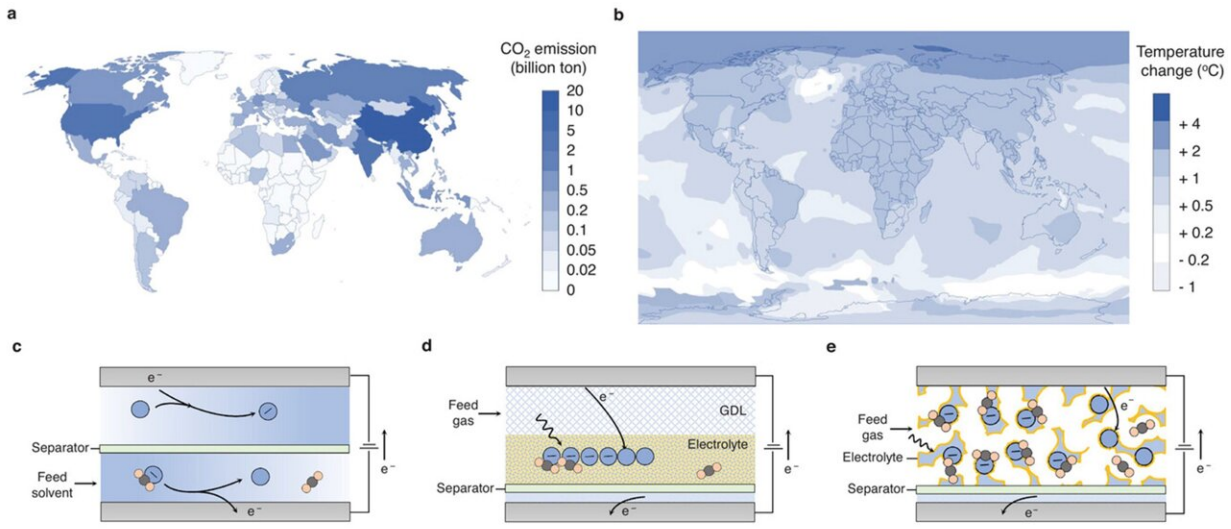
Scientists develop new material for more efficient carbon capture

September 6 2024, by Youhong Nancy Guo



Global warming and design principles of PPEs with a flow-through configuration for electro-swing carbon capture. a) Annual CO_2 emissions from fossil fuels and industry. b) Average surface air temperature change over the last 50 years.[30] c–e) Schematics of electrochemical cells in c) continuous-flow process with CO_2 carriers dissolved in solvents, d) flow-by mode where active materials are immobilized within a solid electrode wetted by high volume of electrolyte interacting with CO_2 feed gas directly, a gas diffusion layer (GDL) is required to enable sufficient gas transport, and e) the flow-through mode used in this work, where active materials are distributed in PPEs with enlarged surface area and a much thinner layer of electrolytes to shorten diffusional distances of CO_2 feed gas. Credit: *Advanced Materials* 2024, 10.1002/adma.202407567

In a significant advance for climate change mitigation efforts, we have developed a new material that could revolutionize carbon dioxide capture. Our study, published in *Advanced Materials*, introduces porous polymeric electrodes (PPEs) that dramatically enhance the efficiency of removing CO_2 from low-concentration sources.

Our research team, led by Professor T. Alan Hatton, created PPEs using a novel combination of common materials: melamine foam coated with polyvinyl alcohol and infused with carbon nanotubes and quinone molecules. This innovative structure allows for vastly improved gas transport and interaction between CO_2 and the capture material.

Our porous polymeric electrodes represent a significant leap forward in electrochemical carbon capture technology. By enhancing gas transport and increasing the active surface area, we've created a more efficient and potentially more scalable approach to capturing CO_2.

Our new electrodes achieved up to 90% utilization of the active capture material, significantly outperforming previous carbon-based electrodes. In practical terms, this translates to a CO_2 capture capacity of 30–80 kg per cubic meter per day, depending on CO_2 concentration—a substantial improvement over existing technologies.

Notably, our PPEs maintained excellent performance over 100 capture-release cycles and demonstrated stability under humid conditions, addressing key challenges in real-world applications. The porous structure also eliminates the need for separate gas diffusion layers, allowing for more compact and potentially cost-effective capture systems.

We successfully demonstrated the material's effectiveness in capturing CO_2 from air and dilute gas streams, opening up possibilities for applications ranging from direct air capture to emissions reduction from

various industrial sources.

As we race against time to mitigate climate change, innovations like this are crucial. Our PPEs could significantly enhance our ability to remove CO_2 from the atmosphere and industrial emissions, contributing to global efforts to reach net-zero targets.

While our results are promising, we acknowledge that further development is needed before large-scale implementation is possible. We are now focusing on optimizing the electrodes for different operating conditions and exploring ways to scale up production.

This breakthrough comes at a critical time, as the latest IPCC reports underscore the urgent need for effective carbon capture technologies to meet global climate goals. As governments and industries worldwide seek solutions to reduce greenhouse gas emissions, innovations like our porous polymeric electrodes could play a pivotal role in shaping a more sustainable future.

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More information: Youhong Guo et al, Porous Polymeric Electrodes for Electrochemical Carbon Dioxide Capture, *Advanced Materials* (2024). DOI: 10.1002/adma.202407567

I am currently a Postdoctoral Associate in Department of Chemical Engineering at Massachusetts Institute of Technology, working with Prof. T. Alan Hatton. I obtained my Ph.D. from the University of Texas at Austin, advised by Prof. Guihua Yu, and received my M.S. & B.S. from the University of California San Diego. In early 2025, I will join

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