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Negative Emission: Closing the Carbon Loop

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ABSTRACT:

Direct air capture (DAC) of carbon dioxide is perhaps the most promising pathway to bridge CO2 capture and CO2 conversion (utilization), thereby closing the carbon loop. We report a disruptive approach of DAC enabled by unconventional reverse chemical reaction driven by water quantities in nanopores. The humidity-swing system absorbs CO2 from the air when the surrounding is dry, whereas releases CO2 when wet. The thermodynamics and kinetics of the system are investigated using molecular dynamics and quantum mechanics simulations, further validated using experiments. Since the regeneration of the sorbent does not require heating or pressure, the distributed system may capture CO2 directly from ambient air (anywhere in the world) at extremely low cost. Moreover, the novel DAC seamlessly integrates with many low-cost and large-scale carbon utilization pathways and carbon sequestration, bridging CCUS and leading to enormous potential economic and societal impact. The "grand science" and future prospects of engineering the carbon loop are also discussed.

BIOGRAPHY:

Xi Chen is the Director of the Earth Engineering Center (EEC) of the Earth Institute, and the Director of the Center for Advanced Materials for Energy and Environment (CAMEE) in the School of Engineering and Applied Sciences (SEAS) at Columbia University. He received his Ph.D. in Solid Mechanics from Harvard University in 2001 and joined Columbia University in 2003. He received numerous awards including the NSF CAREER Award, the Presidential Early Career Award for Scientists and Engineers (PECASE), ASME Sia Nemat-Nasser Early Career Award, ASME Thomas J. R. Hughes Young Investigator Award, and SES Young Investigator Medal. He is a Fellow of ASME and chaired its Materials Division in 2017. He has published over 350 journal papers with a h-index over 55. His wide research interests span from energy (novel energy conversion materials, large-scale energy storage systems, flexible battery, material genomics for energy applications) to environment (negative carbon emission, carbon dioxide utilization, nanomaterials for water and soil treatment, sustainable mining) and to biotechnology (soft materials, biomimic soft robotics, mechanobiology, morphogenesis).