NEWS RELEASE

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NTU Singapore scientists develop new method to recover high-purity silicon from expired solar panels for upcycling into lithium-ion batteries

Scientists from **Nanyang Technological University, Singapore (NTU Singapore)** have devised an efficient method of recovering high-purity silicon from expired solar panels to produce lithium-ion batteries that could help meet the increasing global demand to power electric vehicles.

High-purity silicon makes up the majority of solar cells, yet they are typically discarded at the end of their operational lifespan after 25 to 30 years. It is challenging to separate the silicon from other solar cell components such as aluminium, copper, silver, lead, and plastic. Moreover, recycled silicon has impurities and defects, making it unsuitable for other silicon-based technologies.

Existing methods to recover high-purity silicon are energy-intensive and involve highly toxic chemicals, making them expensive and limiting their widespread adoption among recyclers.

The NTU researchers overcame the challenges through a new extraction method using **phosphoric acid**, a substance commonly used in the food and beverage industry.

The NTU approach demonstrated a **higher recovery rate and purity** than present silicon recovery technologies. The process is also more efficient, involving just a single reagent (phosphoric acid), whereas conventional methods include at least two types of chemicals (highly acidic and highly alkaline).

Principal investigator of the study, **Associate Professor Nripan Mathews, Provost's Chair in Materials Science and Engineering** and **Cluster Director of the Energy Research Institute @ NTU (ERI@N)**, said, "Our approach to silicon recovery is both efficient and effective. We do not have to use multiple chemicals, reducing the time spent on post-treatment of the chemical wastes. At the same time, we achieved a high recovery rate of pure silicon comparable to those produced by energy-intensive

extraction techniques."

While the use of solar renewable energy has climbed over the last few decades, the limited lifespan of 30 years for solar panels means that 78 million tonnes of solar panels are due to expire by 2050.[1]

The NTU research team believes their silicon recovery method can potentially solve the growing problem of solar panel waste by keeping resources in a loop.

The study, published in the scientific journal *Solar Energy Materials and Solar Cells* in August, signifies NTU's commitment to its **2025 Strategic Plan**, in which sustainability and innovation for a circular economy are key pillars. It also supports the **NTU Sustainability Manifesto**, which charts the University's course for sustainability, carbon neutrality and societal impact.

Powering the growth of lithium-ion batteries for electric vehicles

Silicon is considered one of the most promising materials for next-generation lithium-ion batteries to power electric vehicles (EVs) due to its ability to deliver extended range and quick charging times.

With carmakers racing to develop silicon-based lithium-ion batteries for advanced EVs, the NTU research team believes their newly developed silicon recovery method can support the expected demand for high-purity silicon.

The NTU approach involves first soaking the expired solar cell in hot diluted phosphoric acid for 30 minutes to remove metals (aluminium and silver) from their surfaces. This process is repeated using fresh phosphoric acid to ensure complete removal of the metals, resulting in pure silicon wafer at the end of another 30 minutes.

Using advanced spectroscopic analyses to evaluate the elemental content of the recovered wafer, researchers found that their sample achieved a **recovery rate of 98.9 per cent** with a **purity of 99.2 per cent** - comparable results to silicon recovered through currently available methods.

When the recovered silicon was upcycled into a lithium-ion battery anode and tested for efficiency, it performed similarly to new, commercially bought silicon.

Lead author of the study, **Dr Sim Ying, Research Fellow, Energy Research Institute @ NTU**, said, "The comparable performance between our upcycled silicon-based lithium-ion battery and the newly purchased ones proves that the NTU approach is feasible. We envision our faster and cheaper silicon recovery method to be a positive

[1] IRENA, IEA-PVPS, End-Of-Life Management: Solar Photovoltaic Panels, 2016

boost for the development of EV batteries. Aside from EVs, there are also potential applications such as thermoelectric devices."

The team has filed a technology disclosure to NTUitive - NTU's innovation and enterprise company – for their silicon recovery method, paving the way for potential commercialisation. Meanwhile, the researchers are seeking industry collaborators to explore market applications.

The project is part of the **Singapore-CEA Alliance for Research in Circular Economy (SCARCE)** programme, a collaboration between NTU and the French Alternative Energies and Atomic Energy Commission. SCARCE is supported by Singapore's National Research Foundation and the National Environment Agency (NEA) under the Closing the Waste Loop Funding Initiative (Award No. USS-IF-2018-4).

The programme seeks to develop a variety of innovations that turn trash into treasures, thereby opening new economic growth areas for waste management and recycling.

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Notes to Editor:

Paper titled "Simplified silicon recovery from photovoltaic waste enables high performance, sustainable lithium-ion batteries" published in *Solar Energy Materials and Solar Cells*, 1 August 2023, Volume 257.
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About Nanyang Technological University, Singapore

A research-intensive public university, Nanyang Technological University, Singapore (NTU Singapore) has 33,000 undergraduate and postgraduate students in the Engineering, Business, Science, Medicine, Humanities, Arts, & Social Sciences, and Graduate colleges.

NTU is also home to world-renowned autonomous institutes – the National Institute of

Education, S Rajaratnam School of International Studies, Earth Observatory of Singapore, and Singapore Centre for Environmental Life Sciences Engineering – and various leading research centres such as the Nanyang Environment & Water Research Institute (NEWRI) and Energy Research Institute @ NTU (ERI@N).

Under the NTU Smart Campus vision, the University harnesses the power of digital technology and tech-enabled solutions to support better learning and living experiences, the discovery of new knowledge, and the sustainability of resources.

Ranked amongst the world's top universities, the University's main campus is also frequently listed among the world's most beautiful. Known for its sustainability, NTU has achieved 100% Green Mark Platinum certification for all its eligible building projects. Apart from its main campus, NTU also has a medical campus in Novena, Singapore's healthcare district.

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