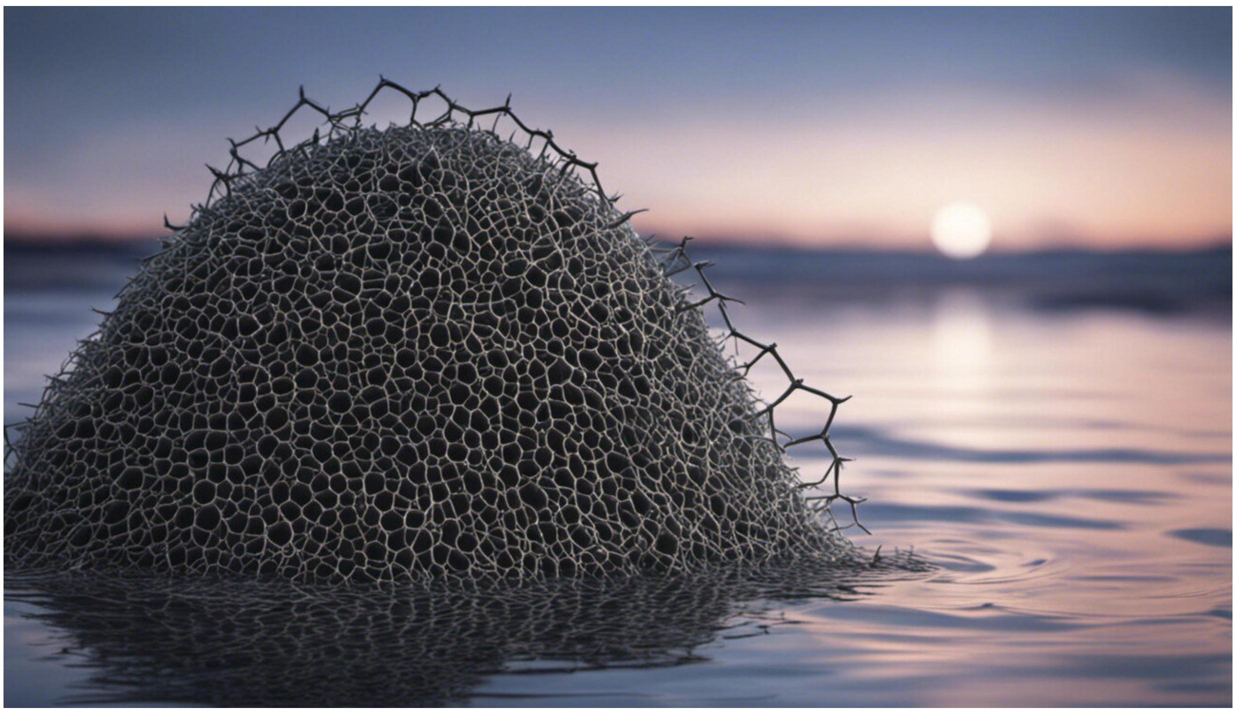
Carbon capture: Durable plastic doubles as a cleaner

September 25 2013



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Melamine, a small aromatic molecule loaded with nitrogen atoms, has traditionally found fame as a tough plastic that is ideal for making durable dishware and laminate coatings. Research by Mei Xuan Tan, Yugen Zhang and Jackie Ying at the A*STAR Institute of Bioengineering and Nanotechnology, Singapore, has shown that this material could play a valuable role in reducing greenhouse gas emissions. They demonstrated that a synthetic procedure turns melamine polymers into low-cost 'scrubbers' that trap and release carbon dioxide (CO2) gas on demand.

Conventional scrubbers use amino alcohols as liquid sorbents to catch waste CO2 gas. The intense energy needed to regenerate these corrosive and unstable liquids after carbon capture has prompted a search for better alternatives. One approach employs highly porous materials, such as activated charcoal or inorganic zeolites, to soak up large quantities of polluting gases. Unfortunately, most porous substances have poor selectivity towards CO2 and thus must be replaced often.

Tan, Zhang and Ying investigated whether these problems could be alleviated using porous organic polymers as the robust substances can be chemically tuned to maximize carbon capture. Because melamine has an abundance of amino sites that selectively bind CO2, the team suspected it might act as an efficient sorbent. Until now, however, chemists could introduce pores into melamine polymers only through the use of complex inorganic templates.

The production of melamine plastics usually requires the use of formaldehyde dissolved in water—a procedure that yields little to no porosity. By switching to a more polar organic solvent known as dimethyl sulfoxide (DMSO) and higher reaction temperatures, the researchers generated a high-surface-area polymer with well-defined 'nanopores'. They theorize that DMSO bonds to melamine and formaldehyde early in the process and helps to assemble the molecules into nanometer-wide rings, which subsequently link together into a foam-like structure.

Tests revealed that the new melamine polymer had impressive carbon capture capacity—it removed over 99% of CO2 from an analyte gas in a typical industrial through-flow column setup and operated nearly instantaneously. Furthermore, the researchers could quickly remove adsorbed CO_2 by applying a vacuum that restored its scrubbing capabilities for numerous cycles. The team attributes this unique behavior to reversible CO_2 binding inside the polymer's nanopores.

"Compared with other carbon dioxide capture materials, poly(melamine–formaldehyde) is cost efficient, easily synthesized and can be readily scaled up. We welcome industrial partners to work with us to commercialize this technology," say Zhang and Ying.

More information: Tan, M. X., Zhang, Y. & Ying, J. Y. Mesoporous poly(melamine–formaldehyde) solid sorbent for carbon dioxide capture, *ChemSusChem* 6, 1186–1190 (2013).dx.doi.org/10.1002/cssc.201300107

Provided by Agency for Science, Technology and Research (A*STAR), Singapore

Citation: Carbon capture: Durable plastic doubles as a cleaner (2013, September 25) retrieved 27 June 2024 from https://phys.org/news/2013-09-carbon-capture-durable-plastic-cleaner.html