Upcycling plastic waste into more valuable materials could make recycling pay for itself

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A new and simple method for upcycling plastic waste at room temperature has been developed by a team of researchers at the Centre for Sustainable and Circular Technologies (CSCT) at the University of

Bath. The researchers hope the new process will help recycling become more economically viable.

Plastic waste residing in either landfill or the natural environment currently outweighs all living biomass (4 Giga tonnes), culminating in one of the great environmental challenges of the 21st century. Whilst recycling rates are increasing across Europe, traditional methods remain limited because the harsh remelting conditions reduce the quality of the material each time it's recycled.

Now researchers at the CSCT have developed a mild and rapid chemical recycling process for polycarbonates, a robust class of plastics commonly used in construction and engineering.

Using a zinc-based catalyst and methanol, they were able to completely break down commercial poly(bisphenol A carbonate) (BPA-PC) beads within 20 minutes at room temperature.

The waste can then be converted into its chemical constituents, namely bisphenol A (BPA) and dimethyl carbonate (DMC), helping to preserve product quality over an infinite number of cycles.

Importantly, BPA recovery prevents leakage of a potentially damaging environmental pollutant, whilst DMC is a valuable green solvent and building block for other industrial chemicals.

Their results are published in *ChemSusChem*, noting enhanced process efficiency and milder conditions compared to previous methods.

Promisingly, the catalyst is also tolerant to other commercial sources of BPA-PC (e.g. CD) and mixed waste feeds, increasing industrial relevance, whilst being amenable to other plastics (e.g. poly(lactic acid) (PLA) and poly(ethylene terephthalate) (PET)) at higher temperatures.

The team has also demonstrated a completely circular approach to producing several renewable poly(ester-amide)s (PEAs) based on terephthalamide monomers derived from waste PET bottles. These materials have excellent thermal properties and could potentially be used in biomedical applications, for example drug delivery and tissue engineering.

Lead researcher Professor Matthew Jones, at the University of Bath's CSCT, said: "It's really exciting to see the versatility of our catalysts in producing a wide range of value-added products from plastic waste.

"It's crucial we target such products, where possible, to help promote and accelerate the implementation of emerging sustainable technologies through economic incentives."

First author of the paper, Jack Payne from the CSCT, said: "Whilst plastics will play a key role in achieving a low-carbon future, current practices are unsustainable.

"Moving forward, it's imperative we source plastics from renewable feedstocks, embed biodegradability/recyclability at the design phase and diversify existing waste management strategies.

"Such future innovation should not be limited to emerging materials but encompass established products too.

"Our method creates new opportunities for polycarbonate recycling under mild conditions, helping to promote a circular economy approach and keep carbon in the loop indefinitely."

Presently, the technology has only been demonstrated on a small scale, however, the team is now working on catalyst optimisation and scaling up the process (300 mL) with collaborators at the University of Bath.

More information: Jack M. Payne et al, Versatile Chemical Recycling Strategies: Value-Added Chemicals from Polyester and Polycarbonate Waste, *ChemSusChem* (2022). DOI: 10.1002/cssc.202200255

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