Researchers develop highly-efficient, non-toxic method to upcycle single-use plastic

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A team of researchers at NYU Abu Dhabi has developed a single-step, organic solvent-free, hydrothermal process to convert polyethylene-based plastic bags and polypropylene-based surgical masks into carbon

dots.

An estimated 26,000 metric tons of pandemic-related plastic waste —from medical waste to online shopping packaging—have been released into the world's oceans, making it even more urgent to find efficient methods to upcycle this non-degradable material. One solution is to convert the single-use plastic into so-called carbon dots, carbon nanomaterials that are biocompatible, and have applications in the fields of biological imaging, environmental monitoring, chemical analysis, targeted drug delivery, disease diagnosis and therapy, and anti-counterfeiting. Existing methods to upcycle plastic into carbon dots involve multiple, time-consuming steps and utilize toxic chemicals.

In the study titled "High-yield, One-pot Upcycling of Polyethylene and Polypropylene Waste into Blue-Emissive Carbon Dots," published in the journal *Green Chemistry*, the researchers present the development of a new synthesis method, which is a simple, cost-effective, and highly scalable approach to upcycling plastic waste.

Importantly, this oxidative degradation method can upcycle plastics contaminated with organic waste such as food scraps, which poses a significant challenge to traditional recycling technologies. The senior author is Khalil Ramadi, Assistant Professor of Bioengineering at NYUAD. Mohammed Abdelhameed, a scientist at NYUAD, and Mahmoud Elbeh, an NYUAD undergraduate student, are first authors of the study.

The researchers also estimated the economic feasibility of the synthetic method by comparing the variable costs of this process to existing chemical recycling processes, considering the economic value of the created carbon dots. They found that the global market value of carbon dots is expected to reach $6.412 billion U.S. dollars by 2025, up from $2.496 billion in 2019—a high commercial value that more than justifies

the associated processing costs.

The high volume of single-use plastics used during the pandemic, particularly surgical masks and medical waste, presents an increased need to find a solution for managing non-biodegradable waste. It is also estimated that only 14 percent of the eligible plastic packaging—whose use has surged due to the boom in online shopping—is recycled, with the rest ending up in landfills and oceans, where it does considerable harm. These materials can be consumed by organisms or fragmented into micro- and nano-plastics that can threaten terrestrial, marine, and freshwater ecosystems and, ultimately, human health.

"The new method our team has developed is a cost-effective and safe method that can be easily implemented to significantly reduce the amount of harmful plastic that is released into our ecosystems," said Ramadi. "In addition to providing a new tool to protect our ecosystems, this approach can efficiently and responsibly produce carbon dots, a versatile nanotechnology whose potential applications are nearly boundless."

Elbeh stated, "We're very delighted to further support the UAE's Circular Economy Policy. Given that we are tackling the plastic waste crisis by creating a valuable product using a relatively easy-to-implement method, we're looking forward to more collaborations to not only scale up this project but also utilize the produced dots for further development and applications."

More information: Mohammed Abdelhameed et al, High-yield, one-pot upcycling of polyethylene and polypropylene waste into blue-emissive carbon dots, *Green Chemistry* (2023). DOI: 10.1039/D2GC04177D

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