Sustainable Polymers for the 21st Century

Ulrich S. Schubert

Laboratory for Organic and Macromolecular Chemistry, Friedrich Schiller University Jena, Humboldtstrasse 10, 07743 Jena, Germany
Center for Energy and Environmental Chemistry Jena (CEEC Jena), Friedrich Schiller University Jena, Philosophenweg 7, 07743 Jena, Germany
Helmholtz Institute for Polymers in Energy Applications Jena (HIPOLE Jena), Lessingstrasse 12-14, 07743 Jena, Germany

www.schubert-group.de; ulrich.schubert@uni-jena.de

Over the last century, polymers have become one of the most important classes of materials and are now indispensable in many applications. They enable several applications ranging from packaging to high-end-applications. However, there is also a downside, and the negative effects are omnipresent and include microplastics and a lack of recycling strategies.

This contribution highlights various strategies for how polymers can contribute to a sustainable society and thereby make a significant contribution to the UN Sustainability Goals.

For instance, polymers play a crucial role in the development of the latest generation of batteries for energy storage. In this context, polymers can be applied in various fields of the batteries ranging from electrolytes to the active materials. Following this approach, new battery concepts based on polymers, such as redox flow batteries, could also be implemented.

On the other hand, the integration of reversible units into the chemical structure enables self-healing ability, resulting in durable materials that do not need to be replaced. Furthermore, the approach of reversible chemistry in polymers is also suitable for obtaining recyclable materials. Particularly noteworthy here is the concept of vitrimers, in which polymer networks, *i.e.* thermosets, are designed to be recyclable and can be reprocessed.

Finally, the biodegradability of polymers, in particular of polyesters, is presented, illustrating an end-of-life scenario for these materials that enables them to be returned into the natural material cycle.

All of the approaches presented demonstrate the enormous potential of polymers in the 21st century to enable sustainable, resource-saving, and climate-neutral applications.

Recent publications:

Nat. Commun. **2026**, *17*, 1141; *Adv. Funct. Mater.* **2026**, e22667, DOI: 10.1002/adfm.202522667; *Adv. Healthcare Mater*. **2026**, *15*, e04060; *Carbohydr. Polym*. **2026**, *380*, 124890; *ACS Appl. Energy Mater.* **2025**, *8*, 4220-4230; *Chem. Eur. J.* **2025**, *31*, e202404267; *Polym. Chem*. **2025**, *16*, 492-502; *J. Mater. Chem. B* **2025**, *13*, 15516-15529; *J. Appl. Polym. Sci*. **2025**, *142*, e56530; *Macromol. Rapid Commun.* **2025**, *46*, e00273; *Energy Storage Materials* **2024**, *65*, 103063; *ChemSusChem* **2024**, *17*, e202400626; *J. Phys. Chem.* **2024**, *128*, 11465; *Chem. Eur. J.* **2024**, *302*, e202302979; *J. Mater. Chem. A* **2024**, *12*, 4806; *Adv. Sustainable Syst.* **2024**, *8*, 2400050; *J. Computational Chem.* **2024**, *45*, 1112; *Sensors and Actuators B: Chemical* **2024**, *403,* 135101.