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As our society's carbon dioxide emissions increasingly threaten our planet through climate change, it is imperative that we reduce the emissions associated with human activity. At the same time, however, the carbon dioxide that humans have already emitted is expected to continue to warm the planet even if emissions were to drop to zero tomorrow.[1] To avoid the worst consequences of climate change, we will need an economic and scalable method to draw carbon dioxide directly out from the atmosphere and achieve net negative emissions. This technology is known as direct air capture (DAC). A DAC unit would take in air and separate CO_2 from the gaseous mixture for sequestration or use. A key component for a DAC unit is the mechanism of separating CO_2 from the other gases in air. In this course, we saw one example in a CO_2 adsorption packed bed that selectively adsorbed CO_2 onto activated carbon. A range of alternate separation methods have been proposed and investigated. One promising medium for CO_2 separation is molten salts.

Researchers at the Norwegian University of Life Sciences have developed a method using molten inorganic halide salt-based mixtures containing CaO to separate CO_2.[2] In a fluidized bed reactor, CO_2 reacts with CaO to create calcium carbonate. In a second reactor, the calcium carbonate is decomposed to re-release CO_2 in a controlled manner so the molecule can be stored or utilized in downstream chemical processes. This method was found to have an efficiency of >90%, meaning 90% of CO_2 was removed from the input stream. This is a higher efficiency than the packed bed we tested in lab, which separated 60-70% of the CO_2 fed. This high efficiency is in part achieved by dissolving the active substances—CaO and CO_2—in a liquid phase molten salt mixture. The gas-liquid reaction will have more favorable reactant transport than a gas-solid phase setup. The system also represents an improvement on the cyclability of previously tested solid-phase CaO-based minerals, which showed severely reduced reactivity after only 3 cycles. By contrast, the molten salt-based technology demonstrates >80% regeneration of CaO after forming calcium carbonate, which is highly favorable for cyclability.

One caveat to this study is that the technology was tested using diluted flue gas, which has a different composition and higher CO_2 concentration than air. Thus, these findings would be directly applicable to a use case of capturing carbon from emissions sources such as coal power plants. While this helps prevent emissions, is cannot lead to negative emissions as DAC would. This technology should be tested using air instead of flue gas to ensure its transferability to DAC. I would expect the low concentration of CO_2 in air to make mass transfer particularly slow and hinder the rate of reaction, so further efforts must be made to promote mixing of reactants. All in all, however, this carbon capture technology shows great promise for removing carbon dioxide from the atmosphere through DAC and helping reverse our society's emissions.

[1] Mauritsen, T., Pincus, R. Committed warming inferred from observations. *Nature Clim Change* **7,** 652–655 (2017). https://doi.org/10.1038/nclimate3357
[2] Olsen, E., Tomkute, V. Carbon capture in molten salts. *Energy Science & Engineering* 1(3), 144-150 (2013). doi: 10.1002/ese3.24