Net Direct Air Capture: Novel Contact Liquid-Based Approach for Efficient, Cost-Effective, and Scalable Cryogenic Carbon Capture

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Implementation of carbon capture & storage (CCS) is vital for alleviating detriments from carbon dioxide (CO_2) emissions. However, all current processes are deemed ineffective due to inefficiency or expense. Cryogenic carbon capture (CCC) is a relatively new, promising process that outperforms current state-of-the-art CCS processes with roughly half the cost and energy. CCC currently uses an energy-intensive and non-eco-friendly contact liquid—isopentane—to desublimate CO_2. Using isopentane, 80-85% of CO_2 is captured at ~~-120°C, which is considered inefficient. This project presents a novel contact liquid—to replace isopentane—that possesses high efficiency, low operating costs (~20+% cost reduction), and the ability to incorporate direct air capture (DAC). Additives were first explored by conducting miscibility, contact angle, and melting point tests, followed by efficiency calculation and then implementation. Overall, the study found 2 effective, novel solvents: 1:1 of 2-methylbutane/1-pentene and 1:2 2-methypentane/1-hexene mixtures. For efficiency, both solvents can capture 100%+ of CO_2 compared to isopentane's original 80%, introducing Net Direct Air Capture (NDAC) effectively for the first time. Using this approach, CO_2 is captured at as low as 10% of the cost of traditional DAC and CCS systems with higher efficiency, in return potentially saving billions of dollars. In fact, scalability was proven through implementation on two of Saudi Arabia's largest power plants—Rabigh2IPP and Duba Green—where 1 ton/CO_2 and 30 tons/CO_2 will be captured daily, respectively. Overall, these results demonstrate scalability, low cost, and high efficiency. This potentially offers the most effective carbon capture process to date, helping possibly impede fossil fuel drawbacks fully.

Awards Won:

First Award of $5,000