

A clean, green, metal-free approach to making high-performance polycarbonates

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From the transparent cockpit canopy of fighter jets to everyday applications such as spectacle lenses and Blu-ray discs, polycarbonate plastics are valued for being light, strong and offering exceptional optical clarity. Researchers at King Abdullah University of Science and Technology (KAUST), Saudi Arabia, have discovered a simple, clean, metal-free way to make polycarbonates from CO₂.

One of the more environmentally friendly ways to make polycarbonates is to use carbon dioxide as one of the component monomers, making good use of what is otherwise an unwanted greenhouse gas. However, to make polycarbonates this way, manufacturers must currently use complex organometallic catalysts, which are difficult to make and which leave metal residues in the finished plastic. Not only can these metals be toxic, but they also discolor the polymer with a yellow taint that requires extra purification steps to remove.

Instead of an organometallic catalyst, Nikos Hadjichristidis and Yves Gnanou and colleagues from the University's Physical Science and Engineering Division developed a purely organic catalyst system that is highly effective, simple to use and requires no additional purification steps.

To make polycarbonates from CO₂, the gas is mixed with a partner monomer called an epoxide.

"Common wisdom told us that to produce linear polycarbonate chains

from the copolymerization of CO₂ with epoxides, there is no option but to resort to organometallic complexes," said Gnanou.

The organometallic catalyst's role is to capture epoxide molecules from the mixture and attach them to the growing polymer chain. Without the organometallic catalyst, the sluggish epoxide addition step meant the growing chains would often react with their own tail instead, forming cyclic structures rather than the desired long-chain polymer.

"In polymerizations that are crippled by side reactions such as cyclizations, one classical way to foster the formation of linear chains is to activate the monomer," Gnanou explained, which is what the researchers did.

In place of the organometallic catalyst, the team used a pair of reaction initiators: an ammonium compound to capture and activate the CO₂ and an electron-poor boron-based compound to activate the epoxide. This combination coupled the two monomers just as effectively as many organometallic catalysts.

"The [polycarbonates](#) samples we obtained are not at all colored, and the activator used can be easily removed by washing the sample with water," Gnanou said.

The team believes that their approach could be used to make a wide range of polymers, Gnanou added. "The next step would be to apply the same concept to other epoxides and more generally to other related monomers," he said.

More information: Dongyue Zhang et al. Metal-Free Alternating Copolymerization of CO₂ with Epoxides: Fulfilling "Green" Synthesis and Activity, *Journal of the American Chemical Society* (2016). [DOI: 10.1021/jacs.6b06679](https://doi.org/10.1021/jacs.6b06679)

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