

## Green Polymers

The Green Polymers group applies science and engineering principles to enable the more sustainable generation and use of polymeric materials.



The Green Polymers group applies science and engineering principles to enable the more sustainable generation and use of polymeric materials.

### Main expertise fields

- Generation of monomers, pre-polymers and fillers from renewable resources
- Synthesis, formulation and structure-properties relations of bio-based / sustainable thermoplastics, thermosets and their composites
- Materials classes: aminoplasts, benzoxazines, cellulose & cellulose derivatives, elastomers & rubbers, epoxies, fiber composites, interpenetrating networks, lignin, nanoparticles & nanocomposites, plant oils & derivatives, phenolic resins, polyesters, polysaccharides & derivatives, polyurethanes (conventional & non-isocyanate, foams), silicones, vinyl ester resins, vitrimers
- Process approaches: additive manufacturing, chemical recycling, composite & nanocomposite processing, compression molding, extrusion, injection molding, mechanical recycling
- Characterization techniques: FTIR, NIR & NMR spectroscopy, fire testing, gas sorption & surface area analysis, GPC, mass spectrometry, permeability testing, porosimetry, rheology, thermal analysis, x-ray diffraction

### Research challenge

- Design of monomers, (pre-)polymers and fillers with enhanced safety and sustainability in mind
- Extraction, isolation and chemical modification of monomers, (pre-)polymers and fillers from biomass
- Identifying of safer, more sustainable synthetic methods and (re-)processing approaches
- Developing new approaches to manage the end-of-life of polymeric materials
- Ensuring that solutions deliver necessary performance levels, scalability, industrial relevance and socioeconomic impact

### Application areas

- Additive manufacturing
- Adhesives and coatings
- Automotive and transportation
- Biomedical applications
- Electronics and electrical applications
- High performance polymeric materials
- Packaging
- Space & aerospace
- Structural materials
- New polymers and additives for tires

### Main assets

1. **3DPRINTING** (ongoing)
  - Bio-derived materials for additive manufacturing
2. **CARBONISE** (ongoing)
  - Hemicellulose-derived polyesters
3. **Goodyear-LIST partnership** (ongoing)
  - Bio-based process & performance additives
    - Novel traction resins
    - Additive compatibility, migration and performance
4. **LIGNOBLEN** (ongoing)
  - Lignin-based benzoxazine resins
5. **Other assets (academic & industrial)**
  - Alternative thermoset, adhesive and coating formulations for industrial applications
  - Bio-based epoxies, vitrimers and fiber composites
  - Carbanol based adhesives and polymeric materials
  - High performance foams and porous materials for industrial applications
  - Nanocomposites adapted to specific industrial needs

### Equipment

- Anton Paar MCR 302 rheometer
- Christ Martin Alpha 3-4 LSC basic freeze dryer
- LabThink VAC-VBS permeation analyser
- Nussli MKZALU 20 Supermassivolver ultra fine friction grinder
- Mbraun LABStar four-arm glove box
- Mbraun SPS 800 solvent purification systems
- Parr 4564 benchtop carbon dioxide reactor
- Schlenk lines
- Synthesis reactors up to 5 L
- Top Industrie custom-built polycondensation reactor
- UV conveyor
- Vacuum ovens

### Selected publications

- Schmidt, D. F. Processing of polymer nanocomposites. In *Industry Guide to Polymer Nanocomposites*, 1. ed.; Beyer, G., Ed.; A PID technical book; Plastics Information Direct: Bristol, 2009.
- Dunkerley, E.; Schmidt, D. F. *Understanding the Consequences of Interpolation Using Model Polymer Nanocomposites*. *Macromolecules* 2015, 48 (20), 7620-7630.
- Puchot, A.; Verge, P.; Fouquet, T.; Vanczykiewicz, C.; Vidal, F.; Habibi, Y. *Breaking the Summery of Benzoxazines: A Paradigm to Take the Design of Bio-Based Thermosets*. *Green Chem.* 2016, 18 (11), 3346-3353.
- Buono, P.; Davari, A.; Averous, L.; Habibi, Y. *Lignin-Based Materials Through Thiol-Maleimide "Click" Polymerization*. *ChemSusChem* 2017, 10 (5), 984-992.
- Liu, W.; Reynaud, E.; Schmidt, D. F. *Carbonyl Selection, Curing, and Stress Relaxation in High-Performance Epoxy Vitrimers*. *Ind. Eng. Chem. Res.* 2017, 56 (10), 2667-2672.
- Trejo Machin, A.; Verge, P.; Puchot, A.; Quintana, R. *Dioxane Acid as an Alternative to the Detection of Dynamic Supersites in the Synthesis of Polybenzoxazines*. *Green Chem.* 2017, 19 (21), 5065-5073.
- Valdebentón, F.; García, R.; Cruzes, K.; Cudad, G.; Chinga Carrasco, G.; Habibi, Y. *CO<sub>2</sub> Adsorption of Surface-Modified Cellulose Nanofiber Films Derived from Agricultural Wastes*. *ACS Sustainable Chem. Eng.* 2018, 6 (10), 12603-12612.
- Kurocho, C. N.; Liu, W.; Müller, J.; Karmeliner, J.; Stehle, J.; Kahl, A.; Reynaud, E.; Schmidt, D. F. *In Enhancing the Sustainability of High-Performance Fiber Composites*. ACS Symposium Series; Cheng, H. N., Gross, R. A., Smith, P. B., Eds.; American Chemical Society: Washington, DC, 2018; Vol. 1310, pp 281-295.
- Geesens, G. D.; Li, C.; Pireaux, E.; Habibi, Y.; Remita, M.; Colbeau-Jacquin, C.; Oberndorfer, M. N. *Controlled Photocrosslinked Chitosan and Chitosan/Carbon Nanotubes (CN) Films with a Local Biocatalytic Activity*. *Chem Mater* 2019, 31 (13), 4653-4663.
- Quenne, B.; Kasmi, N.; Dieden, R.; Collot, S.; Habibi, Y. *Isocyanate-Free Fully Bio-Based Star Polymer-Urethanes: Synthesis and Thermal Properties*. *Biomacromolecules* 2020, 21 (5), 1943-1951.
- Trejo Machin, A.; Ajjouf, A.; Puchot, A.; Dieden, R.; Verge, P. *Elucidating the Thermal and Polymerization Behaviours of Benzoxazines from Lignin Derivatives*. *European Polymer Journal* 2020, 124, 109468.

## Partners

University of Cergy-Pontoise, Fraunhofer Institute for Manufacturing Technology and Advanced Materials (IFAM), Goodyear Tire & Rubber Company, Roquette

## Contact

5, avenue des Hauts-Fourneaux  
L-4362 Esch-sur-Alzette  
phone: +352 275 888 - 1 | LIST.lu

Daniel SCHMIDT ([daniel.schmidt@list.lu](mailto:daniel.schmidt@list.lu))  
© Copyright August 2022 LIST

LUXEMBOURG  
INSTITUTE OF SCIENCE  
AND TECHNOLOGY

