CO2 released from burning fuel today goes back into new fuels tomorrow

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The search for ways to use megatons of carbon dioxide that may be removed from industrial smokestacks during efforts to curb global warming has led to a process for converting that major greenhouse gas back into the fuel that released it in the first place. Research on the project was a topic here today at the 245th National Meeting & Exposition of the American Chemical Society (ACS).

"It may seem like trying to put the genie back into the bottle," Wojciech Lipiński, Dr. Sc.Techn., said. "But it already has been proven with laboratory scale equipment. The process uses three of the world's most abundant and inexpensive resources. Sunlight is the energy source and carbon dioxide and water are the raw materials."

Lipiński also discussed another project that uses inexpensive calcium oxide, made from ordinary limestone, to capture carbon dioxide (CO_2) before it leaves the smokestacks of coal-fired electric power stations. The CO_2 reacts with calcium oxide, forming calcium carbonate, the same material in blackboard chalk, some calcium dietary supplements and some antacids. The calcium carbonate then goes into a reactor that removes the CO_2 and regenerates the calcium oxide for another encounter with CO_2.

Both processes use highly concentrated sunlight as the energy source. The test facility built at the University of Minnesota by Lipiński and his colleague Jane Davidson, Ph.D., is a high-flux solar simulator consisting of seven 6,500-watt light bulbs and mirrors that focus the light into a spot about 2 inches in diameter. Temperatures in that spot can reach 3,600 degrees Fahrenheit, way beyond the melting point of steel.

In smokestack process, that heat would remove the carbon dioxide from calcium carbonate and regenerate the calcium oxide. In the genie-out-of-the-bottle CO_2 process, that heat fosters breakdown of carbon dioxide and water to form carbon monoxide and hydrogen, the two components of "synthesis gas" or "syngas."

The name comes from its time-tested use—for more than a century—in making or synthesizing other products. Syngas can be converted into synthetic hydrocarbons, for instance, gasoline, diesel and jet fuel or aviation kerosene. Jet fuel is already industrially produced in significant quantities from syngas obtained from coal and natural gas. Lipiński and his colleagues are developing prototype reactors to demonstrate syngas production from water and captured carbon dioxide in the solar simulator. A full-scale commercial facility would use a field of mirrors to focus sunlight onto a central reactor, similar to the emerging concentrated solar power, or CSP, facilities that now use heat from sunlight to produce electricity.

Lipiński noted that the sunlight-to-synfuels technology could be the basis of "carbon-neutral" energy production, in which CO_2 is reused, with the same amount released into the air from burning of fossil fuels removed and put back into synfuels. With their similarity in composition to conventional fuels and long history of use, synfuels made with the solar process also would not require a new infrastructure.

More information: Abstract

This paper presents current research progress towards solar thermochemical CO2 capture based on the carbonation/calcination reaction pair. A thermodynamic analysis is performed to determine the

effects of input CO_2 concentration, reaction temperatures, and gas and solid phase heat recovery on the total solar energy required for the cycle. Transient heat and mass transfer in a non-uniform emitting, absorbing and anisotropically scattering medium inside semi-transparent, optically large and chemically reacting particle of $CaCO_3$/CaO under direct high-flux irradiation is analyzed numerically to investigate the coupling between the heterogeneous reactions and the conjugate heat and mass transfer. A novel solar thermochemical reactor design for the CO_2 capture process is discussed.

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