HOW INDUSTRIAL EXHAUST HEAT COULD BE USED TO EXTRACT CARBON DIOXIDE

Clever use of absorbent materials could help harness the **80% OF INDUSTRIAL EXHAUST HEAT ENERGY THAT IS CURRENTLY WASTED** to power carbon capture technology.

Japan has a huge unharnessed energy source in the form of moderately hot exhaust fumes that could help industry power its own carbon capture technology and clean up its act, says environmental technologist, Akio Kodama.

Already exhaust fumes hotter than 500°C from industrial activities — including melting and processing metals, and operating transport machinery — are sometimes repurposed for uses such as electricity generation, explains Kodama, who is based at the Institute for Frontier Science Initiative at Kanazawa University. But the heat from cooler exhaust fumes typically goes to waste.

"Nearly 80% of exhaust heat produced in Japan is under 200°C, and the current use of this heat is limited to making hot water," he says. "That's a significant source to be unlocked."

Kodama is pioneering a method for extracting waste CO_2 using relatively low heat fumes and absorbent materials.

His team leverages 'temperature swing adsorption', an established technique for purifying gases, in which adsorbents with small pores capture and release CO_2, depending on the temperature. In this process, the release stage is maneuvered so that the CO_2 can be extracted by vacuum pumps.

CONCENTRATED EFFORT

The current issue with many carbon-capture and sequestration technologies is that they require huge amounts of energy to power them, meaning that more carbon is generated than they can suck up from the environment. "High-energy-input carbon capture machinery only makes sense where a good renewable energy source is readily available, such as geothermal energy in Iceland. It has been a challenging balancing act in other parts of the world," explains Kodama.

One problem is that at low temperatures, traditional temperature swing adsorption requires numerous hot air currents to warm adsorbents, releasing captured CO_2, but the air tends to dilute the released CO_2 so that the concentrations extracted are too small.

In response, Kodama created an alternative heat exchange mechanism to air currents composed of zeolite or activated carbon placed within an adsorption tower[1]. Waste heat in the 200°C range should be able to fuel this process, but the goal is to get this working at temperatures of 80°C or less.

"The places where we find this type of exhaust heat are also in many cases major CO_2 emission sources. How good would it be if industrial plants could use the heat that they are wasting to help reduce their CO_2 emissions?" says Kodama.

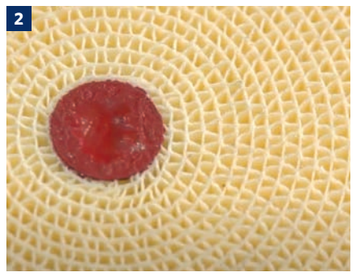
DIRECT AIR CAPTURE

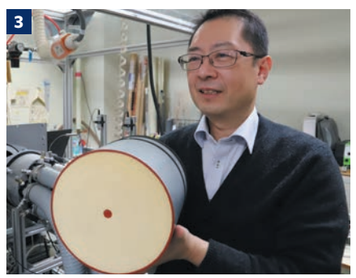
Kodama and his team are also hoping to use rotors fitted with honeycomb-like lattices for 'direct air capture', which sucks up ambient carbon dioxide from the atmosphere. For this, they are employing amine-based adsorbents being developed by The Research Institute of Innovative Technology for the Earth, based in Kyoto. In future, they intend to integrate these rotors and the heat exchangers.

To make the rotor technology workable, Kodama says the plan is to use it in tandem with other processes that can capture enough carbon to outweigh the energy emissions required to power the technology. "Other techniques can achieve high concentrations of CO_2, but need extensive energy and massive equipment, such as large vacuum pumps," says Kodama. "By adding a rough concentration increasing process as a first step, we're trying to drastically reduce the amount of air that needs to be processed. This means the machinery can be more compact, with a small vacuum pump."

This project has been selected for the New Energy and Industrial Technology Development Organization Moonshot Research and Development Program, a Japanese government initiative supporting ambitious projects tackling major societal issues. The eventual plan is for sequestered CO_2 to be converted into liquid hydrocarbon to fuel cars, recyclings the CO_2.

Finding a new use for currently wasted industrial exhaust heat is also very attractive, says Kodama. "Even as the world moves towards carbon-free energy sources, we will likely still produce significant waste heat beyond 2050," meaning this potential energy source for carbon capture is here for the foreseeable future. ■





▲ 1. Direct air capture technology from Kanazawa University sucks up ambient CO_2 from the atmosphere.
2. Honeycomb-like lattices of amine-based adsorbents on rotors help absorb and concentrate CO_2 for sequestration.
3. Akio Kodama is pioneering a method for extracting waste CO_2 using the energy of relatively-low-heat fumes.

ADVERTISEMENT FEATURE

SETTINGS ITS SIGHTS ON THE FUTURE

Kanazawa University has been growing its research institutes, which welcome international scholars.

▲ Kanazawa University President Takashi Wada.

Kanazawa University has long had a scheme to incubate specialized research centres, helping them grow from modest hubs of basic research to extensive institutes also engaging in applied projects. "Concentrated investment in promising research areas has brought success," says President Takashi Wada. "It is crucial to integrate different research fields, as well as fine-tune basic research. We engage in empirical research for the good of society and then disseminate our outcomes globally," explains Wada.

One of six such flagship centres, the Nano Life Science Institute, was selected in 2017 for the World Premier International Research Center Initiative (WPI), a government programme to establish world-renowned research hubs in specific academic fields. Here researchers study topics ranging from biological phenomena at the nanoscale to advanced microscopy techniques, and more than 40% of the faculty herald from overseas, one of the highest proportions in the country.

"The university offers extensive support for foreign faculty, international students and their families, such as school enrollment for children," says Wada.

Another flagship centre is The Institute for the Study of Ancient Civilizations and Cultural Resources, established in 2022. This brings together diverse researchers, such as leading experts in ancient civilization and genomics experts, who can weave together a tapestry of diverse findings. "It's a success case for integrating the humanities with the sciences, and is the type of interdisciplinary research which we hope to expand upon," says Wada.

The launch of a center for empirical research in 2023 to test futuristic technologies developed at the university will be a key part of the effort to find solutions. To harness what he calls 'future-oriented intelligence' and overcome the challenges that lay ahead, Wada says grit, communication skills, teamwork and expert knowledge will all need to be leveraged.

REFERENCE

1. Masuda, S. *et al. Separation and Purification Technology* (2023)

金沢大学 KANAZAWA UNIVERSITY

www.kanazawa-u.ac.jp/e

Advertiser retains sole responsibility for content