Next-gen membranes for carbon capture

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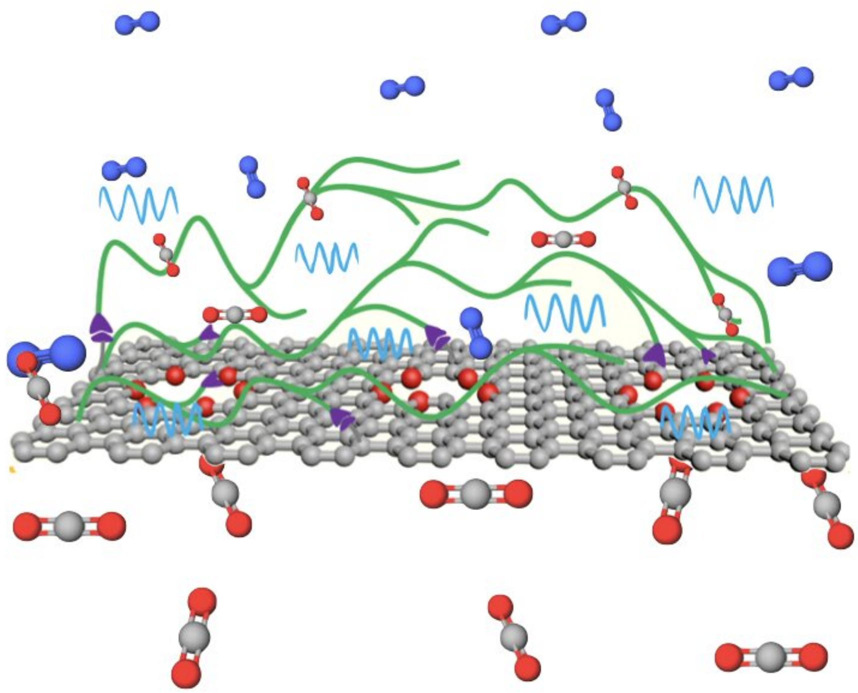

CO2-selective polymeric chains anchored on graphene effectively pull CO2 from a flue gas mixture. Credit: KV Agrawal (EPFL)

CO_2 produced from burning fossil fuels is still mostly released into the atmosphere, adding to the burden of global warming. One way to cut

CO_2 levels is through carbon capture, a chemical technique that removes CO_2 from emissions ("postcombustion"), preventing it from entering the atmosphere. The captured CO_2 can then be recycled or stored in gas or liquid form, a process known as sequestration.

Carbon capture can be done using high-performance membranes, which are polymer filters that can specifically pick out CO_2 from a mix of gases, such as those emitted from a factory's flue. These membranes are environmentally friendly, they don't generate waste, they can intensify chemical processes, and can be used in a decentralized fashion. They are now considered as one of the most energy-efficient routes for reducing CO_2 emissions.

Scientists led by Kumar Varoon Agrawal at EPFL Valais Wallis have now developed a new class of high-performance membranes that exceeds post-combustion capture targets by a significant margin. The membranes are based on single-layer graphene with a selective layer thinner than 20 nm, and have highly tunable chemistry, meaning that they can pave the way for next-generation high-performance membranes for several critical separations.

Current membranes are required to exceed 1000 gas permeation units (GPUs), and have a CO_2/N2 separation factor above 20—this is a measure of their carbon-capturing specificity. The membranes that the EPFL scientists developed show six-fold higher CO_2 permeance at 6,180 GPUs with a separation factor of 22.5. The GPUs shot up to 11,790 when the scientists combined optimized graphene porosity, pore size, and functional groups (the chemical groups that actually react with CO_2), while other membranes they made showed separation factors up to 57.2.

"Functionalizing CO_2-selective polymeric chains on nanoporous graphene allows us to fabricate nanometer-thick yet CO_2-selective membranes," says Agrawal. "This two-dimensional nature of the membrane drastically increases the CO_2 permeance, making membranes even more attractive for carbon capture. The concept is highly generic, and a number of high-performance gas separations are possible in this way."

More information: High-permeance polymer-functionalized single-layer graphene membranes that surpass the postcombustion carbon capture target. *Energy & Environmental Science* 26 July 2019. DOI: 10.1039/c9ee01238a

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