Flexibility: The key to carbon capture

August 12 2011

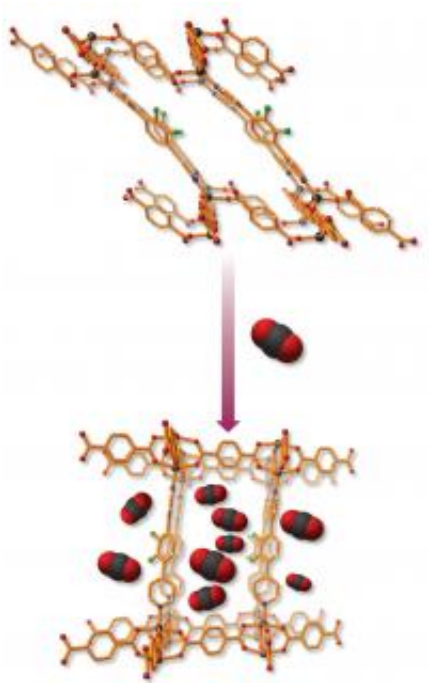

Figure 1: In the presence of carbon dioxide molecules (red and black), the molecular PCP cage expands to adsorb the gas. Credit: 2011 Ryotaro Matsuda

From power plants that capture their own carbon dioxide emissions to vehicles powered by hydrogen, clean energy applications often demand materials that can selectively adsorb large volumes of harmful gases. Materials known as porous coordination polymers (PCPs) have great gas-trapping potential, and now their adsorptive properties can be boosted using a new technique developed by a research team in Japan.

The key to the development is making PCPs that can flex, since it allows the team to tune the gas-adsorbing properties of these materials—whether it is to improve the ability to selectively adsorb one gas from a mixture or to fine-tune the pressure at which the gas is captured and released.

While structural flexibility in PCPs is not new, team member Ryotaro Matsuda from the RIKEN SPring-8 Center, Harima, explains that he and his colleagues successfully incorporated this flexibility into a PCP built from molecular components known as secondary building units (SBUs). At the molecular scale, PCPs consist of vast networks of tiny interlinked cages, inside which gas molecules can sit. SBUs are made from clusters of metal atoms that can be used to form the corner of each cage. Their use gives materials scientists great control over the structure of a cage, but they can also lock the structure.

Matsuda and colleagues overcame the rigidity problem by connecting the cage corners into cubes using long, slim carbon-based linkers. In the absence of carbon dioxide, these slender linkers allow the cage framework to collapse into a non-porous solid; but in the presence of a gas, the material expands—a behavior known as gate-opening adsorption (Fig. 1).

It is a behavior that could prove useful, Matsuda explains. “Gate-opening-type adsorption, which is induced by the structural transformations from a non-porous structure to a porous structure at a certain pressure of gas, would provide a way to enhance the efficiency of pressure swing adsorption,” he says. Pressure-swing adsorption is being investigated as a way to capture carbon dioxide emissions from power plants. The concept relies on finding materials that will release the gas in response to a drop in pressure, so that it can be piped away for long-term, underground storage.

The researchers are now looking to improve the performance of their material. “We are currently trying to tune the soft porosity of the prototype PCP to separate mixtures of gases,” says Matsuda. “We have also been working to reveal the relationship between the structure, adsorption property and separation ability of [other] PCPs.”

More information: Seo, J. et al. Soft secondary building unit: dynamic bond rearrangement on multinuclear core of porous coordination polymers in gas media. Journal of the American Chemical Society 133, 9005–9013 (2011).

Provided by RIKEN