INNOVATION: CO2 CONVERSION

Mouthwash for a smokestack

Biological process cleanses carbon dioxide from industrial emissions -- and turns the pollutant into materials that can be recycled or sold

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Concrete has underpinned urban society for thousands of years, supporting structures from Rome's 2,000-year-old Pantheon to our modern network of highways and high-rise buildings. But like most other industrial sectors in Canada these days, concrete manufacturing is due for a change as it looks for ways to reduce its ecological footprint.

Case in point: the emissions from cement-plant smokestacks. The world's Portland cement plants, which produce one of concrete's key ingredients, churn out nearly 80 million tonnes of carbon dioxide a month -- nearly half as much CO_2 as comes from coal-fired power generation.

Current technology such as electrostatic precipitators can scrub pollutants such as nitrogen oxides, sulphur compounds and particulates from the stack emissions of cement plants.

But so far there has been nothing available for cost-effective removal of the biggest villain in the stacks: carbon dioxide, a major greenhouse gas.

"In recent years, we have paid a lot of attention to improving our environmental performance," says Philippe Arto, chief executive officer of Montreal-based concrete giant St. Lawrence Cement.

"Producing 'clinker,' a precursor of cement, requires intensive use of natural raw materials and energy," he notes. "It also results in emissions to the atmosphere, the most significant being carbon dioxide."

Now, new technology from a Quebec company that uses a biological catalyst to defuse CO_2 may hold the key to cutting such emissions -- and produce cement-making ingredients in the process.

CO_2 Solution first emerged in 1997 from original research conducted at Laval University in Quebec. The Laval labs found a new way to isolate CO_2 from gaseous emissions and immobilize it in an inert solid.

Field-trial demonstrations and larger pilot projects followed. In 2005, the technology met or exceeded performance and reliability expectations during a multi-day, round-the-clock field test at a garbage incinerator in Quebec City.

"We are actively pursuing opportunities in other key [non-concrete] end markets, such as iron and steel, and in Alberta oil sands," says Jacques Raymond, president and CEO of CO_2 Solution.

If used in older power-generating plants alone, the technology has the potential to sequester nearly two billion tonnes of CO_2 each year -- an amount roughly equal to all the carbon dioxide emitted by every passenger vehicle in North America.

Like many recent innovations, the CO_2 Solution technology ties together data from disparate disciplines.

The company's scientists are neither process engineers nor inorganic chemists, but rather molecular biologists. Working backward from a final goal of extracting CO_2, they found that a complex protein called human carbonic anhydrase II could do the work required. The enzyme was originally isolated from human metabolism, and is produced by genetically modified E. coli bacteria -- biotechnology in the service of cement.

This tiny workhorse is only 7 nanometers across at its widest, nearly as thin as a strand of DNA. Although it comprises more than 5,000 atoms it has a single, simple function: it's a catalyst.

In the carbon-conversion process, a CO_2 rich emission is sent from the smokestack through water, in which the gas dissolves. The gas-bearing liquid then reacts with the catalyst, which takes one molecule of carbon dioxide and one of water, rips them apart, and rejigs them into ions of hydrogen and bicarbonate.

Each molecule of catalyst can immobilize up to a million CO_2 molecules as extractable bicarbonate. The bicarbonate can then be extracted and stored. The residue needn't be tossed away, because it's a good source of pure carbon dioxide for other industrial processes. Isolated bicarbonates can be recycled back into concrete production as fine-particle aggregates.

Mr. Raymond says his company has "no known competitors with a biological approach. Our only competition comes from the chemical industry, which tends to use [chemical] solvents -- Mitsubishi, for example."

Although the technology can be applied to many types of industries, the company's initial target is concrete manufacture, Mr. Raymond says.

In July, CO_2 Solution will have a perfect opportunity to display its wares when the International Congress on the Chemistry of Cement convenes in Montreal, the ICCC's first gathering in Canada since 1962. Topping the global conference's pre-published list of topics is sustainability and climate change for the industry.

Pierre Boucher, president of the Cement Association of Canada, admits his industry has a way to go to reduce greenhouse gases. But he's optimistic that if new targets are realistic in terms of timelines and target quantities, they can be met.

"We're always looking for new technologies to do this," he says.

Meanwhile, like many high-tech startups, CO_2 Solution is weaning itself from provincial and federal government grants and is considering a number of strategic alliances. Six weeks ago, Ohio-based energy multinational Babcock & Wilcox Co. signed a co-operative agreement with CO_2 Solution, giving the company two payments of $500,000 (U.S.) for the acquisition of a licence option, and for joint development of technology to reduce the carbon dioxide emitted by burning coal.