Pacific Northwest NATIONAL LABORATORY

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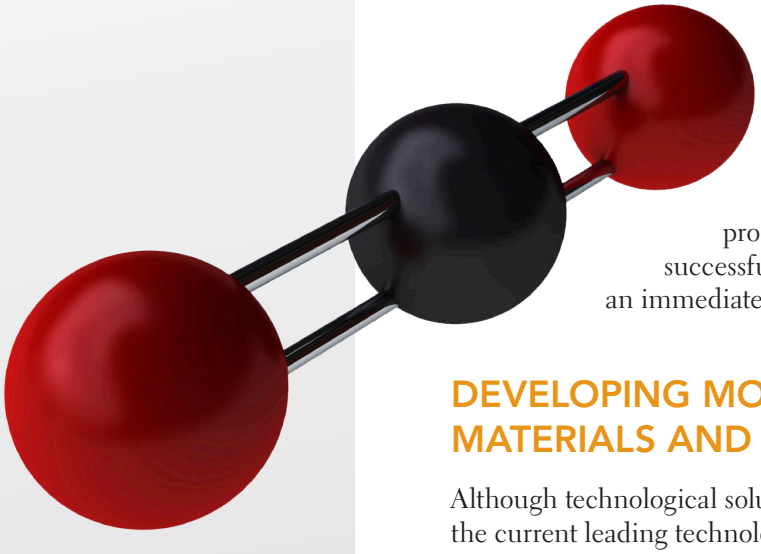
Carbon capture: a critical step in reducing carbon dioxide emissions

The increase of carbon dioxide (CO_2) in the atmosphere is considered a key contributor to global climate change, and fossil fuel emissions from energy production are considered the greatest contributors to increasing CO_2 in the atmosphere. Because existing coal-burning power plants are a major contributor to CO_2 emissions and will be part of energy production in the foreseeable future, reducing emissions from these plants is critical.



Pacific Northwest National Laboratory researchers are developing and demonstrating novel materials and technologies for capturing and separating CO_2, with a focus on capturing flue-gas emissions from existing coal-burning power plants. Carbon capture and separation are the first steps in the carbon management process and must be done effectively for later steps to be successful. Hence this research plays an important role in solving an immediate and urgent national need.

DEVELOPING MORE EFFICIENT CAPTURE MATERIALS AND TECHNOLOGY

Although technological solutions exist for the capture of CO_2 from power plants, the current leading technology, which involves the use of basic organic solvents dissolved in water, is expensive. In this liquid system, CO_2 is captured selectively at a low temperature and released subsequently at a higher temperature. The organic solvent is corrosive, so it must be diluted by water. During the higher temperature regeneration step, this water diluent must also be heated. Estimates indicate that implementing this technology will result in a huge energy penalty, that is, as much as 30 percent more coal will need to be burned to generate the electricity required to run this CO_2 capture and release technology. This energy penalty translates to higher power cost to the customer. PNNL's carbon capture research focuses on identifying new CO_2 capture materials and technologies that can significantly reduce the energy penalty of current CO_2 capture technology.

U.S. DEPARTMENT OF ENERGY

Our work focuses on four areas of materials development: materials discovery and proof-of-principle demonstration; scale up of materials and processes; process economics; and testing with actual coal-derived emissions gases.

Materials discovery and development

PNNL scientists are investigating a broad range of materials for capturing CO_2—including both liquid solvent and solid adsorbent systems—that have the potential to provide high performance at low cost. These include liquid systems that change polarity in the presence of CO_2 thereby increasing capacity, and liquid systems that employ an electrical switching process for the CO_2 capture and release. Solid adsorption systems include engineered materials prepared at the nano scale with unique physical and chemical properties, as well as inexpensive naturally occurring materials that are being modified to maximize CO_2 capacity while maintaining low cost. All these materials are thoroughly characterized and tested at a relatively small scale, under conditions of temperature, gas composition and flow rate that would be expected for the flue gas from a coal-burning power plant.

Scale up of materials and processes

Any material developed for CO_2 capture must have the potential to be produced cost-effectively at the necessary scale and by methods that are well understood in the industry. Researchers at PNNL are examining a variety of synthesis methods and conditions to minimize the cost of material scale up. But scale up also applies to testing. It is important to test these materials under the conditions and at the scale that make it possible to bring the process up to plant scale so the plant can be readily designed and implemented.

Moreover, it is important to test these materials under continuous operation and to show consistent performance over a significant period of time. PNNL is developing test facilities employing "carts" that allow researchers to examine materials at an initial scale up, with the flexibility to quickly interchange carts, so that different technologies can be investigated efficiently and cost effectively. These test and scale-up facilities will be made available to other developers in the future, as PNNL's goal is to make capabilities available to other researchers in addition to developing specific materials at the Laboratory.

Process economics

At PNNL, it is not enough to demonstrate that our technologies work. They also must work cost effectively—and that means much more economically than existing technology. A significant aspect of our work with carbon capture involves developing the tools and methods to evaluate these technologies from the perspective of cost. Similarly, PNNL researchers identify the best engineering approaches for implementing the technology, providing baseline economics for the current best processes as well as comparisons with emerging technologies.

Testing with actual coal-derived emissions gases

Frequently, testing for CO_2 capture or for other emissions studies is carried out with gas simulants rather than real gases coming from coal power plants. PNNL is developing a facility that can operate with coal, either as a gasifier producing "syngas," or as a source of combustion, producing power-plant flue gases. This facility will allow us to test the cart-mounted materials and processes at the same scale but with actual coal-derived gases, which is key in developing credibility with industry.

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