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Electrochemical CO2 capture through pH-independent redox chemistry

Efficient removal of CO2, a greenhouse gas, from the atmosphere is critical for mitigating climate change and meeting climate goals. The Stanford team's new invention has the potential to remove CO2 continuously at the scale of billions of tons with significantly reduced energy cost and enhanced energy efficiency.

Many current carbon capture technologies at point sources use amine-functionalized sorbents and thermal stimuli to capture and then release CO2 upon heating. These methods are energy-intensive due to the need to heat and evaporate large quantities of inactive water solvent. While new strategies use porous materials like metal-organic frameworks (MOFs) to improve efficiency, energy losses from heating inactive components remain a significant challenge.

To address this bottleneck, the new invention utilizes an electrochemical CO2 capture mechanism through a pH swing, employing pH-independent redox chemistry of a water-soluble molecule that remains stable in both oxidized and reduced states. At high pH, the molecule captures CO2, and upon oxidation, the resulting low pH releases CO2. This innovative use of pH-independent redox chemistry eliminates the high energy costs associated with thermal desorption, enabling highly efficient CO2 capture and release for practical deployment.

Stage of Development: Prototype

Applications

- **CO2 capture facility for point sources**
- **Direct Air Capture (DAC)**

Advantages

- **Reduces energy cost** - an order of magnitude lower compared to current technologies
- **Enhanced energy efficiency**
- **Reduced long-term material costs**

Publications

- Chu, S., Wang, Q. (2024). "Climate change and innovative paths to a more sustainable future." *Front. Energy* **18**, 717–726.

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