REINFORCED RECYCLED POLYMER COMPOSITES

Multiple plastic waste streams from carpets and bottles combine for use in new industrial products.

Carpets and bottles often contain multiple types of plastic, which complicates efforts to recycle every part of them. Researchers at Oklahoma State University (OSU) are working to increase the recyclability of the waste streams from these products that usually go to landfills or incinerators.

The average soda or water bottle is made mostly from polyethylene terephthalate (PET), a material with a moderate overall recycling rate in the United States—about 29% in 2021.[1]

Even if the PET from a bottle is recycled, though, the labels and caps usually are not.

Similarly, only 9% of U.S. discarded carpets were recycled in 2018.[2] While there is a small market for recycled nylon[3] from carpets and other sources, very little of the PET and polypropylene (PP) from floor coverings gets a second life.

OSU has partnered with beverage bottler Niagara Bottling to explore how these underused mixed plastics could be repurposed in food and beverage pallets and acoustic panels. Their goal is to create a recycled material that exhibits better strength and performance than existing composites produced for the same applications. As part of the project, the team aimed to create pallets that are repairable with standard fasteners such as screws, nails, or ultrasonic welding, further extending the life of the reused materials.

PROJECT DESCRIPTION

By the end of this two-year project, the team will have developed and evaluated a recycling solution that solves many of the problems in managing large quantities of mixed waste streams from bottling recycling and post-consumer carpet. With this solution, neither the carpet nor the mixed polyolefins (PE and PP from bottles) would need to be deconstructed and separated. Instead, whole carpet strips or shredded carpets could be washed and mixed with resins from bottling streams for products that could be used for a wide variety of commercial applications.

The OSU researchers compiled product requirements for the recycled composite material, basing their list on conversations with Niagara and other potential customers. They are measuring the input feedstocks' chemical, physical, and mechanical properties for compositional consistency. In parallel, they are repeating these tests for select virgin plastics, which will serve as a baseline for comparison.

To fabricate composite products for the project, the team is combining resins from recycled bottles with those from recycled carpet, using the entire carpet, face fiber, and backing. The carpet serves as reinforcement to the bottle resins. In addition to fabricating and testing composite samples, the team is looking toward scale-up by evaluating the relevant factors that could limit uptake of the end product.

[1] National Association for PET Container Resources. NAPCOR's 2021 PET Recycling Report Shows Largest Amount of Post-Consumer PET Ever Collected in U.S. https://napcor.com/news/2021-pet-recycling-report/. Accessed May 9, 2023.

[2] U.S. Environmental Protection Agency. Durable Goods: Product-Specific Data, Carpets and Rugs. https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/durable-goods-product-specific-data#CarpetsandRugs. Accessed May 9, 2023.

[3] Textile Exchange. Preferred Fiber and Materials Market Report. October 2022. https://textileexchange.org/app/uploads/2022/10/Textile-Exchange_PFMR_2022.pdf. Accessed May 9, 2023.

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OSU and Niagara are also evaluating the costs to produce carpet-reinforced composite products, including materials, washing, and fabrication. The team will scale up production of the reinforced composites by exploring how to extrusion-mold the composites to produce larger samples.

PROJECT IMPACT

This project paves the way for an improvement of at least 30% in the amounts of PET and PP recycled from carpets. This improvement would save 1,400 megajoules of energy and 64 metric tons of carbon dioxide.

If all the waste plastic from carpets and bottles could be reused, the embodied energy of products made from PET and HDPE would drop 51% and 37%, respectively. Carbon dioxide emissions for PET and PP would drop 38% and 31%.

More generally, demonstrating strides in composite materials from mixed plastics provides insights and inspiration in the development of other new materials and products from waste streams, making them more economically attractive.

NEXT STEPS

OSU is working with recyclers and pallet suppliers to develop a repairable pallet design that meets industry needs. They will also lead efforts to understand supply chain requirements and the approach to commercialization. To support these efforts, the team will also use the U.S. National Science Foundation's Innovation-Corps program to test product market fit and conduct customer discovery with a significant number of potential customers.

OSU is in the process of assessing the use of these panels as panels for acoustic protection and mitigation. Currently, the panels do not show substantial acoustic protection properties. This result is probably due to the lack of porosity and high densities of the composites that gave the composites high strength and modulus.

OSU is planning to make some of these composites on a larger scale and plans to partner with another institution to make samples larger then they are currently able to make on their existing hot press.

PROJECT PARTNERS

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PUBLICATIONS

Chaudhari , S.; Switzer, C.; Azarfam, M.Y.; Maheshwari, A.; Blum, F.D.; Hanan, J.; Vaidyanathan. R. *Sustainable Compression-molded Composites Using Recycled Polyester Carpets and Bottling Discards.* SAMPE Europe 2022, Nov 15–17, 2022; Hamburg, Germany.

Azarfam, M.Y.; Maheshwari, A.; Blum, F.D.; Chaudhari, S.; Switzer, C.; Vaidyanathan, R.; Hanan, J.C. *Recycled carpet-reinforced composites from polyester carpet and recycled PET resin*. ANTEC 2022, June 14-16, 2022; Charlotte, NC, USA.

Azarfam , M.Y.; , Maheshwari, A.; Chaudhari, S.; Switzer, C.; Hanan, J.C.; Bandla, S.; Vaidyanathan., R.; Blum, F.D. *Recycled carpet-reinforced composites from polypropylene carpet and HDPE resin*. National ACS Meeting, March 20-24, 2022, San Diego, CA.

Chaudhari, S.; Switzer, C.; Azarfam, M. Y.; Maheshwari, A.; Blum, F.D.; Hanan, J.; Bandla, S.; Vaidyanathan, R. *Recycled carpet-reinforced composites from polyester carpet and recycled PET resin*. CAMX Conference Proceedings. Dallas, TX, October 19-21, 2021.

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