

NTU scientists find way to convert plastic waste into low-carbon hydrogen fuel



Different types of plastics, including marine litter (centre), that can be turned into hydrogen and carbon nanotubes. PHOTO: NTU



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SINGAPORE - Scientists from Nanyang Technological University have found a way to convert plastic waste into low-carbon hydrogen, which is considered a cleaner fuel than natural gas.

The discovery, which could power vehicles and contribute to the power grid in as soon as three years, comes as the Republic looks to adopt hydrogen as an alternative fuel, as it does not produce carbon dioxide (CO₂) when burned.

To help Singapore bring down power-sector emissions to net zero by 2050, the Energy Market Authority's Energy 2050 Committee report had also suggested developing infrastructure suitable for clean-burning hydrogen to be used as a fuel.

The latest UN Intergovernmental Panel on Climate Change (IPCC) report found that greenhouse gas emissions - such as CO₂ - need to peak before 2025 and be reduced by 43 per cent by 2030 to limit the impacts of dangerous climate change.

This will allow the world to limit global warming to 1.5 deg C above pre-industrial levels - a key goal of the 2015 Paris Agreement. The world has already warmed by 1.1 deg C.

Plastic waste, which contains contaminated food packaging, styrofoam and plastic bags, can be challenging to recycle, meaning that they are currently incinerated or buried in landfills.

With 832 million kilograms of plastic waste generated in Singapore annually that cannot be recycled, NTU's new method - a high temperature chemical process known as pyrolysis, can convert the waste into energy that can potentially power up to 1,000 five-room apartments for a year.

Associate Professor Grzegorz Lisak from NTU's Nanyang Environment and Water Research Institute (Newri), who led the project, told reporters during a virtual media briefing on Wednesday (April 6) that the other by-product from the pyrolysis process would be a form of solid carbon, known as carbon nanotubes.

Carbon nanotubes have an array of uses, including sensors, semiconductors and energy conversion devices, such as hydrogen fuel cells.

Newri senior research fellow Andrei Veksha said the gas mixture from the pyrolysis process has about 78 per cent hydrogen concentration, 20 to 24 per cent of methane, and a small amount of CO₂.

This can be used for powering gas turbines to generate electricity, or if a purer form of hydrogen is required, the gases can be separated using existing technologies in the market, he added.

For instance, hydrogen-powered vehicles require very pure hydrogen of more than 99.9 per cent, as the presence of contaminants could impact the performance of the fuel cell.

The remaining methane and CO₂ gases can then be recycled and used to power the reactor for pyrolysis. The chemical reaction will also leave behind a small amount of char, which can be repurposed for other uses so that it does not end up at Semakau Landfill, said Dr Veksha.

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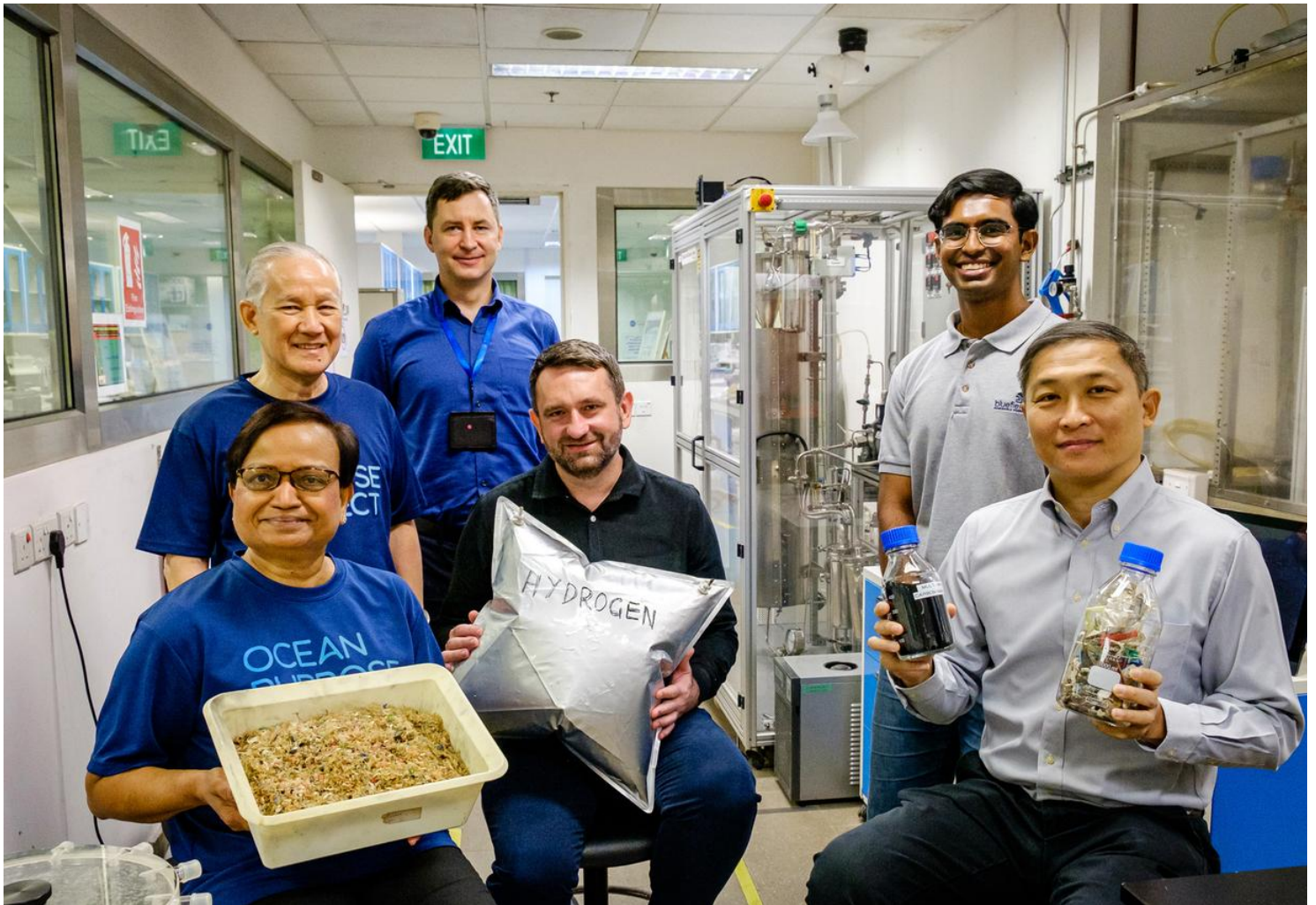
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To further refine the new conversion method and to assess its commercial feasibility, the research team is test-bedding it on the NTU campus to treat local plastic waste, in partnership with Bluefield Renewable Energy, a local environmental firm that specialises in converting waste to useful resources.

Dr Tan Yong-Tsong, its executive director, said that his company will concurrently be testing the NTU tech on its modular plants, using the hydrogen gas to power its reactors.

As part of the research project, marine litter was collected from local and Indonesian waters in collaboration with the Ocean Purpose Project, a non-governmental organisation and social enterprise based in Singapore.



(Clockwise from bottom right) Bluefield Renewable Energy executive director Tan Yong-Tsong, NTU Associate Professor Grzegorz Lisak, Ocean Purpose Project admin and HR lead Margaret Dacruz, Ocean Purpose Project lead engineer Richard Ho, NTU senior research fellow Andrei Veksha and Bluefield Renewable Energy's Mr Irshad Mohamed. PHOTO: NTU

At a separate demonstration facility owned by Ocean Purpose Project in Lombok Indonesia, unsorted ocean plastic waste can be converted into high-profit by-products.

For instance, each tonne of plastic waste can yield 151kg of carbon nanotubes priced at \$15,100, and 27kg of hydrogen, which can be sold for \$57.

The multi-million-dollar joint research project, supported by the Industry Alignment Fund-Industry Collaboration Projects (IAF-ICP) administered by Singapore's Agency for Science, Technology and Research (A*Star), aims to develop feasible solutions to economically scale up the conversion of plastic waste to hydrogen over the next three years.

"If the initiative is successful, it will help Singapore reduce the amount of incineration ash from plastic waste that is sent to Semakau Landfill and help to prolong its lifespan, as it is estimated to run out of space by 2035," said Prof Lisak.