9.

P 5: Photoinitiators for semi- and fully orthogonal photopolymerisation

Randunage Harshi Bagya Rathnayake[1], **Robert Liska**[1], **Katharina Ehrmann**[1]
[1]*Institute for Applied Synthetic Chemistry, TU Wien, Getreidemarkt 9, 1060 Vienna, Austria*

Orthogonality in chemistry refers to reactions that exhibit reaction conditions, which are mutually exclusive and can thus be activated separately at any given time, irrespective of the sequence of the reactions. In contrast, semi-orthogonality describes scenarios in which at least one set of reaction conditions partially overlaps with that of the second reaction. Thus, only one reaction can be targeted exclusively with one set of reaction conditions, whereas the second set of conditions triggers both reactions, limiting the reaction sequence for orthogonal reactivity.[1]

In the case of photochemistry, this overlap can occur for the responsivity of reactions to particular wavelength regions, where the visible light spectrum, delineated as red light in Picture 1, can typically access reactions rather selectively, while the UV-range of the spectrum, depicted as violet light in Picture 1, is very energetic and is thus often able to trigger all photopolymerization reactions. These two spectral regions can ideally act as a fully orthogonal trigger for multiple reactions, or at least as a semi-orthogonal trigger.[1]



Picture 1: Orthogonal (left) and semi-orthogonal (right) activation of radical and cationic initiators, using visible (red) and UV (purple) light.

This concept was already utilized within the group to achieve a sequential interpenetrating network (IPN) formation *via* a two-step process using two colors of light. Thereby, a scaffold was printed, using the highly reactive and fast-curing methacrylate and visible light, followed by curing of slower epoxy system with UV light post-printing, allowing for faster and less energy-consuming printing overall. Hereby, it is required for at least one of the monomers to react orthogonally, specifically the radical monomer, which then forms the scaffold, followed by UV postcuring to form the cationic network.[2]

We are currently focused on establishing radical and cationic photoinitiators that can react fully orthogonally within the same photoreaction types, in an attempt to move on from semiorthogonal photopolymerisation, whilst maintaining the scope of monomers that are already established for cationic and radical photopolymerisation within the photopolymer community.[2]

This is a particularly important step in multi-material 3D printing, as the cross-reactivity within semi-orthogonal systems is limiting for truly spatio-temporally controlled multi-material printing applications. The printing of multiple materials within the same system could then be established, irrespective of the order of the reactions to create complex, multi-material objects.

Acknowledgement

This research project is funded by the Elise Richter Programme of the Austrian Science Fund (FWF, DOI: 10.55776/RIC9773224).

References

(1) Truong, V. X.; Ehrmann, K.; Seifermann, M.; Levkin, P. A.; Barner-Kowollik, C. Wavelength Orthogonal Photodynamic Networks. *Chemistry (Weinheim an der Bergstrasse, Germany)* **2022**, *28* (25), e202104466. DOI: 10.1002/chem.202104466.

(2) Mayer, F.; Laa, D.; Koch, T.; Stampfl, J.; Liska, R.; Ehrmann, K. Rapid 3D printing of unlayered, tough epoxy–alcohol resins with late gel points *via* dual-color curing technology. *Materials Horizons* **2025**, *12*, 1494–1503. DOI: 10.1039/d4mh01261e.

P 6: Highly Porous Poly(N-vinylcaprolactam-co-N,Ndimethylacrylamide) Hydrogels: Composition-Controlled Water Uptake and Volume Phase Transition Behavior

Špela Podgrajšek[1], Janja Majer Kovačič[2], Sebastijan Kovačič[1, 3, *]

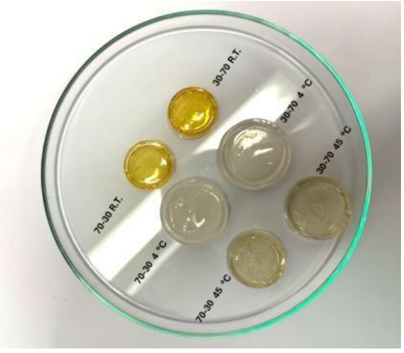
[1]Faculty of Chemistry and Chemical Engineering, University of Maribor, Smetanova ulica 17, 2000 Maribor, Slovenia; email: sebastijan.kovacic@um.si

[2]Faculty of Natural Sciences and Mathematics, University of Maribor, Koroška cesta 160, 2000 Maribor, Slovenia

[3]National Institute of Chemistry, Hajdrihova 19, 1000 Ljubljana, Slovenia

Thermoresponsive polymers have attracted considerable attention due to their unique properties. They can undergo a reversible phase transition when exposed to changes in temperature. Above the lower critical solution temperature (LCST), a polymer becomes insoluble in aqueous solution; below the LCST, the polymer is soluble. One example is poly(Nvinylcaprolactam) (PNVCL), which is non-ionic and has an LCST at around 32 °C. When these thermoresponsive polymers are crosslinked, they become hydrogels and exhibit volume phase transition behaviour at temperatures below and above the LCST region [1,2].

PolyHIPEs are porous, emulsion-templated polymers that are usually synthesized within surfactant-stabilized, water-in-oil, high internal phase emulsions (HIPEs). Here, highly porous N-vinylcaprolactam-co-N,N-dimethylacrylamide-based hydrogel polyHIPEs (HG-PHs), were synthesized within oil-in-oil HIPEs. Different ratios of the monomers N-vinylcaprolactam (NVCL) and N,N-dimethylacrylamide (DMAA) were used, and the thermoresponsive behaviour of these polyHIPEs and non-porous polymers were investigated. Variations in the nature of the polymer were used to tune the temperature-dependent HG-PH water uptake and swelling/deswelling behaviour. The results showed that in non-porous NVCL homopolymers, swelling was minimal, but the material deswelled and even shrank to a size smaller than the original. Increasing the DMAA content in bulk samples led to greater swelling and reduced deswelling, while increasing the VCL content resulted in lower swelling and greater deswelling.



Picture 1: Swelled and deswelled NVCL-co-DMAA polymers

References

(1) Yuan, Y.; Raheja, K.; Milbrandt, N. B.; Beilharz, S.; Tene, S.; Oshabaheebwa, S.; Gurkan, U. A.; Samia, A. C. S.; Karayilan, M. Thermoresponsive Polymers with LCST Transition: Synthesis, Characterization, and Their Impact on Biomedical Frontiers. *RSC Appl. Polym.* **2023**, *1* (2), 158–189. https://doi.org/10.1039/D3LP00114H.

(2) Kermagoret, A.; Fustin, C.-A.; Bourguignon, M.; Detrembleur, C.; Jérôme, C.; Debuigne, A. One-Pot Controlled Synthesis of Double Thermoresponsive N-Vinylcaprolactam-Based Copolymers with Tunable LCSTs. *Polym. Chem.* **2013**, *4* (8), 2575. https://doi.org/10.1039/c3py00134b.

P 7: Impact of Poly(lactic acid) Stereocomplex Integrity on Self-enhancement of Poly(L-lactic acid) and Poly(D,L-lactic acid)

Ingrid Trofin[1], Martin Boruvka[2], Christian Angerer[1], Dominik, Kaineder[1], Sabine Hild[1]

[1] *Institute of Polymer Sciences, Johannes Kepler University Linz, Altenbergerstraße 69, 4040, Linz, AT*

[2] *Faculty of Mechanical Engineering, Technical University of Liberec, Studentská 1402/2, 461 17 Liberec 1, Czech Republic*

Poly(lactic acid) (PLA) is widely studied as an eco-friendly alternative to conventional polymers, due to its biodegradability, biocompatibility, and comparable material properties. Although PLA is already vastly used in in biomedical, industrial, and commercial applications, its use in further engineering applications is limited by its lower thermal stability and brittleness, compared to fossil-based polymers. Therefore, improving its thermal and mechanical properties is mandatory in order to broaden PLA's utility, ideally while preserving its positive life cycle assessment.[1] The proposed methodology adheres to the principles of green chemistry, involving no additive incorporation and maintaining a chemically-uniform material via a physical stereocomplexation.

The current study investigates the crystallization behavior of poly(L-lactic acid) (PLLA) and poly(D,L-lactic acid) (PDLLA) matrices of different optical purities (i.e., D-isomer content), nucleated by low concentrations (1, 3, and 5 wt.%) of PLA stereocomplex (PLA-SC). The PLA-SC was melt-blended under industrial processing conditions (PLLA/PDLA 1:1), then post-annealed in two steps to support phase transitions. The driving force of this stereocomplexation is the hydrogen bonding ($–CH_3 \cdots O=C$) between the two enantiomeric chains, leading to highly-ordered structures with increased melting temperatures compared to the homopolymers. Thus, PLA-SC was incorporated into the PLA matrices at different PLA-SC melting threshold temperatures (200, 210, and 220 °C), in order to alter the strength of the hydrogen-bonding and induce conformational changes.

Differential scanning calorimetry data were complemented by Raman spectroscopic analysis, in order to investigate the effect PLA-SC content and integrity on crystallization behavior and structural development via self-nucleation. Additional rheological testing evaluated the possibility of achieving PLA self-reinforcement via the proposed solvent-free methodology.

References

(1) Xingang Li, et.al., Heat-resistant polylactide fibers: An in-depth review of research developments. *Int. J. Bio. Macromol.* **2025**, *319* (2), 145475. DOI: 10.1016/j.ijbiomac.2025.145475

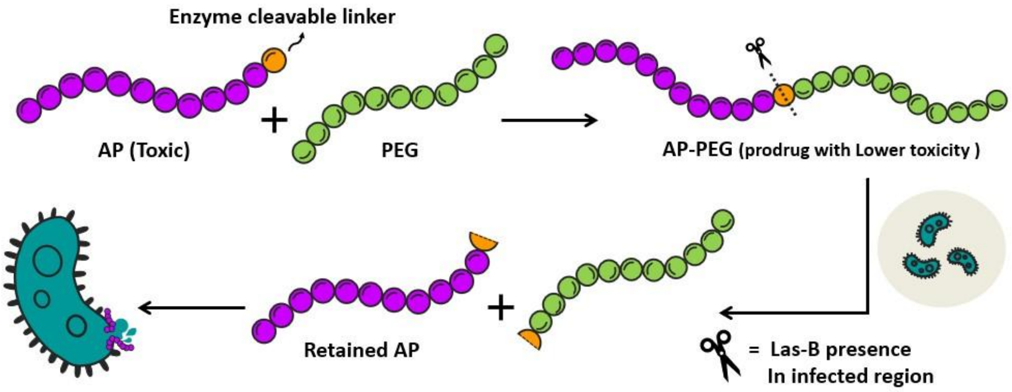
P 8: Targeted delivery of APs in conjugation with PEG

Heliya Javadi[1], **Tzu-Chien Wu**[1], **Tom Fielitz**[1], **Alain Bapolisi**[1], **Antje Stindt**[1], **Vitalii Tkachenko**[1], **Matthias Hartlieb**[1,2]
[1] *Institute of Chemistry University of Potsdam, Karl-Liebknecht-Straße 24-25, 14476, Potsdam, Germany*
[2] *Fraunhofer Institute for Applied Polymer Research (IAP), Geiselbergstraße 69, 14476, Potsdam, Germany*

Antimicrobial resistance is expected to cause up to 169 million deaths worldwide between 2025 and 2050 [1]. Consequently, there is an urgent need for new antimicrobial strategies that avoid the resistance mechanisms associated with conventional antibiotics. Antimicrobial polymers (APs) are promising in this regard, as they typically act by disrupting bacterial membranes. However, their clinical use is still limited by undesired toxicity toward mammalian cells [2].

In this work, we explore an enzyme-responsive approach to control AP activity. The polymer, synthesized via PI-RAFT polymerization [3], was conjugated to polyethylene glycol (PEG) through a short peptide linker composed of glycine, leucine, and alanine (GLA). This sequence can be cleaved by LasB, a protease secreted by *Pseudomonas aeruginosa*, enabling sitespecific activation of the material.

Initial studies show that conjugation influences the biological behavior of the polymer system, pointing to a complex interplay between polymer structure, activation, and interactions with cells. These observations emphasize the importance of understanding how structural modifications affect both antimicrobial performance and cytocompatibility. Further work is ongoing to clarify these effects and guide the design of improved antimicrobial polymer systems.



Picture 1: Schematic representation of PEG- AP conjugate incorporating a LasB-cleavable peptide

References

(1) Naghavi, M.; *et al.* Global Burden of Bacterial Antimicrobial Resistance 1990–2021: A Systematic Analysis with Forecasts to 2050. *Lancet* **2024**, *404*, 1199–1226. DOI: 10.1016/S0140-6736(24)01867-1

(2) Javadi, H.; Lehnen, A. C.; Hartlieb, M. Bioinspired Cationic Antimicrobial Polymers. *Angew. Chem. Int. Ed.* **2025**, e202503738. DOI: 10.1002/anie.202503738

(3) Lehnen, A.-C.; Kurki, J. A. M.; Hartlieb, M. The Difference between Photo-Iniferter and Conventional RAFT Polymerization: High Livingness Enables the Straightforward Synthesis of Multiblock Copolymers. *Polym. Chem.* **2022**, *13*, 1537–1546. DOI: 10.1039/D1PY01530C

P 9: Sol–Gel derived ZnO–rGO coatings: Impact of rGO reduction routes on photocatalytic activity

Lara Maierbrugger, Jürgen Lackner

JOANNEUM RESEARCH (Graz, Austria)

The increasing demand for functional surfaces in environmental applications has intensified the need for materials capable of degrading organic pollutants and preventing surface fouling. Photocatalytic materials offer a promising strategy for degrading such compounds into harmless products. Among semiconductor photocatalysts, ZnO is widely studied due to its favorable properties; however, its efficiency is often limited by rapid charge carrier recombination.

In this work, ZnO-based photocatalytic systems were synthesized starting from zinc acetate and doped with reduced graphene oxide (rGO) to enhance charge separation and light absorption. Graphene oxide (GO) was introduced as a functional carbonbased component and subsequently reduced to rGO via two different approaches: (i) chemical reduction using ascorbic acid and (ii) hydrothermal treatment under elevated temperature and pressure. These reduction pathways enable controlled tuning of the structural and electronic properties of the resulting rGO. [1, 2]

The resulting ZnO–rGO nanocomposites were incorporated into a sol–gel matrix based on tetraethyl orthosilicate (TEOS), (3-aminopropyl)triethoxysilane (APTES), and 3-(trimethoxysilyl)propyl methacrylate (TMSPMA), forming thin film coatings on polymer substrates. Subsequent curing was applied to obtain mechanically stable layers while maintaining accessibility of the photocatalytically active components.

The photocatalytic performance was evaluated by the degradation of methylene blue. Particular attention was given to the influence of the two reduction routes on the overall activity. The results show that the preparation method of rGO has a clear impact on the material properties and the photocatalytic behavior, providing useful insights for the design of more effective self-cleaning coatings.

References

(1) Van Tuan et al. In-situ hydrothermal fabrication and photocatalytic behavior of ZnO/ reduced graphene oxide nanocomposites with varying graphene oxide concentrations. *Materials Science in Semiconductor Processing,* **2020**, *68* (23), 1369–8001. DOI: 10.1016/j.mssp.2020.105114.

(2) Tewatia K. et al. Synthesis of ZnO/rGO and Green Approach for its Reduction by Ascorbic Acid. Department of Physics, J.C. Bose University of Science and Technology, YMCA, Faridabad,121006, India. *AIP Conf. Proc.* **2022**, 2597 (1): 070006. DOI: 10.1063/5.0118780.

P 10: Investigating the Role of Conductive Polymer Coatings on Carbon Felt Electrodes in Organic Redox Flow Batteries

Yining Huang[1], Ahmad Alem[1], Dominik Wickenhauser[2], Bernhard Marius[2], Ícaro Silva Fida Carneiro[3], Matheus A. Tunes[3], Stefan Spirk[2,4], Christine Bandl[1]
[1]Department of Polymer Engineering and Science, Chair of Chemistry of Polymeric Materials, Montanuniversität Leoben, Austria
[2]Ecolyte GmbH, Austria
[3]Department of Metallurgy, Chair of Nonferrous Metallurgy, Montanuniversität Leoben, Austria
[4]Institute of Bioproducts and Paper Technology (BPTI), Graz University of Technology, Austria

Carbon felts (CFs) are widely used as electrodes in redox flow batteries (RFBs); however, their inherent chemical inertness limits efficient electrochemical interactions with redox species in the electrolyte. Surface modification with functional materials offers a promising strategy to improve electrochemical activity of CFs by enhancing hydrophilicity, electrical conductivity, and effective surface area. In this study, conductive polymers including polyaniline (PANI), polypyrrole (PPy), and PEDOT:PSS were employed as coating materials for carbon felt electrodes. PANI and PPy were deposited via electrochemical polymerization, while PEDOT:PSS was applied via dip-coating. The surface composition of the polymer coatings was studied using X-ray photoelectron spectroscopy (XPS), while the electrochemical performance of the modified electrodes was evaluated in organic redox flow battery (ORFB) systems through polarization measurements. In addition, the durability of the coatings under the harsh conditions experienced during charge–discharge cycling was investigated through post-cycling XPS analysis. These results contribute to the development of next-generation high-performance electrodes for RFBs.

Acknowledgement

This research has received funding from the European Innovation Council program under the grant agreement No. 101115293 (VanillaFlow).

P 11: Plasmon-Induced RAFT Polymerization

Anahita Heraji Esfahani[1], Namitha Deepak[1], Ilko Bald[1], Matthias Hartlieb[1,2]
[1]University of Potsdam, Institute of Chemistry, Karl-Liebknecht-Straße 24-25, 14476, Potsdam, Germany
[2]Fraunhofer Institute for Applied Polymer Research (IAP), Geiselbergstraße 69, 14476, Potsdam, Germany

Plasmonic nanoparticles (NPs) exhibit distinct optical properties arising from localized surface plasmon resonance (LSPR), which can be tuned by varying their composition, size, and shape. Upon excitation of LSPR, enhanced electric fields are generated at specific regions on the NP surface. In assemblies of closely spaced NPs, near-field interactions between neighboring particles lead to strong localization of the electric field in interparticle gap regions, commonly referred to as “hot spots.” In these regions, the increased electric field and/or localized heating can be exploited to drive chemical reactions. Owing to these properties, plasmonic NPs have been used in applications such as energy conversion, catalysis, chemical sensing, and therapeutic approaches [1,2].

The presence of macromolecules at the surface of NPs enables control over their interactions and properties, such as hydrophilicity, colloidal stability, and biocompatibility. In particular, when polymers are arranged in a controlled manner around the NPs, they can direct self-assembly into defined structures and further tune the optical properties [2].

Reversible addition–fragmentation chain transfer (RAFT) polymerization enables the synthesis of polymers with well-defined chain lengths and narrow dispersity. Different RAFT polymerization methods include thermal RAFT, photo-iniferter (PI-RAFT), and photoinduced electron/energy transfer RAFT (PET-RAFT), enabling temporal and spatial control over polymer growth. Among these, PET-RAFT polymerization has recently gained attention. In this approach, light excitation of a photocatalyst (PC) activates a chain transfer agent (CTA) via electron and/or energy transfer, generating radical species. The CTA controls the radical polymerization via the RAFT equilibrium, ensuring efficient exchange of active radicals between growing chains and ultimately yielding polymers with well-defined chain lengths and narrow molecular weight distributions. While PET-RAFT polymerization is well established for small-molecule photocatalysts, plasmon-driven variants remain less explored and their underlying mechanisms are still not fully understood [3,4.]

In this project, plasmonic NPs act as both reaction sites and PCs, with CTAs immobilized on the NP surface. This is enabled by the strong affinity of thiocarbonylthio moieties in RAFT CTAs for gold surfaces, allowing their attachment to gold. PET-RAFT polymerization was carried out using spherical Au NPs, a range of CTAs, monomers, and different excitation wavelengths to elucidate the underlying mechanisms of plasmonically triggered, catalyzed, and directed RAFT polymerization on NPs. This work presents results toward understanding the CTA–Au NP interaction and the mechanism behind PET-RAFT in different systems.

Acknowledgement

The authors gratefully acknowledge funding by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) – CRC/SFB 1636 –Project ID 510943930: Project No. B03

References

(1) Hamon, C.; Liz-Marzán, L. M. Hierarchical Assembly of Plasmonic Nanoparticles. *Chemistry - A European Journal* **2015**, *21* (28), 9956–9963. DOI: 10.1002/chem.201500149.

(2) Jiang, J.; Ye, G.; Lorandi, F.; Liu, Z.; Liu, Y.; Hu, T.; Chen, J.; Lu, Y.; Matyjaszewski, K.; Jiang, J. J.; Ye, G.; Liu, Y. Q.; Hu, T.; Chen, J.; Lu, Y. X.; Lorandi, F.; Matyjaszewski, K. Localized Surface Plasmon Resonance Meets Controlled/Living Radical Polymerization: An Adaptable Strategy for Broadband Light-Regulated Macromolecular Synthesis. *Angew. Chem. Int. Ed.* **2019**, *58* (35), 12096–12101. DOI: 10.1002/ANIE.201906194.

(3) Jing, X.; Zhang, Y.; Li, M.; Zuo, X.; Fan, C.; Zheng, J. Surface Engineering of Colloidal Nanoparticles. *Materials Horizons*. Royal Society of Chemistry January 20, 2023, pp 1185–1209. DOI: 10.1039/d2mh01512a.

(4) Lee, Y.; Boyer, C.; Kwon, M. S. Photocontrolled RAFT Polymerization: Past, Present, and Future. *Chemical Society Reviews*. Royal Society of Chemistry April 11, 2023, pp 3035–3097. DOI: 10.1039/d1cs00069a.

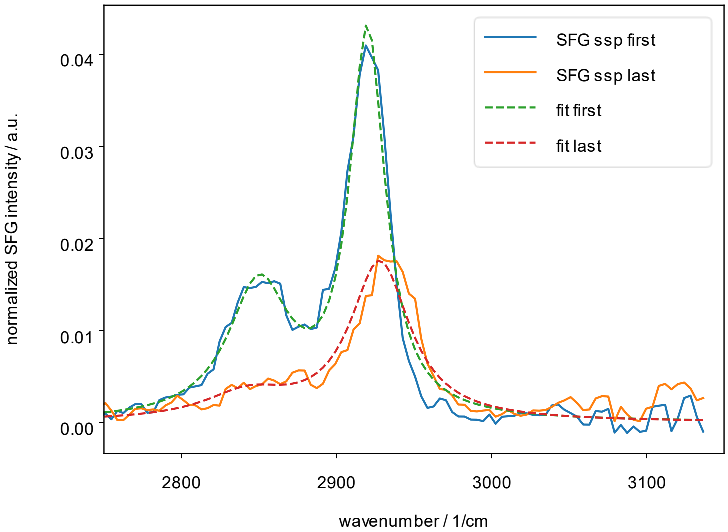
P 12: In Situ SFG Study of UV-Induced Interfacial Degradation in Styrene–Isoprene–Styrene Block Copolymer

Wolfgang Lakata[1], **Gerald Auböck**[1]
[1]*Affiliation: Silicon Austria Labs GmbH / Sensor Systems/Photonic Systems, Europstraße 12, 9524 Villach*

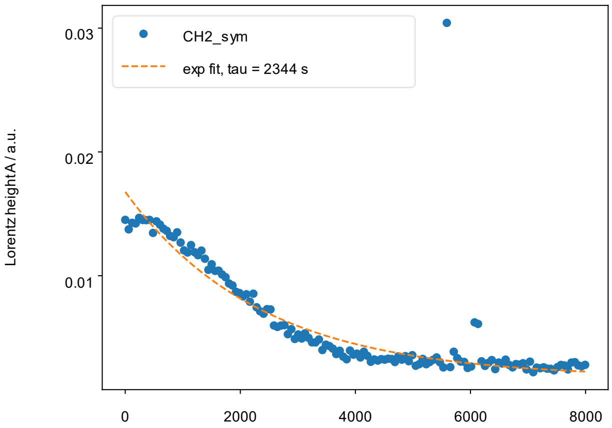
Understanding how ultraviolet irradiation modifies soft polymer surfaces is important for improving the durability and functional performance of materials used in adhesives, coatings, and other interfacial applications. Styrene–isoprene–styrene (SIS) is particularly relevant in this context because styrenic block copolymers are widely used in hot-melt and pressure-sensitive adhesive formulations, where surface chemistry and interfacial structure directly influence adhesion and aging behavior. Sum-frequency generation infrared (SFG-IR) spectroscopy is particularly well suited for investigating such processes because it is intrinsically selectively sensitive to surfaces and interfaces where inversion symmetry is broken and has been widely applied to probe molecular structure, orientation, and conformation at polymer interfaces. [1]

Here, we present an in situ SFG study of UV-induced interfacial degradation in SIS. During UV illumination, clear spectral changes are observed in the CH stretching region, demonstrating that the surface molecular structure evolves significantly during exposure, which can be seen in figure 1. The overall spectral evolution is consistent with a progressive loss of the initially ordered aliphatic interfacial population and results in a strongly modified residual surface environment at later stages of illumination. This behavior is consistent with previous studies of styrene–isoprene copolymers, which showed that photooxidation is governed primarily by the polyisoprene segments, while the polystyrene segments remain comparatively stable on the relevant timescale. [2, 3, 4]

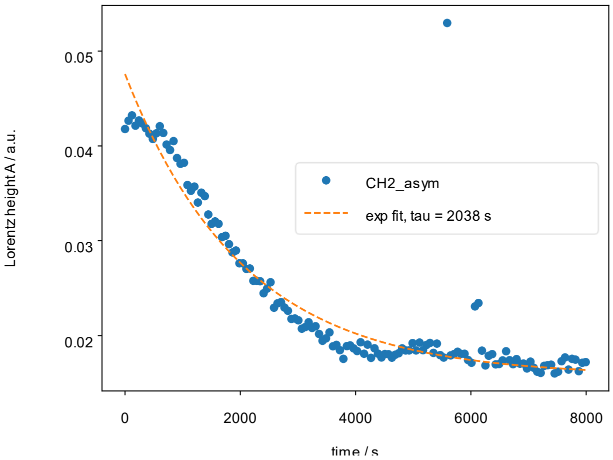
More broadly, this work highlights the value of in situ SFG experiments to investigate degradation-driven interfacial restructuring of technologically relevant block copolymers. By directly tracking molecular changes at the air/polymer interface during UV exposure, SFG can provide insight into the earliest stages of surface aging that are not readily accessible with other spectroscopies sensitive to bulk (or thicker layer) material properties.



c.) SFG-spectrum before and after radiation



a.) Decline of intensity versus time of CH2 symmetric vibration



d.) Decline of intensity versus time of CH2 asymmetric vibration

Figure 1: a.) SFG-spectra of SIS-polymer before and after radiation with 265 nm UV light, measured in ssp configuration, b.) corresponding decay-curve of the CH2-symmetric stretch vibration, c.) corresponding decay-curve of the CH2-symmetric stretch vibration

Acknowledgement

This work has been supported by Silicon Austria Labs (SAL), owned by the Republic of Austria, the Styrian Business Promotion Agency (SFG), the federal state of Carinthia, the Upper Austrian Research (UAR), and the Austrian Association for the Electric and Electronics Industry (FEEI).

References

(1) Ilyin, S. O.; Melekhina, V. Y.; Kostyuk, A. V.; Smirnova, N. M. Hot-Melt and Pressure-Sensitive Adhesives Based on Styrene-Isoprene-Styrene Triblock Copolymer, Asphaltene/Resin Blend and Naphthenic Oil. *Polymers* **2022**, *14* (20), 4296. https://doi.org/10.3390/polym14204296

(2) Zhang, D.; Dougal, S. M.; Yeganeh, M. S. Effects of UV Irradiation and Plasma Treatment on a Polystyrene Surface Studied by IR-Visible Sum Frequency Generation Spectroscopy. *Langmuir* **2000**, *16* (10), 4528–4532. https://doi.org/10.1021/la991353i

(3) Chen, Z. Investigating Buried Polymer Interfaces Using Sum Frequency Generation Vibrational Spectroscopy. *Prog. Polym. Sci.* **2010**, *35* (11), 1376–1402. https://doi.org/10.1016/j.progpolymsci.2010.07.003

(4) Gonon, L.; Gardette, J.-L. Photooxidation Mechanism of Styrene–Isoprene Copolymer: Evolution of the Profile of Oxidation According to the Composition. *Polymer* **2000**, *41* (5), 1669–1678. https://doi.org/10.1016/S0032-3861(99)00346-8

P 13: Cationic selenuranes as Lewis acids for polymerization reactions

Edma Gjata[1], Kirill Zhiliaev[2], Javier Mateos[2], Robert Liska[1], Patrick Knaack[1]

[1]Institute of Applied Synthetic Chemistry, TU Wien (Getreidemarkt 9, 1060 Vienna)

[2]Institute of Organic Chemistry, University of Vienna (Währinger Straße 38, 1090 Vienna)

In recent years, organocatalysis has gathered attention as a feasible platform for metal-free cationic polymerization reactions. Here, a unique form of initiation by organocatalysts is through non-covalent supramolecular forces, especially halogen bonding (HX) and chalcogen bonding (ChB) σ-hole interactions.[1, 2] Concerning group 16 atoms, in particular, a few inspiring examples of ChB interactions involving Se or Te based organocatalysts for polymerizations have been reported.[2, 3] Nonetheless, the use of these classes of compounds remains broadly unexplored and rather scarce.

On the other hand, among recent reports on selenium related transformations outside of polymer chemistry communities, a new type of bench-stable cationic selenurane salts has been disclosed. These solid salts are characterized by a rigid Se-Se backbone that dissociates into Se(III)-based radical cations in solution, which can undergo dimerization and form a dicationic species.

Prompted by these precedents, this work pairs the application of this selenurane dication as a Lewis acid with the concept of ChB catalysis as a new, simple and efficient tool for initiating cationic polymerizations. Its utility is shown with an array of monomer families, e.g. cyclic ethers, vinyl ethers, styrene-derivatives, etc., thus highlighting the broad scope of this methodology.

References

(1) Takagi, K.; Murakata, H.; Yamauchi, K.; Hashimoto, K. Cationic polymerization of vinyl monomers using halogen bonding organocatalysts with varied activity. *Polymer Chemistry* **2020**, *11* (42), 6739–6744.

(2) Takagi, K.; Sakakibara, N.; Hasegawa, T.; Hayashi, S. Controlled/Living Cationic Polymerization of p-Methoxystyrene Using Tellurium-Based Chalcogen Bonding Catalyst─ Discovery of a New Water-Tolerant Lewis Acid Catalyst. *Macromolecules* **2022**, *55* (9), 3671–3680.

(3) Shu, W.; Cheng, X.; Gao, Y.; Lin, X.; Pan, X.; Li, J.; Zhu, J. Metal-free living cationic ring-opening polymerization of cyclic esters using selenonium salts as Lewis acids. *Polymer Chemistry* **2024**, *15* (23), 2337–2341.

P 14: Germanium-Photoinitiator Functionalized Silica Nanoparticles for High-Performance UV-Curable Polyester Coatings

Zizheng Zhang[1], Peter Berce[2], Thomas Griesser[1], and Christine Bandl[1]
[1]*Montanuniversität Leoben, Institute of Chemistry of Polymeric Materials; Otto-Glöckel-Strasse 2, A 8700 Leoben – Austria*
[2]*Helios Tovarna Barv, Lakov in Umetnih Smol Kolicevo, d.o.o., Količevo 65, 1230 Domžale, Slovenia*

The present work contributes to the development of high-performance and low-migration UV-curable coatings that combine efficient curing with reduced mobility and improved compatibility within the resin matrix. For this purpose, silica nanoparticles (SiO_2NPs) are functionalized with Germanium-based photoinitiators (Ge-PI) and explored as multifunctional additives for unsaturated polyester resin (UPR)-based coating systems. The immobilization of the Ge-PI on the nanoparticle surfaces is expected to suppress migration, improve photoinitiator dispersion, and enable localized initiation processes at the organic–inorganic interface. Under UV irradiation, the surface-bound photoinitiators generate reactive species which are employed to initiate radical polymerization of the unsaturated polyester network in the coating system. This approach is anticipated to influence curing behavior through interfacial initiation, potentially affecting polymer network formation, crosslinking density, and filler–matrix interactions. Curing efficiency, oxygen tolerance, and the spatial distribution of polymerization proximal to the nanoparticle surface will be investigated. Preliminary studies also examined the effects of nanoparticle loading on film formation, mechanical properties, and adhesion in coating applications.

In this contribution, we provide insight into the role of photoinitiator-immobilized nanoparticles as hybrid functional additives in UV-curable polyester systems and to establish a foundation for designing low-migration, high-performance coatings with enhanced interfacial control.

P 15: Synthesis and Characterization of DMA/PEGMA/FMA Amphiphilic Nanoparticles

Emrah CELEN[1*], Magdalena Martinka-Maksymiak[2],Anita Eckstein[1]
[1]Department of Synthesis and Characterization of Polymers, Polymer Institute, Slovak Academy of Sciences, Bratislava, Slovakia
[2]Centre of Polymer Materials of the Polish Academy of Sciences, Zabrze, Poland;
**emrahcelen@savba.sk*

Amphiphilic polymeric nanoparticles based on methacrylate monomers provide a flexible platform for nanomaterials design, particularly in drug delivery applications[1]. In this study, nanoparticles were synthesized via conventional free radical copolymerization of dodecyl methacrylate (DMA), poly (ethylene glycol) methacrylate (PEGMA)[2], and furfuryl methacrylate (FMA). The hydrophobic DMA segments contribute to the formation of hydrophobic core domain[3], while PEGMA imparts hydrophilicity and steric stabilization in aqueous media[4]. FMA introduces additional functional groups within the polymer backbone, enabling further chemical versatility [5]. Due to the nature of free radical polymerization, the resulting systems exhibit inherent dispersity in molecular weight and particle size, limiting precise structural control but allowing scalable preparation.

The synthesized nanoparticles were characterized with respect to their physicochemical properties, including particle size distribution, morphology, and chemical composition. Particular emphasis was placed on evaluating their colloidal behaviour in aqueous media, where the balance between hydrophobic and hydrophilic components governs dispersion stability. The results demonstrate that stable nanoparticulate systems with diameter of 202 ± 35 nm can be obtained through appropriate monomer selection and composition. These findings highlight the potential of DMA/PEGMA/FMA-based nanoparticles as amphiphilic carriers and underscore the importance of formulation parameters in determining their final properties. The functionality of the prepared nanoparticles was evaluated by the process of encapsulation and subsequent release of active derivatives. The results confirmed that the particles are able to absorb bioactive compounds of lipoic acid and dihydrocaffeic acid. After loading, subsequently release them over time.

Acknowledgement

This work was supported by VEGA grant No. 2/0172/26 and the Slovak Academy of Sciences Doktogrant APP0703.

References

(1) Calandra, P.; Caschera, D.; Turco Liveri, V.; Lombardo, D. How Self-Assembly of Amphiphilic Molecules Can Generate Complexity in the Nanoscale. *Colloids Surf. Physicochem. Eng. Asp.* **2015**, *484*, 164–183. https://doi.org/10.1016/j.colsurfa.2015.07.058.

(2) Kono, H.; Ouchi, M.; Terashima, T. Precisely Controlled yet Dynamically Exchanged Micelles *via* the Self-Assembly of Amphiphilic Acrylate Random Copolymers in Water. *Polym. Chem.* **2025**, *16* (6), 652–660. https://doi.org/10.1039/D4PY01272K.

(3) Wagner, A. M.; Duggal, I.; Lawrence, A.; Shearer, A.; Schroeder, A.; Al-Sayyad, N.; Rodriguez-Cruz, J. J.; Villarreal, F. A. C.; Peppas, N. A. Systematic Design of Polybasic Nanogels: Influence of Hydrophobic Monomers on Tunable Physicochemical and Biological Properties. *Npj Biomed. Innov.* **2026**, *3* (1), 8. https://doi.org/10.1038/s44385025-00058-2.

(4) Savin, C.-L.; Popa, M.; Delaite, C.; Costuleanu, M.; Costin, D.; Peptu, C. A. Chitosan Grafted-Poly(Ethylene Glycol) Methacrylate Nanoparticles as Carrier for Controlled Release of Bevacizumab. *Mater. Sci. Eng. C* **2019**, *98*, 843–860. https://doi.org/10.1016/j.msec.2019.01.036.

(5) Gevrek, T. N.; Sanyal, A. Furan-Containing Polymeric Materials: Harnessing the DielsAlder Chemistry for Biomedical Applications. *Eur. Polym. J.* **2021**, *153*, 110514. https://doi.org/10.1016/j.eurpolymj.2021.110514.

P 16: Towards Intelligent Rock Bolts: Printed Strain Sensors for Real-Time Underground Monitoring

Pauline Vailhé[1,2], Michel Varelija[2,3], Philipp Hartlieb[2], Alice Lassnig[1]
[1]*Institute of Chemistry of Polymeric Materials, Technical University of Leoben, Austria*
[2]*Chair of Mining Engineering and Mineral Economics, Technical University of Leoben, Austria*
[3]*International Relations Office (MIRO), Technical University of Leoben, Austria*

Printed electronics offers a versatile route for integrating sensing functionalities directly onto structural components[1–3]. In this work, conductive silver ink-based strain sensors are developed and evaluated for application on steel substrates, with a focus on material behaviour and processing conditions in the context of underground mining.

The sensor consists of a multilayer architecture including a polymer-based insulating base coat, a printed conductive silver ink layer, and a protective top layer. The sensing mechanism, illustrated in Fig. 1, relies on a strain-dependent change in electrical resistance governed by the evolution of the conductive particle network under deformation[4].

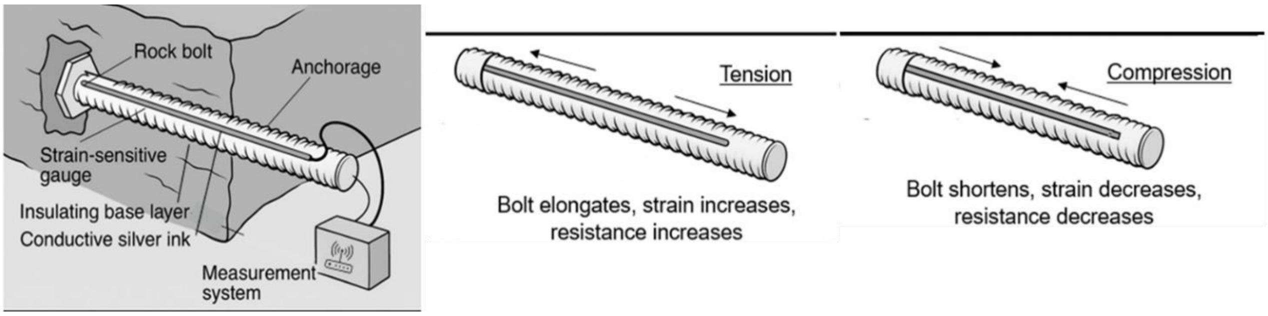


Figure 1: Schematic Illustration of the intelligent rock bolt and its strain sensing principle

The influence of processing parameters, including ink formulation, deposition technique, and curing conditions, was systematically investigated. The optimized system exhibits a stable and reproducible response under tensile loading, with reliable sensing performance up to approximately 15% strain and functional behaviour at higher deformation levels.

The developed sensors were integrated onto steel rock bolts, which are widely used as reinforcement elements in underground mining[5]. The proof of concept was validated through laboratory testing and a preliminary deployment in an operating mine. The instrumented bolts successfully withstood installation and provided measurable resistance changes during operation, indicating sensitivity to deformation. However, at this stage, the measurement accuracy and the precise correlation between the recorded signals and the actual mechanical state of the rock mass remain to be fully established.

These results highlight the potential of printed silver ink systems for the development of intelligent rock bolts, offering a promising route toward scalable structural health monitoring in harsh mining environments.

Acknowledgement

The authors acknowledge DSI Underground (Sandvik Mining & Rock Solutions) for providing the rock bolts and Boliden AB (Kristineberg Mine) for enabling in-mine testing. This work was supported by the Horizon 2020 project illuMINEation (Grant No. 869379). The authors also thank JOANNEUM RESEARCH (Weiz) for support with sensor fabrication.

References

(1) Zikulnig, J.; Chang, S.; Bito, J.; Rauter, L.; Roshanghias, A.; Carrara, S.; Kosel, J. Printed Electronics Technologies for Additive Manufacturing of Hybrid Electronic Sensor Systems. *Adv. Sens. Res.* **2023**, *2* (7), 1–39. https://doi.org/10.1002/adsr.202200073.

(2) Khan, S.; Lorenzelli, L.; Dahiya, R. S. Technologies for Printing Sensors and Electronics over Large Flexible Substrates: A Review. *IEEE Sens. J.* **2015**, *15* (6), 3164–3185. https://doi.org/10.1109/JSEN.2014.2375203.

(3) Rim, Y. S.; Bae, S. H.; Chen, H.; De Marco, N.; Yang, Y. Recent Progress in Materials and Devices toward Printable and Flexible Sensors. *Adv. Mater.* **2016**, *28* (22), 4415– 4440. https://doi.org/10.1002/adma.201505118.

(4) Yao, S.; Zhu, Y. Wearable Multifunctional Sensors Using Printed Stretchable Conductors Made of Silver Nanowires. *Nanoscale* **2014**, *6* (4), 2345–2352. https://doi.org/10.1039/c3nr05496a.

(5) Fuławka, K.; Pytel, W.; Szumny, M.; Mertuszka, P.; Pałac-Walko, B.; Hartlieb, P.; Jakić, M.; Nöger, M. Prototype of Instrumented Rock Bolt for Continuous Monitoring of Roof Fall Hazard in Deep Underground Mines. *Sensors* **2023**, *23* (1). https://doi.org/10.3390/s23010154.

P 17: Development of low-viscosity silicone resin systems for fire-resistant mica composites

Daniel Bautista-Anguís[1,2], Evelyn Sattler[1], Lukas Tribuser[3], Matthias Gsellmann[3], Susanne Fischer[3], David Löffler[4], Rico Schmerler[4], Arthur Laporte[5], Sandra Schlögl[1,2]
[1]Polymer Competence Center Leoben GmbH; Sauraugasse 1, 8700 Leoben, Austria
[2]Inst. of Chemistry of Polymeric Materials, TU Leoben, Otto-Glöckel-Str., 8700 Leoben, Austria
[3]Isovolta AG; Vianovastraße 20, 84002 Werndorf, Austria
[4]Fraunhofer IWU; Reichenhainer Str. 88, 09126 Chemnitz, Germany
[5]APESA; 23 rue Hélène boucher, 40220 Tarnos, France

The rapid expansion of electric mobility has increased the demand for battery systems with enhanced safety and thermal stability. Within this context, the IsoFoamComp project aims to develop advanced materials for passive thermal management and fire protection. This work focuses on the formulation of low-viscosity silicone resins suitable for mica paper impregnation, with the additional capability of curing via either thermal or ultraviolet processes. The influence of curing conditions and the incorporation of flame-retardant additives on the thermal and fire-resistant performance of the resulting mica-silicone composites was investigated.

The developed composites, intended for integration into a multilayer structure (Figure 1) by bonding them to an aluminium foam sandwich infiltrated with a phase-change material, exhibited high thermal stability up to 250-300 °C, as demonstrated by thermogravimetric analysis. Their fire resistance was evaluated through direct flame exposure tests, during which no ignition or flame propagation was observed.

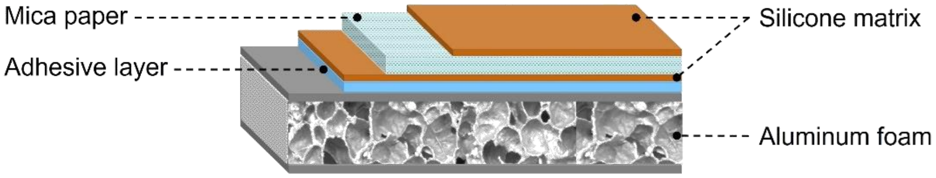


Figure 1: Schematic representation of the final IsoFoamComp structure

Comparative analysis between thermally cured and UV-cured systems revealed negligible differences in both thermal stability and fire resistance. Similarly, the presence of flame-retardant additives did not significantly enhance performance, indicating that the intrinsic properties of the mica-silicone system are sufficient to ensure high fire resistance. Overall, the developed mica-silicone composites demonstrate strong potential for application in battery protection systems, offering a combination of thermal stability, flame resistance and process versatility.

Acknowledgement

The research work was performed within the framework of the M-ERA.NET 3 network (project no.: 10210) and is funded by the following funding agencies: FFG – Austrian Research Promotion Agency, State Ministry for Science, Culture and Tourism (SMWK) and Région Nouvelle Aquitaine (RNAQ) with the participation of APESA (France), Fraunhofer Institute for Machine Tools and Forming Technology IWU (Germany), Isovolta AG (Austria) and the Polymer Competence Center Leoben GmbH (Austria).

P 18: Innovative on-demand debonding strategies for disassembly of adhesion joints

Fleana A. Sabatino,[1,2] **Milena O. Gleirscher,**[1,2] **Sandra Schlögl**[1,2]
[1]Polymer Competence Center Leoben GmbH (PCCL), Sauraugasse 1, 8700 Leoben, Austria;
e-mail: sandra.schloegl@pccl.at
[2]Chair of Chemistry of Polymeric Materials, Technical University of Leoben (TUL), Otto-Glöckel-straße 2/IV, 8700 Leoben, Austria

In response to the increasing global demand for sustainable materials and circular economy design strategies, this work introduces the concept of chemical amplification mechanisms and latent catalysts in a covalent adaptable network (CANs) for reversible adhesive system.[1] Chemical amplification refers to a process in which a single external trigger induces a cascade of subsequent reactions, for instance catalyst activation and transesterification. CANs are capable of undergoing chain rearrangement in response to external stimuli, thereby offering on-demand adaptability. In the absence of a stimulus, bonds exchange is slow, and network remains fixed into rigid structures with strong adhesive interaction and high mechanical strength. Upon application of an external stimulus, heat in this work, a rapid covalent bond exchange occurs, leading to a decreasing in modulus and viscosity. This behaviour enables the adhesive de-bonding and material reprocessing. To achieve spatiotemporal control over this process, the integration of latent catalyst can regulate the exchange reaction.[3] The inactivated catalyst maintains a low exchange rate for vitrimer network at lower temperatures, thereby guaranteeing structural integrity and preventing irreversible creep deformation. Once activated at high temperature, it efficiently promotes bond exchange reactions, as evidenced by a rapid decrease in stress relaxation, enabling on-demand debonding.

Acknowledgement

The research was conducted within the project “Repairtecture” (project-no.: 904927) at the Polymer Competence Center Leoben GmbH (PCCL, Austria) within the framework of the COMET-program of the Federal Ministry for Innovation, Mobility and Infrastructure and the Federal Ministry of Economy, Energy and Tourism. The COMET-Module is funded by the Austrian Government and the State Governments of Styria and Upper Austria.

Part of this research project (grant number: 911658) was funded by COMET – Competence Centers for Excellent Technologies – through BMIMI, BMWET, and the co-financing federal provinces (Styria through SFG, Upper Austria, Vorarlberg) and carried out with the participation of scientific and company partners. The COMET program is managed by FFG.

References:

(1) Winne, J. M.; Leibler, L.; Du Prez, F. E. Dynamic Covalent Chemistry in Polymer Networks: A Mechanistic Perspective. *Polymer Chemistry*. Royal Society of Chemistry December 7, **2019**, pp 6091–6108. https://doi.org/10.1039/c9py01260e.

(2) Blaedel, W. J.; Boguslaski, R. C. *Chemical Amplification in Analysis: A Review*.

(3) Nikita, N.; Kumar, A.; Connal, L. A. Latent Catalysts in Vitrimers. *Polymer Chemistry*. Royal Society of Chemistry April 25, **2024**, pp 1932–1936. https://doi.org/10.1039/d4py00151f.

P 19: Bio-Based Dynamic Thiol-Methacrylate Resins for Closed-Loop DLP 3D Printing

Theresa Hartl[1,2], Gregor Trimmel[2], Elisabeth Rossegger[1,2]
[1]Polymer Competence Center Leoben, Austria
[2]Institute for Chemistry and Technology of Materials, TU Graz, Austria

This work presents the development of a closed-loop-inspired digital light processing (DLP) 3D printing system based on dynamic, bio-based thiol-methacrylate resins that enable dissolution, reprocessing, and reprinting of printed objects. To achieve this, four methacrylate-based monomers containing ester functionalities were synthesized using different esterification strategies and formulated into photopolymer resins capable of forming dynamic covalent polymer networks.

Polymer networks were generated via UV-induced photopolymerization, and the influence of monomer structure and resin formulation on network formation, swelling behavior, and thermal stability was systematically investigated using FTIR spectroscopy, sol-gel analysis, and thermogravimetric analysis. Differences in material properties were strongly dependent on monomer chemistry and the amount of thiol crosslinkers.

To improve printability and closed-loop performance, resin formulations were optimized by adding various amounts of a multifunctional thiol crosslinker (trimethylolpropane tris(3-mercaptopropionate)). This adjustment enhanced chain mobility and improved dissolution behavior. The modified resin formulation based on glycidyl methacrylate and malic acid enabled successful 3D printing as well as complete dissolution of the polymer network. Subsequent addition of fresh resin components allowed repeated 3D printing cycles. Chemical analysis via gas chromatography of the recycled material confirmed the breakdown of the network into reusable methacrylate-containing species.

P 20: Small-Data ML Optimisation of a Photocurable Resin for Greyscale 3D Printing

Maksim Stupko[1], Sandra Schlögl[1]

[1]Polymer Competence Center Leoben GmbH, Sauraugasse 1,
AT-8700 Leoben, Austria. maksim.stupko@pccl.at

Grayscale vat photopolymerisation 3D printing enables spatial property control from a single resin through exposure-dose modulation. However, resin development remains largely empirical because formulation space is high-dimensional and cure behaviour of (meth)acrylates is nonlinear.[1] Here, we present a small-data machine-learning workflow for optimising a grayscale photocurable resin within a closed acrylate/methacrylate formulation space. A dataset of 57 formulations and 204 DSC-derived glass-transition-temperature (Tg) measurements was assembled across cure times from 5 to 600 s. Each formulation was encoded using composition, cure time, total polymerisable functionality, and monomer-property descriptors. A CatBoost model was trained to predict dose-dependent Tg evolution despite uneven time-series depth and censoring in the low-Tg region. Grayscale suitability was defined in a two-objective space favouring low Tg at short exposure and a small Tg increase between 5 and 15 s. The model was used to virtually screen 200,000 candidate formulations, rank promising regions of the design space, and select formulations for experimental validation. The optimised resin showed a tunable grayscale response from a single formulation and supported proof-of-concept printing of a cube with a radiopaque feature. These results indicate that information-rich small datasets can support resin screening for grayscale printing, ranking and help guide the development of heterogeneous 3D printed photopolymer systems, with potential applications in functionally graded body-mimicking models.

Acknowledgement

This research project (grant number: 911658) was funded by COMET – Competence Centers for Excellent Technologies – through BMIMI, BMWET, and the co-financing federal provinces (Styria through SFG, Upper Austria, Vorarlberg) and carried out with the participation of scientific and company partners. The COMET program is managed by FFG.

References

(1) Fei, G.; Parra-Cabrera, C.; Zhong, K.; Clays, K.; Ameloot, R. From Grayscale Photopolymerization 3D Printing to Functionally Graded Materials. Adv. Funct. Mater. 2024, 34, 2314635. https://doi.org/10.1002/adfm.202314635

P 21: Light and Temperature Controlled Dual Catalyst Dynamic Polymer Networks

Yunqi Chen[1,2], Matthias Udo Mayer-Kriehuber[1,2], Sandra Schlögl[1,2]

[1]Polymer Competence Center Leoben GmbH, Sauraugasse 1, A-8700 Leoben, Austria
[2]Department of Polymer Engineering and Science, Technical University of Leoben, Otto Glöckel-Strasse 2, Leoben, Austria

Thermally responsive polymer systems are increasingly explored as a route toward more sustainable and resource-efficient materials, as they enable recovery of functionality after damage and thereby extend service life[1]. Within this context, covalent adaptable networks (CANs) have emerged as a key strategy, combining the dimensional stability of thermosets with the ability to undergo bond exchange reactions, which allows reshaping, repair, and recycling without loss of network integrity[2]. A central challenge, however, lies in controlling the onset and rate of these dynamic processes[3]. In this regard, latent catalysts provide a powerful strategy, as they enable precise tuning of stress relaxation kinetics and decouple viscoelastic behavior from permanent network formation[4]. This approach resolves the fundamental trade-off in conventional CANs by preserving creep resistance under service conditions while enabling fast and efficient reprocessing upon selective activation.

To achieve such spatiotemporal control over bond exchange reactions, stimulus-responsive catalyst systems are required. Photo-base generators (PBGs) enable rapid and spatially resolved activation under light irradiation, allowing high-resolution patterning. In contrast, thermo-base generators (TBGs) provide uniform activation throughout bulk materials and complex geometries via thermal triggering[4, 5]. The combination of these complementary activation modes enables orthogonal and selective control over network dynamics in dynamic polymer systems.

In this work, we propose a dual-stimuli approach to gate transesterification reactions in a thiol–ene dynamic network through the combined use of PBGs and TBGs. This system enables switchability of dynamic bond exchange reactions via light and temperature. High spatial precision and uniform bulk activation are achieved simultaneously without compromising network robustness, enabling highly reproducible and fully reversible ON/OFF states.

Acknowledgement

The research work was carried out within the COMET-Module project “Repairtecture” (project-no.: 904927) at the Polymer Competence Center Leoben GmbH (PCCL, Austria) within the framework of the COMET-program of the Federal Ministry for Innovation, Mobility and Infrastructure and the Federal Ministry of Economy, Energy and Tourism. The COMET-Module is funded by the Austrian Government and the State Governments of Styria and Upper Austria.

Part of the research was also conducted within the production of the future project “CircularEpoxy” (project number: 58728995), which received funding from the Austrian Research Promotion Agency (FFG).

References

(1) Bowman, C. N.; Kloxin, C. J. Covalent Adaptable Networks: Reversible Bond Structures Incorporated in Polymer Networks. Angew. Chem. Int. Ed. 2012, 51 (18), 4272–4274. https://doi.org/10.1002/anie.201200708.

(2) Alabiso, W.; Schlögl, S. The Impact of Vitrimers on the Industry of the Future: Chemistry, Properties and Sustainable Forward-Looking Applications. Polymers 2020, 12 (8), 1660. https://doi.org/10.3390/polym12081660.

(3) Giebler, M.; Sperling, C.; Kaiser, S.; Duretek, I.; Schlögl, S. Epoxy-Anhydride Vitrimers from Aminoglycidyl Resins with High Glass Transition Temperature and Efficient Stress Relaxation. Polymers 2020, 12 (5), 1148. https://doi.org/10.3390/polym12051148.

(4) Mayer-Kriehuber, M. U.; Sattler, E.; Reisinger, D.; Bautista-Anguís, D.; Gaca, S.; Egger, P. M.; Sabatino, F. A.; Maar, S.; Schlögl, S. Temperature Orthogonal Dynamic Polymer Networks. Chem. Sci. 2026, 17 (16), 8260–8271. https://doi.org/10.1039/D5SC10098D.

(5) Reisinger, D.; Dietliker, K.; Sangermano, M.; Schlögl, S. Streamlined Concept towards Spatially Resolved Photoactivation of Dynamic Transesterification in Vitrimeric Polymers by Applying Thermally Stable Photolatent Bases. Polym. Chem. 2022, 13 (9), 1169–1176. https://doi.org/10.1039/D1PY01722E.

P 22: Gas-signaling polymer coatings with reprocessable properties for battery safety applications

Florine Grave[1], Van-Kien Hoang[1], Daniel Bautista-Anguís[1], Sandra Schlögl[1]
[1]*Polymer Competence Center Leoben, Sauraugasse 1, 8700 Leoben, Austria*

While lithium-ion batteries are essential components of modern energy storage systems, their safety remains a critical concern. As energy density increases and battery packs become more integrated, the risk of thermal runaway and explosions also rises. In many cases, these failures are preceded by localized hot spots that conventional battery management systems struggle to detect due to their limited spatial resolution and delayed response.[1,2]

For this reason, gas-based diagnostics have lately been investigated as a complementary early warning strategy. One promising approach relies on thermo-responsive polymer coatings that release volatile tracer molecules at defined temperatures. When combined with metal oxide (MOx) gas sensors, these coatings enable indirect and noninvasive detection of overheating events.[1,2] Recent work has also shown that thermally activated functionalities can be covalently incorporated into polymer networks, leading to more reproducible trigger temperatures and improved stability under ambient conditions.[1,2] In parallel, integrating these functionalities within dynamic covalent polymer networks offers additional advantages, such as reprocessability after gas release or self-healing prior to outgassing.[2,3]

In this work, polyurethane coatings containing additives as functional components designed to release tracer gases at temperatures critical for lithium-ion batteries are considered. Emphasis is placed on additives activating around 120 °C to promote controlled outgassing during early overheating events, while simultaneously contributing to dynamic processes within the polymer network. This study examines thermoactivated systems that integrate gas release with dynamic exchange in the polymer matrix, including reactive components such as thermo-generated bas (TBG) precursors, latent catalysts, network modifying agents, and multifunctional compounds like Ethylenediamine-N,N,N′,N′-tetra-2-propanol (EDTP), which acts as crosslinker and transcarbamoylation catalyst

Acknowledgement

The research was conducted as part of the COMET-Module Project BattLab (project no.: 904924), with contributions by Technical University of Leoben (Austria), Virtual Vehicle Research GmbH (Austria), hofer powertrain GmbH (Austria), Isovolta AG (Austria) and Resch GmbH (Austria) and the Polymer Competence Center Leoben GmbH (Austria). BattLab is funded within the COMET Competence Centers for Excellent Technologies Programme by the Austrian Federal Ministry for Innovation, Mobility and Infrastructure, the Austrian Federal Ministry for Economy, Energy and Tourism, and the province Styria and SFG. The COMET Programme is managed by FFG founded by the national funding institution for industry-related research and development (FFG) in Austria.

References

(1) Bautista-Anguís, D.; Wolfberger, A.; Rabe, M.; Tomaszczyk, S.; Schlögl, S. Implementation of Thermo-Responsive Polymer Coatings for an Early Warning against Critical Temperature States of Thermo-Sensitive Electronic Devices with Metal Oxide (MOx) Gas Sensors. Prog. Org. Coat. 2023, 178, 107444. DOI: 10.1016/j.porgcoat.2023.107444.

(2) Hoang, V.-K.; Bautista-Anguís, D.; Ferdigg, G.; Schlögl, S. Dynamic Thermo-Responsive Polythiourethane–Urethane Coatings for Enhanced Energy Storage Safety. Polymer 2026, 349, 129758. DOI: 10.1016/j.polymer.2026.129758.

(3) Mayer-Kriehuber, M. U.; Sattler, E.; Reisinger, D.; Bautista-Anguís, D.; Gaca, S.; Egger, P. M.; Sabatino, F. A.; Maar, S.; Schlögl, S. Temperature-Orthogonal Dynamic Polymer Networks. Chem. Sci. 2026. DOI: 10.1039/D5SC10098D.

P 23: Impact of Molecular Representations and Data Splitting Strategies on Polymer Glass Transition Temperature Prediction and Uncertainty Estimation

Angelika Hable[1], Dieter P. Gruber[1]
[1]Polymer Competence Center Leoben, Saurauggasse 1 8700 Leoben

Accurate prediction of polymer properties using machine learning can significantly accelerate materials discovery and reduce experimental effort in polymer design[1]. However, the use of random data splits can lead to overly optimistic estimates of model generalization[2]. In this work, we investigate the impact of molecular representations and data splitting strategies on predictive performance and uncertainty estimation for glass transition temperature (T_g) prediction using the OpenPoly dataset[1]. The dataset was evaluated using both a random split and a scaffold-based split[3] to assess generalization to structurally novel polymers. Structural fingerprints, physicochemical descriptors, and their combination were compared using an ensemble of XGBoost (XGBRegressor) models to estimate predictive uncertainty. A set of 15 interpretable molecular descriptors was constructed using RDKit[4], inspired by previous work[5], and combined with Morgan fingerprints (radius=2, 2048 bits), corresponding to the widely used ECFP4 representation[6]. In case of a random split, the combined representation achieves the best performance (R^2=0.89, RMSE=38.1 K), outperforming fingerprints and descriptors. However, in case of a scaffold-based split designed to evaluate generalization to unseen polymer chemistries, performance of the combined representation decreases significantly (R^2=0.77, RMSE=58.9 K), revealing substantial limitations in extrapolation capability. Uncertainty quality was evaluated using the Spearman correlation (ρ) between predicted uncertainty and absolute error. While the combined model performs best under random split conditions (ρ=0.31), descriptor-based models provide more robust uncertainty estimates under scaffold split conditions (ρ=0.32), whereas fingerprint-based models show weak correlation (ρ=0.09). Under scaffold split conditions, prediction errors increase significantly for low T_g values (<250 K), which are underrepresented in the dataset. The model shows a bias toward the dominant T_g range, leading to systematic overestimation in sparsely populated regions of the data space. No such dependence is observed under random split conditions. Overall, the results demonstrate that both feature representation and evaluation strategy strongly influence polymer property prediction. While combined representations yield the best predictive performance, generalization and uncertainty estimation remain challenging under distribution shift. These findings highlight the need for more robust and balanced datasets and provide guidance for the reliable application of machine learning in polymer design.

Acknowledgement

This research project (grant number: 911658) was funded by COMET – Competence Centers for Excellent Technologies – through BMIMI, BMWET, and the co-financing federal provinces (Styria through SFG, Upper Austria, Vorarlberg) and carried out with the participation of scientific and company partners. The COMET program is managed by FFG.

References

(1) Wang, J.-F.; Sun, Y.-B.; Chen, Q.-T.; Ji, F.-F.; Song, Y.-Y.; Ruan, M.-Y.; Wang, Y. OpenPoly: A Polymer Database Empowering Benchmarking and Multi-property Predictions. *Chin J Polym Sci* **2025**, *43* (10), 1749–1760. DOI: 10.1007/s10118-025-3402-y.

(2) Deng, J.; Yang, Z.; Wang, H.; Ojima, I.; Samaras, D.; Wang, F. A systematic study of key elements underlying molecular property prediction. *Nature communications* **2023**, *14* (1), 6395. DOI: 10.1038/s41467-023-41948-6. Published Online: Oct. 13, 2023.

(3) Wu, Z.; Ramsundar, B.; Feinberg, E. N.; Gomes, J.; Geniesse, C.; Pappu, A. S.; Leswing, K.; Pande, V. MoleculeNet: a benchmark for molecular machine learning. *Chemical science* **2018**, *9* (2), 513–530. DOI: 10.1039/C7SC02664A. Published Online: Oct. 31, 2017.

(4) Greg Landrum; Paolo Tosco; Brian Kelley; Ricardo Rodriguez; David Cosgrove; Riccardo Vianello; sriniker; Peter Gedeck; Gareth Jones; Eisuke Kawashima; NadineSchneider; Dan Nealschneider; tadhurst-cdd; Andrew Dalke; Matt Swain; Brian Cole; Samo Turk; Aleksandr Savelev; Niels Maeder; Rachel Walker; Alain Vaucher; Maciej Wójcikowski; Hussein Faara; Ichiru Take; Vincent F. Scalfani; Yakov Pechersky; Kazuya Ujihara; Daniel Probst; Jeremy Monat; Juuso Lehtivarjo. *rdkit/rdkit: 2026_03_1 (Q1 2026) Release*; Zenodo, 2026.

(5) Casanola-Martin, G. M.; Karuth, A.; Pham-The, H.; González-Díaz, H.; Webster, D. C.; Rasulev, B. Machine learning analysis of a large set of homopolymers to predict glass transition temperatures. *Communications chemistry* **2024**, *7* (1), 226. DOI: 10.1038/s42004-024-01305-0. Published Online: Oct. 2, 2024.

(6) Rogers, D.; Hahn, M. Extended-connectivity fingerprints. *Journal of chemical information and modeling* **2010**, *50* (5), 742–754. DOI: 10.1021/ci100050t.

P 24: Environmental Stress Cracking as a Limiting Factor in Recycled HIPS Performance

Katarina Marković[1,2], Jutta Geier[1,2], Florian Arbeiter[2,3],
Márton Bredács[1], Gernot Oreski [1,2]

[1]*Polymer Competence Center Leoben GmbH, Leoben, Austria*
[2]*Chair of Materials Science and Testing of Polymers, Technical University of Leoben, Leoben, Austria*
[3]*Christian Doppler Labor ImReMat, Technical University of Leoben, Leoben, Austria*

The increasing incorporation of recycled polymers into structural materials requires a deeper understanding of their performance under combined mechanical and environmental loading. In particular, environmental stress cracking (ESCR) represents a critical failure mechanism, as it can drastically reduce material lifetime in the presence of aggressive media, even when conventional mechanical properties appear largely unaffected.[1,2] In this study, the ESCR behavior of high-impact polystyrene (HIPS) systems containing both virgin and recycled fractions was investigated using tensile creep rupture testing under different environmental conditions. A pronounced reduction in time to failure was observed when specimens were exposed to an oil-based medium, clearly demonstrating the strong influence of environmental conditions on crack initiation and propagation. This effect was consistently observed across all investigated material systems, highlighting the dominant role of the surrounding medium in determining long-term performance. Beyond the environmental influence, particular attention was given to the material architecture, specifically the distribution and interaction of virgin and recycled layers. The results indicate that not only the presence of recycled content, but also its spatial arrangement within the material, plays a crucial role in ESCR resistance. When the recycled phase is exposed to the medium, a significant reduction in performance is observed, suggesting that direct contact between media and more susceptible material regions accelerates failure. In contrast, sufficient coverage by a virgin material layer can act as a protective barrier, delaying crack initiation and improving overall resistance. The findings underline the importance of considering both environmental conditions and material design when evaluating recycled polymer systems. In particular, they highlight the need for tailored material architectures and appropriate testing methodologies that capture realistic service conditions. This work contributes to a better understanding of ESCR in both recycled polymers and systems containing different layers of recycled and virgin material combinations. It supports the development of more reliable material concepts for circular material applications.

Acknowledgement

This research project (grant number: 911658) was funded by COMET – Competence Centers for Excellent Technologies – through BMIMI, BMWET, and the co-financing federal provinces (Styria through SFG, Upper Austria, Vorarlberg) and carried out with the participation of scientific and company partners. The COMET program is managed by FFG.

References

(1) Robeson, L. M. Environmental stress cracking: A review. Polymer Engineering & Sci 2013, 53 (3), 453–467. DOI: 10.1002/pen.23284.

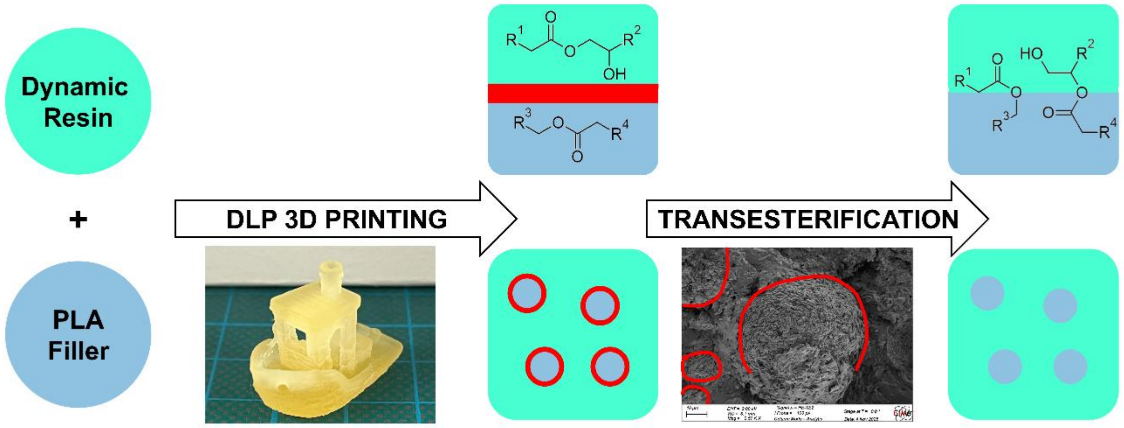
(2) Andena, L. Effect of processing on the environmental stress cracking resistance of high-impact polystyrene. Polymer Testing 2016 (54). DOI: 10.1016/j.polymertesting.2016.06.017. Published Online: June 2016.

P 25: Thermoset meets Thermoplastic: Upcycling PLA in Digital Light Processing 3D Printing of Dynamic Thiol–Ene Composites

Szymon Gaca[1,2], Daniel Bautista-Anguís[1,2], Milena Gleirscher[1,2], Michele Bonacina[3], Yves Leterrier[3], Véronique Michaud[3], and Sandra Schlögl[1,2]

[1] *Polymer Competence Center Leoben GmbH (PCCL), Sauraugasse 1, 8700 Leoben, Austria*
[2] *Technical University of Leoben (TUL), Otto Glöckel-Straße 2/IV, 8700 Leoben, Austria*
[3] *Ecole Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland*

This work presents a photo-curable covalent adaptable network (CAN) based on a dynamic thiol–ene system incorporating polylactic acid (PLA) as a functional filler. In contrast to conventional inert fillers, PLA can participate in the material through ester-based transesterification reactions at the matrix–filler interface, enabling dynamic bond exchange.[1] At room temperature, PLA acts as a reinforcing phase, increasing stiffness and creep resistance. Above the melting range of PLA, the material retains fast stress relaxation behaviour comparable to the unfilled dynamic network.[2] These results demonstrate that PLA can function as an active component within DLP-printable dynamic polymer networks, linking processability, green strength, and adaptive behaviour. This approach supports the development of more sustainable and cost-efficient materials for additive manufacturing.



Acknowledgement

The research work was performed at the Polymer Competence Center Leoben GmbH (PCCL, Austria) within the #horizoneurope20212027 programme under the Marie Skłodowska-Curie Doctoral Networks (MSCA-DN) grant agreement No 101073432. Funding was provided by the European Union. Part of the research work was also carried out within the COMET-Module project “Repairtecture” (project-no.: 904927) at the Polymer Competence Center Leoben GmbH (PCCL, Austria) within the framework of the COMET-program of the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology and the Federal Ministry of Labour and Economy. Funding is provided by the Austrian Government and the State Governments of Styria and Upper Austria.

References

(1) Anthony, H.; Sandra, S.; Yves, L.; Véronique, M. Enhancing Reprocessability of Dynamic Polymer Composites with Thermally Sensitive Particles and Controlled Particle-Matrix Interfaces. Adv Compos Hybrid Mater 2026, 9 (2), 154. https://doi.org/10.1007/s42114-026-01669-y.

(2) Gaca, S. S.; Bautista Anguís, D.; Gleirscher, M.; Bonacina, M.; Leterrier, Y.; Michaud, V.; Schlögl, S. Thermoset Meets Thermoplastic: Upcycling PLA in Digital Light Processing 3D Printing of Dynamic Thiol-Ene Composites. Polym. Chem. 2026, 10.1039.D6PY00184J. https://doi.org/10.1039/D6PY00184J.

P 26: Tuning thiol-thioester dynamics in CANs via pre- and post-polymerization strategies

Roman Korotkov [1,2], John Vincent Tumaneng [3], Sara Dalle Vacche [3], Roberta Bongiovanni [3], Milena Gleischer [1,2], Sandra Schlögl [1,2] and Elisabeth Rossegger [1,2,4]
[1]Polymer Competence Center Leoben GmbH, Sauraugasse 1, 8700 Leoben, Austria; e-mail: roman.korotkov@pccl.at
[2]Institute of Chemistry of Polymeric Materials, Montanuniversität Leoben, Franz Josef-Strasse 18, 8700 Leoben, Austria
[3]Institute of Chemistry and Technology of Materials, Graz University of Technology Stremayrgasse 9, 8010 Graz, Austria
[4]Department of Applied Science and Technology, Politecnico di Torino, Corso Duca degli Abruzzi 24, Turin, 10129 Italy

Covalent adaptable networks (CANs) are a novel class of polymers which can undergo network rearrangement under external stimuli by dynamic bond exchange reactions. Depending on the dynamic chemistry, the exchange rate can be tuned by selection of suitable catalysts and the concentration of the dynamic compounds. Herein, we study the exchange dynamics in photo-curable CANs relying on thiol-thioester bond exchange mechanism. The concentration of dynamic thioester motifs influences the stress relaxation rate (pre-polymerization strategy). In addition, reducing the number of dynamic linkages increases the impact of diffusion, leading to deviations from the linear Arrhenius temperature dependence of the relaxation time.The ratio of Arrhenius-dependent input to the Rouse-dependent diffusion input was studied for different thioester concentrations. The performed investigations enabled the design of temperature sensors based on stress relaxation. Besides that, the possibility of 3D printing of materials differing substantially in their stress-relaxation kinetics via dual-vat multi-material DLP 3D-printing was demonstrated by printing multimaterial objects [1]. For the material with the highest dynamic bond concentration, we further investigated local control of bond-exchange dynamics through deactivation of the basic catalyst via photolysis of a covalently attachable photoacid (= post-polymerization strategy). Curing of the photopolymer was performed under 405 nm light, while local deactivation of the bond exchange was achieved by irradiation with 365 nm light. Spatial deactivation of the polymer surface was demonstrated by patterning of the material's surface by thermal imprinting [2].

Acknowledgement

The project was performed with the FORTIFIEDx project has received funding from the Horizon Europe programme under grant agreement Nº 101092049. Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the granting authority European Union's Horizon Europe research and innovation programme. Neither the European Union nor the granting authority can be held responsible for them.

Part of this project has received funding from the EU's Horizon 2021 programme under the Marie Skłodowska-Curie Doctoral Networks (MSCA-DN) grant agreement No 101073432.

Part of the research was also carried out within the COMET-Module project ”Repairtecture” (project-no.: 904927) at the Polymer Competence Center Leoben GmbH (PCCL, Austria) within the framework of the COMET-program of the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology and the Federal Ministry of Labour and Economy. The PCCL is funded by the Austrian Government and the State Governments of Styria, Upper and Lower Austria.

References

(1) Korotkov, R.; Gleirscher, M.; Schlögl, S.; Rossegger, E. Multimaterial Digital Light Processing Three-Dimensional Printing of Materials with Different Relaxation Kinetics | ACS Applied Polymer Materials. ACS Applied Polymer Materials 2025, 7 (21), 14581–14592. https://doi.org/10.1021/acsapm.5c02906.

(2) Korotkov, R.; Tumaneng, J. V.; Bongiovanni, R.; Dalle Vacche, S.; Rossegger, E.; Schlögl, S. Building From the Ground Up: A Procedural Guide to Locally Controlling Bond Exchange Kinetics in Dynamic Thiol-Thioester Networks. Macromolecular Rapid Communications 2025, 46 (22), e00654. https://doi.org/10.1002/marc.202500654.

P 27: Catalysis on Demand: Designing Thermally Latent Bases for Temperature-Orthogonal Vitrimers

M. U. Mayer-Kriehuber[1,2], E. Sattler[1], D. Reisinger[1,2], D. Bautista-Anguís[1,2], S. Gaca[1,2], P. M. Egger[1,3], F. A. Sabatino[1,2], S. Maar[1,2] and S. Schlögl[1,2]

[1]Polymer Competence Center Leoben GmbH, Sauraugasse 1, A-8700 Leoben, Austria.

[2] Department of Polymer Engineering and Science, Technical University of Leoben, Otto Glöckel-Strasse 2, Leoben, A-8700, Austria.

[3] Institute of Chemistry and Technology of Materials, Graz University of Technology, Stremayrgasse. 9, A-8010 Graz, Austria.

Thermally induced self-healing polymer systems have attracted growing interest in recent years, largely due to their potential to reduce material waste and prolong the service life of polymer-based products. Vitrimers represent a distinct class of intrinsically healable covalent adaptable networks that rely on thermo-activated associative bond exchange reactions. When heated above the glass transition temperature (Tg), these exchange reactions are markedly accelerated, allowing vitrimers to display viscoelastic, flow-like behaviour while preserving their crosslinked network structure. In hydroxyl–ester-based vitrimer systems, efficient transesterification above Tg typically requires the presence of a suitable catalyst. (1, 2)

To balance high creep resistance with rapid reprocessability (induced by thermos-activated bond exchange reactions), a comprehensive library of thermally latent base catalysts for transesterification was synthesised and systematically investigated. (3–5) The resulting thermo-base generators (TBGs) were characterized with respect to their thermal stability, decomposition pathways, and thermally triggered base release using thermogravimetric analysis (TGA), evolved gas analysis (EGA), nuclear magnetic resonance (NMR), and infrared (IR) spectroscopy. Controlled thermal activation and subsequent deactivation of the released bases enabled the design of polymer networks with switchable dynamic behaviour. The performance of these systems was validated through stress relaxation experiments, reshaping tests and healing evaluations.

By tailoring the molecular structure of the thermally latent catalysts, decomposition temperatures and activation times could be precisely adjusted across a wide temperature window. This tunability allows the design of temperature-orthogonal dynamic polymers, offering sequent-dependent activation and deactivation profiles. Overall, this approach provides a powerful platform for the development of dynamically switchable and sustainable polymer networks, opening new opportunities for advanced applications in future green composite industries.

Acknowledgement

The research work was carried out within the COMET-Module project "Repairtecture" (project-no.: 904927) at the Polymer Competence Center Leoben GmbH (PCCL, Austria) within the framework of the COMET-program of the Federal Ministry for Innovation, Mobility and Infrastructure and the Federal Ministry of Economy, Energy and Tourism. The COMET-Module is funded by the Austrian Government and the State Governments of Styria and Upper Austria. Part of the research was also conducted within the production of the future project "CircularEpoxy" (project number: 58728995), which received funding from the Austrian Research Promotion Agency (FFG).

References

1. Alabiso, W.; Schlögl, S. The Impact of Vitrimers on the Industry of the Future: Chemistry, Properties and Sustainable Forward-Looking Applications. *Polymers* **2020,** *12* (8). DOI: 10.3390/polym12081660.

2. Klingler, A.; Reisinger, D.; Schlögl, S.; Wetzel, B.; Breuer, U.; Krüger, J.-K. Vitrimer Transition Phenomena from the Perspective of Thermal Volume Expansion and Shape (In)stability. *Macromolecules* **2024,** *57* (9), 4246–4253. DOI: 10.1021/acs.macromol.4c00207.

3. Mayer-Kriehuber, M. U.; Sattler, E.; Krämer, J.; Reisinger, D.; Bautista-Anguís, D.; Uher, J.; Vidovic, E.; Schlögl, S. Synthesis of guanidine-based salts with benzoate and citrate counterions for application as thermolatent bases. *Monatsh Chem* **2025. DOI:** 10.1007/s00706-025-03405-6.

4. Mayer-Kriehuber, M. U.; Sattler, E.; Reisinger, D.; Bautista-Anguís, D.; Gaca, S.; Schmidleitner, C.; Duretek, I.; Vidovic, E.; Schlögl, S. Synthesis and characterization of thermolatent bases with varying activation temperatures. *RSC Adv.* **2025,** *15* (42), 35265–35280. DOI: 10.1039/D5RA05095B.

5. Reisinger, D.; Kriehuber, M. U.; Bender, M.; Bautista-Anguís, D.; Rieger, B.; Schlögl, S. Thermally Latent Bases in Dynamic Covalent Polymer Networks and their Emerging Applications. *Advanced materials (Deerfield Beach, Fla.)* **2023,** *35* (24), e2300830. DOI: 10.1002/adma.202300830.

<u>P 28:</u> Friction modification of laser-induced graphene (LIG) films through surface texturing

<u>Milena Gleirscher</u>[1,2], Francesco Greco[3],Sandra Schlögl[1,2]
[1]Chemistry of Functional Polymers, Polymer Competence Center Leoben GmbH, Sauraugasse 1, 8700 Leoben, Austria
[2]Chair of Chemistry of Polymeric Materials, Technical University of Leoben, 8700 Leoben, Franz Josef-Straße 18, Austria
[3]The Biorobotics Institute and Dept. of Excellence in Robotics & AI, Scuola Superior Sant'Anna, viale R. Piaggo34, 56025 Pontedera, Italy

Surface modification through texturing or patterning is an exciting strategy to modify the tribological behaviour of a surface.[1] Many techniques for surface texturing of various materials are available; here, an approach based on transformative Direct Laser Writing was explored. Irradiating a suitable precursor material (e.g., polyimide) with a laser source leads to the formation of laser-induced graphene (LIG).[2] This single-step, fast, maskless, and chemical-free process was used to fabricate repeating line patterns ranging from 200 µm to 30 µm. The friction and wear behaviour of the graphenic films was evaluated using a reciprocating ball-on-plate setup, and it was found that patterns with smaller line sizes exhibit lower coefficients of friction. The wear behaviour was investigated to gain an understanding of the impact of sliding on the LIG and the underlying abrasive mechanism that leads to the formation of fine wear debris.[3]

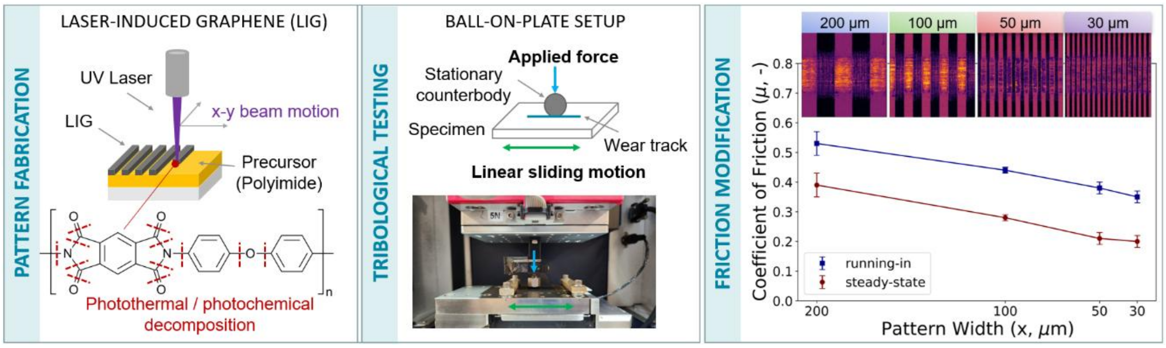


Figure 2: Schematics of laser scribing of LIG (left), the tribological test setup (center), and the resulting friction coefficients of the different patterns, including images of the resulting wear tracks (right).

References

(1) Costa, H. L.; Schille, J.; Rosenkranz, A. Tailored surface textures to increase friction—A review. Friction 2022, 10 (9), 1285–1304. DOI: 10.1007/s40544-021-0589-y.

(2) Lin, J.; Peng, Z.; Liu, Y.; Ruiz-Zepeda, F.; Ye, R.; Samuel, E. L. G.; Yacaman, M. J.; Yakobson, B. I.; Tour, J. M. Laser-induced porous graphene films from commercial polymers. Nat. Commun. 2014, 5, 5714. DOI: 10.1038/ncomms6714. Published Online: Dec. 10, 2014.

(3) Gleirscher, M.; Zeiler, S.; Parlanti, P.; Bandl, C.; Maier-Kiener, V.; Greco, F.; Schlögl, S. Friction and Wear Behavior of Laser-Induced Graphene Structures on Polyimide Films. Small science 2025, 5 (12), e202500335. DOI: 10.1002/smsc.202500335. Published Online: Oct. 15, 2025.

P 29: Material-Driven Design of Printed Strain Sensors for Structural and Industrial Monitoring

A. Lassnig[1], A. Hellmayr[2], P. Vailhé[1,3], T. Griesser[1]

[1]*Chemistry of Polymeric Materials, Department of Polymer Engineering and Science, Technical University of Leoben, Austria*
[2]*Ressources Innovation Center, Technical University of Leoben, Austria*
[3]*Chair of Mining Engineering and Mineral Economics, Department Mineral Resources Engineering, Technical University of Leoben, Austria*

Integrating tailored strain sensors directly into structural materials enables continuous in-service monitoring of critical components across a wide range of operating environments. Printed electronics, drawing on mature techniques from the graphic arts industry, provide a versatile platform for fabricating such sensors with geometries, dimensions, and mechanical properties customized to the field of application. This work presents design strategies for resistive strain sensors produced primarily by screen printing metal- and carbon-based conductive inks onto flexible polymeric substrates. The influence of curing conditions on film morphology and baseline electrical behavior is examined, and electromechanical testing is used to evaluate sensitivity, linearity, hysteresis, and durability under repeated loading. Design trade-offs between conductivity, gauge factor, and mechanical robustness are discussed, with practical guidelines for tuning sensor performance through ink formulation and processing. Particular emphasis is placed on applications requiring large strain tolerance and chemical resilience, including wearable devices, mining environments, and pressurized pipe systems. The results highlight printed electronics as a scalable and adaptable route for engineering strain sensors capable of reliable operation in both small-scale and harsh industrial settings.

P 30: Influence of Cation Structure on Oxalate-Based ThermoBase Generators for Dynamic Epoxy-Anhydride Networks

Nikolina Miočić[1,3], **Yuya Xiong**[1,2], **Yunqi Chen**[1,2], **Nanlan Wang**[1,2], **Matthias Udo Mayer-Kriehuber**[1,2], **Sandra Schlögl**[1,2]

[1]*Polymer Competence Center Leoben GmbH, Sauraugasse 1, A-8700 Leoben, Austria*
[2]*Department of Polymer Engineering and Science, Technical University of Leoben, Otto Glöckel-Strasse 2, Leoben, Austria*
[3]*Faculty of chemical engineering and technology, University of Zagreb, Trg Marka Marulića 20, Zagreb, Croatia*

Research on covalent adaptable networks (CANs) has increased in recent years due to the growing demand for sustainable and long-lasting polymeric materials. A prominent class of CANs is represented by vitrimers, which rely on associative exchange reactions to combine the mechanical properties of thermosets with the processability of thermoplastics.[1] A key challenge in these novel approaches is maintaining long-term storage stability and extended pot life in the resin formulation, as well as high stability of the latent catalyst in the cured material, while achieving defined activation temperatures and rapid catalytic activity within the dynamic network upon selective thermal activation.[2,3] While oxalate-based thermobase generators (TBGs) are promising candidates for high-Tg dynamic polymer networks, the role of the cation structure remains underexplored, especially with regard to extended storage stability.[1,3] The primary objective of this work is to systematically determine how variation of the base in oxalate based quaternary ammonium salts can tune the thermal stability and activation threshold of TBGs for potential future industrail application (e.g automotive or aerospace industriesTo investigate the influence of base structure, basicity, and steric hindrance on thermal stability, oxalate-based TBGs derived from imidazole, methylimidazole, and tetramethylguanidine were synthesized.[4] The thermal activation and release of the active bases were characterised in solid state using thermogravimetric analysis and evolved gas analysis. Furthermore, the catalysts were incorporated at 5 mol%, relative to epoxy groups, into a dynamic epoxy-anhydride network. To evaluate the catalyst performance within the dynamic network, TGA of the cured samples was performed alongside stress relaxation measurements of the non-activated and activated specimens.[5] This work provides a framework for tuning the thermal stability of TBGs through cation engineering, enabling the design of dynamic polymer networks with tailored processing and activation windows as well as enhanced shelf-life.

Acknowledgement

The research work was carried out within the COMET-Module project “Repairtecture” (projectno.: 904927) at the Polymer Competence Center Leoben GmbH (PCCL, Austria) within the framework of the COMET-program of the Federal Ministry for Innovation, Mobility and Infrastructure and the Federal Ministry of Economy, Energy and Tourism. The COMET-Module is funded by the Austrian Government and the State Governments of Styria and Upper Austria. Part of the research was also conducted within the production of the future project “CircularEpoxy” (project number: 58728995), which received funding from the Austrian Research Promotion Agency (FFG).

References

(1) Montarnal, D.; Capelot, M.; Tournilhac, F.; Leibler, L. Silica-Like Vitrimers from Transesterification in Epoxy Networks. Science 2011, 334 (6058), 965–968. https://doi.org/10.1126/science.1212648.

(2) Mayer-Kriehuber, M. U.; Sattler, E.; Gaca, S.; Schlögl, S. Synthesis and Characterization of Thermolatent Bases with Varying Activation Temperatures. RSC Adv. 2025, 15 (2), 102– 110. https://doi.org/10.1039/D4RA08211C.

(3) Mayer-Kriehuber, M. U.; Sattler, E.; Gaca, S.; Schlögl, S. Advanced Characterization of Thiol-Ene Vitrimer Networks for High-Performance Applications. Polymer 2026, 294, 130175. https://doi.org/10.1016/j.polymer.2026.130175.

(4) Vozzolo, G.; Ximenis, M.; Mantione, D.; Fernández, M.; Sardon, H. Thermally Reversible Organocatalyst for the Accelerated Reprocessing of Dynamic Networks with Creep Resistance. ACS Macro Lett. 2023, 12 (11), 1536–1542. https://doi.org/10.1021/acsmacrolett.3c00544.

(5) Mayer-Kriehuber, M. U.; Sattler, E.; Reisinger, D.; Bautista-Anguís, D.; Gaca, S.; Egger, P. M.; Sabatino, F. A.; Maar, S.; Schlögl, S. Temperature Orthogonal Dynamic Polymer Networks. Chem. Sci. 2026, 17 (16), 8260–8271. https://doi.org/10.1039/D5SC10098D.

P 31: Thiol-yne click-derived dynamic networks for 3D printing and reprocessing

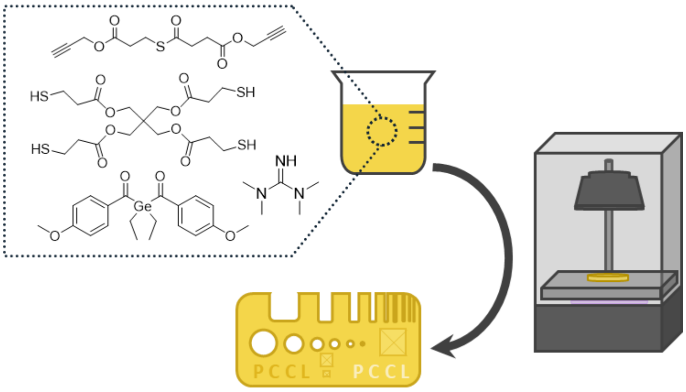
Pia-Maria Egger[1,2], Roman Korotkov[1], Gregor Trimmel[2], Sandra Schlögl[1,3], Elisabeth Rossegger[1,2]

[1]Polymer Competence Center Leoben GmbH (PCCL), Sauraugasse 1,8700 Leoben, Austria

[2]Graz University of Technology, Institute of Chemistry and Technology of Materials, Stremayrgasse 9, 8010 Graz, Austria

[3]Technical University of Leoben, Institute of Polymer Engineering and Science, Otto Glöckel-Straße 2, 8700 Leoben, Austria

Recent advances in polymer science have focused on materials that maintain their mechanical and functional properties after reprocessing, with covalent adaptable networks (CANs) being a promising strategy. In general, CANs combine the chemical and dimensional stability of thermosets with the recyclability of thermoplastics, enabled by reversible bonds that allow network topology rearrangement.[1] Their dynamic nature allows damaged parts to self-heal, extending product lifetimes and reducing material consumption.[2] Thiol-ene resins are an attractive option compared to commercial (meth)acrylate resins, since they offer delayed gelation, reduced shrinkage stress and nearly quantitative conversions.[3-4] However, thiol-ene networks are often too soft for applications like additive manufacturing, but thiol-yne networks overcome this by increasing the crosslink density and thereby the mechanical properties.[5-6]



Picture 1: Schematic of 3D printing workflow.

Therefore, we synthesized three monomers carrying alkyne functionalities as well as thioester moieties to enable network formation via a thiol-yne click reaction. By using 2 equivalents of thiol, 1 equivalent of the corresponding monomer, 2.5mol% TMG and 4.5 mol% Ivocerin® the photosensitive resins were prepared. To explore the resulting dynamic behaviors, we conducted stress relaxation measurements at various temperatures. Additionally, DSC, DMA and TGA measurements were performed to investigate the thermal properties. Finally, we 3D-printed our resin and successfully reprocessed it using the VCM process.

Acknowledgement

“Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the granting authority European Union's Horizon Europe research and innovation programme. Neither the European Union nor the granting authority can be held responsible for them. The DECIPHER project has received funding under the Horizon Europe research and innovation programme (the grant agreement No 101137242)”.

Part of the research work was performed at the Polymer Competence Center Leoben GmbH (PCCL, Austria) within the framework of the COMET-program of the Federal Ministry for Transport, Innovation and Technology and the Federal Ministry of Science, Research and Economy with contributions by academic and commercial partners. The PCCL is funded by the Austrian Government and the State Governments of Styria, Lower Austria and Upper Austria.

The authors thank Birgit Ehmann (TU Graz) for the upscaling of the TE-1 monomer. We also acknowledge Karin Bartl (TU Graz) for the TGA and DSC measurements, Sebastian Maar (PCCL) for the DMA measurements and Meltprep for providing access to the VCM technology.

References

(1) Kloxin, C. J.; Scott, T. F.; Adzima, B. J.; Bowman, C. N. Covalent Adaptable Networks (CANs): A Unique Paradigm in Crosslinked Polymers. Macromolecules 2010, 43 (6), 2643–2653. DOI: 10.1021/ma902596s.

(2) Voet, V. S. D. Closed-Loop Additive Manufacturing: Dynamic Covalent Networks in Vat Photopolymerization. ACS Mater. Au 2023, 3 (1), 18–23. DOI: 10.1021/acsmaterialsau.2c00058.

(3) Lu, H.; Carioscia, J. A.; Stansbury, J. W.; Bowman, C. N. Investigations of step-growth thiol-ene polymerizations for novel dental restoratives. Dental materials : official publication of the Academy of Dental Materials 2005, 21 (12), 1129–1136. DOI: 10.1016/j.dental.2005.04.001.

(4) Morgan, C. R.; Magnotta, F.; Ketley, A. D. Thiol/ene photocurable polymers. J. Polym. Sci. Polym. Chem. Ed. 1977, 15 (3), 627–645. DOI: 10.1002/pol.1977.170150311.

(5) Kuenstler, A. S.; Hernandez, J. J.; Trujillo-Lemon, M.; Osterbaan, A.; Bowman, C. N. Vat Photopolymerization Additive Manufacturing of Tough, Fully Recyclable Thermosets. ACS applied materials & interfaces 2023, 15 (8), 11111–11121. DOI: 10.1021/acsami.2c22081.

(6) Fairbanks, B. D., Scott T. F., Kloxin C. J., Anseth K. S., Bowman C. N. Thiol−Yne Photopolymerizations: Novel Mechanism, Kinetics, and Step-Growth Formation of Highly Cross-Linked Networks. Macromolecules 2009 42 (1), 211-217. DOI: 10.1021/ma801903w

P 32: Toward Traceable Polyolefins via Fluorescent Coumarin Integration

Johanna M. Uher[1,2], **Martin de Biasio**[3], **Gernot Oreski**[1], **Gregor Trimmel**[2],
Elisabeth Rossegger[1,2]

[1]Polymer Competence Center Leoben GmbH, Sauraugasse 1, 8700 Leoben

[2]Institute of Chemistry and Technology of Materials, Graz University of Technology

Stremayrgasse. 9, 8010 Graz, Austria

uher@student.tugraz.at, https://www.tugraz.at

[3]Silicon Austria Labs GmbH, Sandgasse 34, 8010 Graz

Advancing towards a circular economy that maintains plastics in their highest-value state is essential to mitigate environmental impacts and promote recycling, reuse, and reduction. Despite the ubiquitous relevance of recycling, significant challenges remain, including the detection of microplastics and the accurate classification of polymer recycling qualities. Identifying opaque polymers and producing recyclates with properties comparable to virgin materials is difficult, as the thermal history of polymers is often unknown.[1]

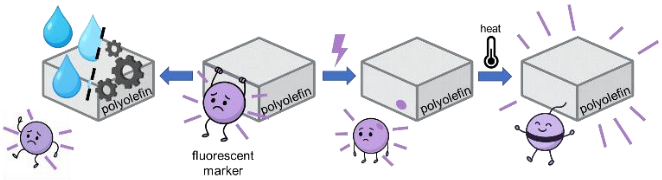


Figure 1. Schematic representation of the grafting process for fluorescent labeling of polyolefins.

Current used functional markers in the recycling industry frequently suffer from migration due to the lack of covalent attachment to the polymer matrix. Consequently, recycled plastics containing such markers are rarely approved for food packaging, as dye migration and contamination cannot be ruled out.[2] This project focuses on the synthesis of fluorescent coumarin-based dyes [3], which are modified to introduce functional groups enabling covalent attachment to polymers through various grafting techniques. These include free radical grafting, plasma grafting combined with silanization. Such methods are scalable and compatible with industrial processing, as they can be applied under elevated temperatures or pressures without requiring polymer dissolution.

References:

(1). Colijn, F. Fraiture, E. Gommeh, K. Schroën, T. Metze, J. Clean. Prod. 2022, 370, 133472.

(2) Z. O. G. Schyns, M. P. Shaver, Macromol. Rapid Commun. 2021, 42 (3), e2000415.

(3) K. Abraham, F. Wöhrlin, O. Lindtner, G. Heinemeyer, A. Lampen, Mol. Nutr. Food Res. 2010, 54 (2), 228–239.

P 33: Frontal Polymerization of Dynamic Networks

Christoph Schmidleitner[1,2], Stefan Hirner[1,2], Matthias Udo Kriehuber[1], Roman Korotkov[1], Sandra Schlögl[1], Elisabeth Rossegger[1,2]

[1]*Polymer Competence Center Leoben GmbH (PCCL), Sauraugasse 1, 8700 Leoben, Austria)*

[2]*Graz University of Technology, Institute of Chemistry and Technology of Materials, Stremayrgasse 9, 8010 Graz, Austria*

Frontal polymerization (FP) allows the transformation of monomers into polymers within a spatially confined reaction zone, known as the front. This reaction front travels through the bulk material in a self-propagating, autocatalytic manner. The driving force is the exothermic heat released during the polymerization reaction, meaning that external energy is only required to initiate the process. Owing to its rapid curing behavior and high energy efficiency, FP has been explored for various monomer systems.[1,2]

In contrast, conventional curing methods such as thermal curing and photopolymerization exhibit notable limitations. Thermal processes generally require long curing times and considerable energy input, while photopolymerization proceeds faster but is restricted by the limited penetration depth of light, making it mainly suitable for thin layers. To address these disadvantages, different types of frontal polymerization have been developed.

As with thermally or photo-cured networks, polymers produced via FP demonstrate high chemical stability and excellent thermomechanical properties. Beyond energy efficiency, current material design increasingly focuses on aspects such as recyclability, reusability, and reprocessability. These properties can be introduced into thermoset materials by incorporating dynamic bonds. Various bond exchange mechanisms can be utilized for this purpose. In this work, different chemical systems, including transesterification and coordinative bond exchange, were examined for their suitability in frontal polymerization and the formation of dynamic polymer networks.

References

(1) Schmidleitner, C.; Kriehuber, M. U.; Korotkov, R.; Schlögl, S.; Rossegger, E. Frontal polymerization of thiol–acrylate covalent adaptable networks. *Polym. Chem.* **2025**, *16* (8), 963–971. DOI: 10.1039/D4PY01106F.

(2) Schmidleitner, C.; Hirner, S.; Rossegger, E. Zinc-based coordination exchange in epoxy networks cured via frontal polymerization. *Polym. Chem.* **2026**, *17* (16), 1555–1561. DOI: 10.1039/D5PY01170A.