Fraunhofer IFAM

Polymeric materials for a circular economy

Sustainable products made with innovative polymers

Stakeholders from different industries are demanding a shift in the current value chain of polymer materials towards greater sustainability. To facilitate this change, consumers, policy makers, manufacturers and material suppliers all seek reliable supply chains sustainably providing these materials for years and decades to come. Polymeric materials, which often exhibit excellent weight-specific properties and versatility, can be produced from renewable resources such as biogenic and circular carbon sources. Recyclable polymers also contribute to a more circular economy and can be used both as adhesives and as matrix resins in fiber reinforced plastics.

Process chains and circularity

Every product on the market is the result of numerous decisions along the process chain. In the development process, considerations must include raw materials, processing techniques, applications, product end-of-life, as well as the interdependencies among these factors. The importance of taking a holistic view of a product's entire lifecycle is increasing, thereby shifting the focus towards implementing the 9R framework into the product development process.

A natural place to start – bio-based materials

Gaining independence from fossil resources continues to grow in importance from both economic and ecological perspectives. Circular and biogenic resources are important alternative sources of raw materials, offering a broad range of properties and substances. New biobased polymers can go beyond merely substituting petrochemical ones and offer unique advantages, such as addressing health issues and hazardous materials. However, finding the right raw materials that meet material needs, ensuring the availability and sustainability, can also present significant scientific challenges.

Find out more on our website!

The Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM can cover the entire process chain of polymeric material development, from molecular design to the right processing techniques, to lifetime prediction using specialized modeling and simulation tools.

Finding the right way to handle new materials

Introducing a new material into a process line is far more complex than it may seem at first glance. Traditionally, the substituting material must exhibit similar or the same product and process-relevant properties. However, from ecological, technological and economic perspectives, it can be advantageous to consider changes in production processes and sometimes even in product properties. In other words, introducing a new material can facilitate a shift towards more efficient processing methods and optimized product properties. Such processes can be optimized in terms of energy efficiency, while also taking into account the specific demands for the new material used such as temperature stability, viscosity, volatility and sensitivity to moisture.

No end in sight – Designing for repairability

Increasing sustainability and reducing waste are two important 9R strategies, which also include extending a product's expected lifetime and designing for repairability. This can be achieved by using appropriate designs, accurate lifetime predictions and materials with suitable repair strategies. The decision whether a modular or an integral construction is more suitable, depends on the specifications and the materials involved. Adopting a holistic approach during the design phase and considering repair strategies can significantly extend a product's lifetime. For example, adhesively bonded parts can be exchanged and separately repaired if "debonding on demand" concepts are integrated. A growing number of debonding mechanisms are available and can be customized for the individual application.

Life goes on – Recyclability enabled by polymers

Closed-loop recycling at a product's end of life is possible using the right polymer. Degradable polymers can be used for adhesive bonding and composites to recover and separately recycle bonded parts and regain reinforcing fibers. Taking it one step further, the additional reusability of the polymer can be achieved by using vitrimeric polymers. Another end-of-life approach, also driven by the polymer, is biodegradability. This can be a particularly interesting feature for biogenic products like natural fiber-reinforced composites in a cradle-to-cradle economy.

From market research to material development and testing

For plastics processing or manufacturing companies looking to replace existing plastics in their products or portfolio, Fraunhofer IFAM researchers develop customized alternatives: biobased, recyclable, or biodegradable polymers. Fraunhofer IFAM takes a holistic view on the lifecycle assessment of a product or material, including the manufacturing process, and can also determine whether and how the product can be broken down into its basic components after use in order to adhere to a circular economy model.

Fraunhofer IFAM provides support in:

- Narrowing down the material selection based on material specifications and component requirements
- Researching commercially available raw materials
- Evaluating materials for specific applications, including using digital simulation
- Developing efficient processing routes that meet a material's specific requirements
- Adapting the product lifecycle design, including its repairability
- Developing sustainable material alternatives from an economic point of view
- Conducting holistic lifecycle assessments

Fraunhofer IFAM has extensive knowledge in all aspects of the development and processing of polymeric materials. Its highly experienced team of researchers holds in-depth market expertise and is well-connected within the international network of raw material suppliers and contract manufacturers.

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