Is glue the answer to climate crisis?

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Chimney stack: a resin developed by a team at Swansea University could help improve carbon capture materials. Credit: Veeterzy

Is glue the answer to climate change? Researchers at the Energy Safety Research Institute (ESRI) at Swansea University have proven that it could certainly help. They have developed a new material capable of capturing the greenhouse gas carbon dioxide (CO_2) with the key

ingredient being a common epoxy resin you probably have at home.

Carbon capture materials are a crucial part of a range of technologies, alongside renewables and energy efficiency solutions, that can help reduce the amount of CO_2 we release into the atmosphere.

"We show that small epoxy molecules typically found in glues can stick larger ones together to make effective carbon capture materials potentially useful to tackle climate change," said Dr. Enrico Andreoli, lead of the research study now subject of a paper published in *Chemistry of Materials*.

Dr. Louise Hamdy, first author of the paper, added "We've developed a new approach to making an effective CO_2 capture material from a widely studied CO_2-reactive polyamine by reaction with an industrially mass-produced epoxy resin. This material shows very high CO_2 uptake and could potentially be used to capture CO_2 from industrial flue gas streams or from the air, relieving us from some of the worst effects of global warming."

Current CO_2 capture technologies need to be significantly advanced. Major challenges include materials cost, capacity, CO_2-selectivity, regeneration, robustness and stability to water. Solid CO_2 capture materials composed of polyamines supported on alumina or silica have emerged as promising carbon capture materials. However, rather than follow suit, the researchers at ESRI cross-linked the polyamine into a solid by using epoxy resin—constituting just one-tenth of the mass of the material—maximising the CO_2-reactive component and avoiding the use of a support. "This confirms the validity of my original idea of using cross-linking as an alternative to bulky supports," said Andreoli.

The cross-linked material modified with a hydrophobic additive captured almost 20% of its weight in pure CO_2 at 90 °C. This finding

confirmed a previous hypothesis that the introduction hydrophobic groups can disrupt the internal structure of the material to promote CO_2 uptake by the polyamine. The additive not only increased the amount of captured CO_2 but did so at a lower temperature. Hamdy commented, "This finding is significant as it proves that through the introduction of additives, we can fine tune these materials for optimum performance at specific working temperatures."

Experiments revealed the functionalised sample to be highly selective for CO_2 over nitrogen (N2), showing negligible uptake of N2. Selectivity was further explored by testing the material performance under flue gas-like conditions. This revealed that the sample could capture 9.5% of its weight in CO_2 under a dilute CO_2 stream of 10% CO_2/90% N2 at 90 °C in only 15 minutes. On subjecting the material to repetitive capture cycles, increasing the temperature to 155 °C under pure CO_2 for 5 minutes to regenerate, the material showed no loss of capacity for 29 cycles, testament to the robustness of the material.

The functionalised material also performed exceptionally well under humid conditions—often a huge challenge for many CO_2 sorbent solids. At 25 °C, in pure CO_2, the pre-hydrated material was able to capture an impressive 23.5%. This opens up the possibility of this material being developed for capture of CO_2 directly from the air.

"This research is defining a new and promising direction to economical and effective carbon capture materials. Our institute has a strong focus on developing and deploying new technologies in the field of carbon capture, utilisation, and storage. This paper is evidence of the level of our expertise," said Professor Andrew Barron, founder and director of ESRI.

More information: Louise B. Hamdy et al, Epoxy Cross-Linked Polyamine CO2 Sorbents Enhanced via Hydrophobic Functionalization,

Chemistry of Materials (2019). DOI: 10.1021/acs.chemmater.9b00574, dx.doi.org/10.1021/acs.chemmater.9b00574