Ammonium salts could provide viable way of removing carbon dioxide from atmosphere via carbon mineralization

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Removing excess carbon dioxide (CO_2) from the atmosphere may be essential to curb severe climate change. Possible, but expensive, methods include burying the gas underground between rock layers or 'scrubbing' the CO_2 in power station cooling towers before it is released. James

Highfield at A*STAR's Institute of Chemical and Engineering Sciences, together with co-workers at the National Junior College of Singapore and Åbo Akademi University in Finland, has now described a cheaper and more permanent solution that would prevent the CO_2 escaping back into the atmosphere.

Their work focused on using carbon mineralization, a process that involves a reaction between CO_2 and minerals, such as magnesium silicates, to form solid carbonates. Mineralization occurs naturally between the atmosphere and rocks, and the carbonates remain geologically stable for millions of years. Crucially, plentiful raw materials would be available to conduct this type of CO_2 removal on a vast scale.

Natural carbon mineralization is very slow, so scientists are working to accelerate the process in an energy-efficient and carbon-neutral way. Using ammonium salts and magnesium-silicate-rich serpentine rocks, Highfield and co-workers induced rapid carbon mineralization. They also found that milling the solids could convert serpentine directly into stable carbonate.

To accelerate the extraction of magnesium (as soluble sulfate) from serpentine, the researchers used ammonium sulfate. This reaction generates by-products such as iron oxide that may be useful for the steel industry. They trapped the leftover ammonia in water, and recycled this by-product in an aqueous wash with the magnesium solution to produce a mineral form of magnesium hydroxide called brucite. Finally, the researchers carbonated the brucite in a pressurized reactor. The heat generated by this exothermic process was recycled to help power the initial magnesium extraction.

A key aim throughout the processing was to recycle as much ammonium sulfate as possible. The final products, magnesites (magnesium carbonates), could also be useful. "Magnesites are commodities in their own right as smoke- and fire-retardants, and have potential for heavy-metal ion sequestration," the team notes.

Highfield and co-workers discovered that the yield of recycled ammonium sulfate drops considerably at temperatures of 400–450 °C, although reactions at these temperatures produce the most brucite. They suggest that this may be rectified by either increasing the humidity during the process or performing the reaction at a lower temperature to extract an alternative mineral to brucite.

"By virtue of their rich chemistry with magnesium, ammonium salts are likely to become ubiquitous in the field of CO2 mineralization," the team says.

More information: Highfield, J., Lim, H.-Q., Fagerlund, J. & Zevenhoven, R. Activation of serpentine for CO2 mineralization by flux extraction of soluble magnesium salts using ammonium sulfate. *RSC Advances* 2, 6535–6541 (2012). pubs.rsc.org/en/content/articl … g/2012/RA/c2ra01347a

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