Site of future demonstration PMMA depolymerisation facility, Rho, Italy

The Evolution of PMMA Recycling

Recycling is a promising route towards a more circular economy for plastics. Technologies to makes this happen for PMMA are on the way. **By Aldo Zanetti**, Global Sustainability Business Development Leader for Engineered Materials, Trinseo

Polymethyl methacrylate (PMMA) has long been known for its transparency, durability, and performance properties – making the material an easy choice for a variety of plastic applications. The material is so intrinsic to our daily lives that the polymer has a forecasted market value of four million tons a year by 2025, and will be worth $6 billion dollars by 2027.1

In particular, PMMA is a sought-after choice for plastic applications needing durability and transparency – such as acrylic cast sheets – and is a strong replacement for glass. The material provides superior aesthetics with high transparency while also offering weathering resistance, making it an excellent choice for applications that require high performance such as automotive taillights, capstocks and electronics. However, the demand for acrylic solutions also contributes to the world's plastic waste challenges.

As the chemical industry continues to seek ways to reduce the environmental impact of plastic materials, one promising approach is to invest in a more circular economy via recycling technologies. For acrylic solutions, manufacturers have introduced recycling methods through avenues of mechanical and chemical recycling, which enables them to collect pre- and post-consumer PMMA waste and convert it into the recycled methyl methacrylate (rMMA) monomer, the polymer's building blocks.

As this technology continues to evolve, progress has been made in higher-yields chemical recycling processes to recover high-purity rMMA that is nearly as pure as its virgin counterpart. By building demand for high purity rMMA, this is helping to reduce the virgin material consumptions while maintaining performances on the finished products. By utilizing recycled feedstocks, companies can support a circular economy and reduce their environmental impact.

Developing mechanical & chemical recycling technologies

To date, mechanical recycling has been the hallmark of recycling for pre- and post-consumer PMMA waste. Under this process, acrylic waste is processed, sorted, and treated before it undergoes grinding and compounding. From there, the recycled material is melted and reprocessed in new products. Materials undergoing mechanical recycling maintain their chemical composition and original colour.

While mechanical recycling plays an important role within the circular economy, it has several limitations—especially for PMMA. First, it has the potential to degrade the polymer during the recycling process and the subsequent recycling cycles, eventually becoming unusable. Additionally, the quality of the plastics collected for recycling can be inconsistent and possibly contaminated, leading to downcycling.2 Second, it is difficult to manage colour separation when mechanically recycling plastic waste, making the technology more suited to process black-coloured finished products. And finally, PMMA mechanical recycling is limited to resins and extrusion sheets waste streams only. Cast sheets, which have a very high molecular weight, cannot be mechanically recycled because they start to degrade before melting. Due to the limitation of

continued on page 28


Aldo Zanetti

continued from page 27

PMMA waste streams that can be mechanically recycled, a significant portion of PMMA waste is landfilled or incinerated.

With these issues in mind, the plastic industry has come to rely on chemical recycling to convert a larger variety of PMMA waste streams into reusable feedstock. This is possible through depolymerisation, which reverts PMMA waste into recycled monomer. This monomer works as a raw material and can be re-polymerized into virgin like resins and cast sheets for demanding applications. However, some limitations remained until recently—namely the ability to generate a high purity rMMA from a variety of pre- and post-consumer waste stream types and quality, through a continuous process with a favourable environmental footprint.

Furthering sustainability with next-gen depolymerisation

To address the shortcomings of existing depolymerisation technology, the plastics industry and its value chain partners invested in research and testing to find new methods of recycling PMMA. Funded by the European Union's Horizon 2020 research and innovation program, the MMAtwo consortium developed a new value chain for PMMA waste and a new depolymerisation technology process.

While PMMA depolymerisation has existed for some time, the research conducted by MMAtwo could potentially enable the infinite generation of high-quality, high purity rMMA from most acrylic waste streams in a high yield and continuous process. The next generation depolymerisation technology developed from the project has the potential to generate rMMA to near virgin-like purity. Furthermore, the project can close the loop for even the highest demanding acrylic applications and recycle scraps that traditionally cannot be processed with other available technologies and are currently landfilled. This type of depolymerisation is also scalable to global investment, meaning that the industry has the potential to easily adapt this technology and improve waste recycling ability.

The recycling of acrylic waste and the creation of recyclate-containing PMMA products has evolved over the last several years as the industry searches for ways to reduce its reliance on virgin raw materials.

Next generation depolymerisation processes can provide the PMMA value chain with an opportunity to fully close the loop through the generation of high-quality and purity, recycled monomers. Able to meet the needs of the most demanding applications, recyclate-containing PMMA can be used in final applications for a variety of industries, including building and construction, consumer goods, and consumer electronics. This depolymerisation technology will change the way that PMMA can be recycled and support the chemical manufacturing industry in its endeavours to address plastic waste.

Resources

1 De Tommaso, J., & Dubois, J.-L. (2021). Risk analysis on PMMA Recycling Economics. Polymers, 13(16), 2724. https://doi.org/10.3390/polym13162724

2 Zsakay, A. (n.d.). Mechanical recycling. Circular Economy Asia. https://www.circulareconomyasia.org/mechanical-recycling/