Docket #: S24-104

Electrochemical CO2 capture through pH-independent redox chemistry

Efficient removal of CO_2, 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 CO_2 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 CO_2 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 CO_2 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 CO_2, and upon oxidation, the resulting low pH releases CO_2. This innovative use of pH-independent redox chemistry eliminates the high energy costs associated with thermal desorption, enabling highly efficient CO_2 capture and release for practical deployment.

Stage of Development: Prototype

Applications

- **CO_2 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.

Patents

- Published Application: WO2026015475

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