New method to solve the plastics sustainability problem

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Dr. Junpeng Wang. Credit: University of Akron

Plastics sustainability has come a long way in recent years thanks in large part to scientific advances. But even as plastics become more and more

environmentally friendly, the world continues to be polluted as many industries rely on them for their widely used products.

The latest research from Dr. Junpeng Wang, assistant professor in UA's School of Polymer Science and Polymer Engineering has a solution to reduce such waste and clear a scientific pathway for a more sustainable future that can appeal to the rubber, tire, automobile and electronics industries. Although this work is supported by UA, Wang recently earned a prestigious National Science Foundation CAREER Award that will support future developments from this research.

The problem at hand: Synthetic polymers, including rubber and plastics, are used in nearly every aspect of daily life. The dominance of synthetic polymers is largely driven by their excellent stability and versatile mechanical properties. However, due to their high durability, waste materials composed of these polymers have accumulated in the land and oceans, causing serious concerns for the ecosystem.

In addition, since over 90% of these polymers are derived from finite natural resources, such as petroleum and coal, the production of these materials is unsustainable if they cannot be recycled and reused.

A promising solution to address the challenges in plastics sustainability is to replace current polymers with recyclable ones in order to achieve a circular use of materials. Despite the progress made thus far, few recyclable polymers exhibit the excellent thermal stability and high-performance mechanical properties of traditional polymers. The recyclable materials Wang and his team have developed are unique in the superior thermal stability and versatile mechanical properties. Their article explaining the research, "Olefin Metathesis–Based Chemically Recyclable Polymers Enabled by Fused-Ring Monomers," was published last week by *Nature Chemistry*.

"We are particularly interested in chemically recyclable polymers that can be broken down into the constituents (monomers) from which they are made," says Wang. "The recycled monomers can be reused to produce the polymers, allowing for a circular use of materials, which not only helps to preserve the finite natural resources used in plastics production, but also addresses the issue of unwanted end-of-life accumulation of plastic objects."

The key in the design of chemically recyclable polymers is to identify the right monomer. Through careful computational calculation, the researchers identified a targeting monomer. They then prepared the monomer and polymers through chemical synthesis, using abundantly available starting materials.

Wang's research group, including polymer science graduate students and a postdoctoral scientist, aims to address those challenges by developing polymers that can be broken down into their constituent parts. When the catalyst for depolymerization is absent or removed, the polymers will be highly stable and their thermal and mechanical properties can be tuned to meet the needs of various applications.

"The chemically recyclable polymers we developed show excellent thermal stability and robust mechanical properties and can be used to prepare both rubber and plastics," says Wang. "We expect this material to be an attractive candidate to replace current polymers. Our molecular design is guided by computation, highlighting the transformational power of integrating computation and experimental work. Compared to other recyclable polymers that have been demonstrated, the new polymers we demonstrate show much better stability and more versatile mechanical properties. When a catalyst is added, the polymer can be degraded into the constituent monomer for recycling."

Next for Wang's research group is to expand the scope of the chemically

recyclable polymers and to develop carbon-fiber reinforced polymer composites. The team will also analyze the economic performance of this industrial process and life-cycle analysis for commercialization of the polymers.

More information: Devavrat Sathe et al, Olefin metathesis-based chemically recyclable polymers enabled by fused-ring monomers, *Nature Chemistry* (2021). DOI: 10.1038/s41557-021-00748-5

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