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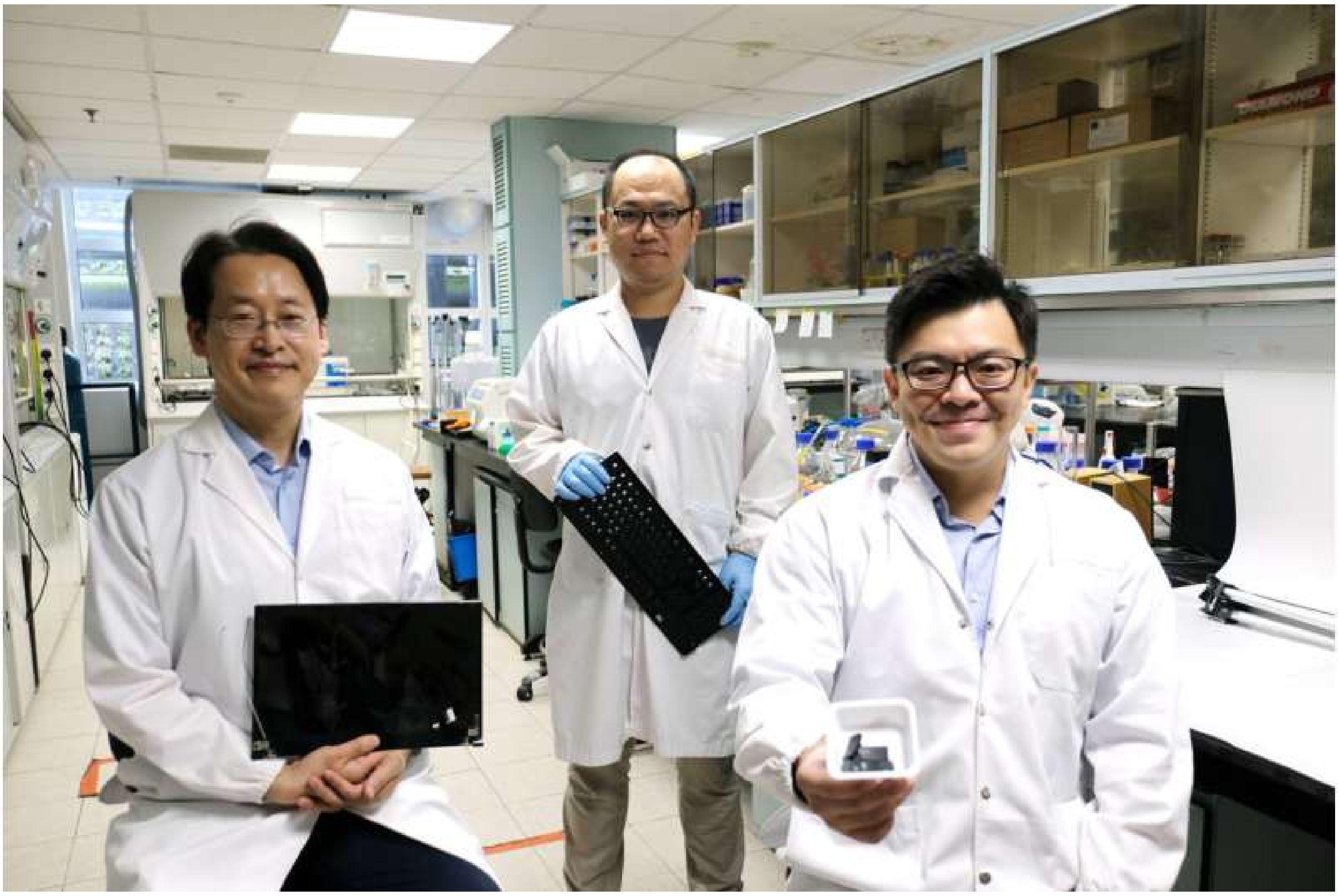
Upcycling method reduces environmental footprint of plastic waste stream

by Nanyang Technological University



Scientists at NTU Singapore have developed a new use for plastics found in e-waste, which is rarely recycled – by repurposing them as an alternative to the plastics used in laboratory cell culture containers, such as petri dishes. Credit: NTU Singapore

Plastics found in electronic waste (e-waste) are rarely recycled due to their complex composition and hazardous additives, but scientists at Nanyang Technological University, Singapore (NTU Singapore) have developed a new use for them—by repurposing them as an alternative to the plastics used in laboratory cell culture containers, such as petri dishes.

The team at NTU Singapore–CEA Alliance for Research in Circular Economy (SCARCE) repurposed the e-waste plastics, subjecting them only to sterilization, before being trialed in lab experiments.

The team found that over 95 percent of the human stem cells seeded on plastics scavenged from discarded computer components remained healthy after a week, a result comparable to cells grown on conventional cell culture plates.

These findings, described in a study published online in the scientific journal *Science of the Total Environment*, indicate a potential new sustainable use for e-waste plastics, which account for about 20 percent of the 50 million tons of e-waste produced worldwide each year.

Repurposing them for cell culture in the lab would not only allow maximum value to be recovered from e-waste plastics, but also help to reduce the amount of plastic waste generated from biomedical research, said the NTU research team. A study in 2015 estimated that 5.5 million tons of lab-related plastic waste, including cell culture dishes, is generated globally in a year.

These new findings build on a 2020 study led by the same NTU team, which investigated the effect of e-waste plastics on six different human cell types and found healthy cell growth despite the hazardous elements to be found in e-waste plastics. These findings inspired the research team to upcycle e-waste plastic scraps and trial them in advanced cell culture applications.

Assistant Professor Dalton Tay of the NTU School of Materials Science and Engineering and School of Biological Sciences, who led this interdisciplinary study, said: "E-waste plastics contain hazardous components which may get released into the environment if not disposed of properly. Interestingly, we found through our studies that certain e-waste plastics could successfully maintain cell growth, making them potential alternatives to the cell culture plastics used in labs today."

"Repurposing them for immediate use rather than recycling them enables the immediate extension of the lifespan of e-waste plastics and minimizes environmental pollution. Our approach is in line with the zero-waste hierarchy framework, which prioritizes the reuse option through materials science and engineering innovation."

Providing an independent point of view, Professor Seeram Ramakrishna, Board Member of the Plastics Recycling Association of Singapore and Chairman of the Plastics Recycling Centre of Excellence, said: "With plastic a critical component in our manufacturing and logistical processes, we are in urgent need of sustainable solutions to plastic waste to mitigate its impact on the environment and social costs. Innovative solutions, such as the idea developed by Asst Prof Tay and his team to repurpose e-waste plastic, could serve to address the ubiquitous plastic waste problem in Singapore and around the world, and move us towards plastics circularity."

The NTU scientists' research that turns waste into treasure is in line with the NTU 2025 vision and the University's Sustainability Manifesto, which aspire to develop sustainable solutions to address some of humanity's pressing grand challenges.

E-waste plastics encourage healthy cell growth

For this study, the NTU team used plastic scavenged from e-waste collected by a local waste recycling facility. Three kinds of e-waste plastic were chosen for their varied surface features—the keyboard pushbuttons and diffuser sheet obtained from LCDs have a relatively flat and smooth surface, while the prism sheet, also found in LCDs, has highly aligned ridges.

To test the viability of using e-waste plastics for cell cultures, the NTU team seeded stem cells onto 1.1cm-wide circular discs of sterilized e-waste plastics.

A week later, the scientists found that more than 95 percent of live and healthy stem cells seeded on the e-plastics remained—a result comparable to the experimental control of stem cells grown on commercially available cell culture plates made of polystyrene.

The stem cells grown on the e-waste plastics also retained their ability to differentiate—a process in which stem cells become specialized cells with a more specific function, such as blood cells, brain cells, heart muscle cells or bone cells.

E-waste plastic surface features affect stem cell growth

Stem cells can undergo differentiation under the right conditions in the body or a lab. One way to facilitate this process in the lab is the addition of a medium that 'nudges' the stem cells in a certain direction.

To investigate the effect of e-waste plastic on the stem cells' differentiation, the NTU team added two types of medium in equal amounts to the cells cultured on e-waste plastic and on polystyrene cell culture plates. One type coaxes the stem cells to develop into fat cells and the other nudges the stem cells to become bone cells.

At the end of two weeks, a higher proportion of stem cells cultured on e-waste plastics successfully went through differentiation compared to those on the conventional polystyrene cell culture plate.

The scientists also found that the stem cells cultured on keyboard plastic and diffuser sheet were more likely to develop into bone cells, while stem cells cultured on the prism sheet, with its ridges, were more likely to develop into fat cells.

Asst Prof Tay said: "In tissue engineering, we use advanced techniques to engineer surfaces and study how they can influence stem cell differentiation. Now, we have shown that e-waste plastics are a ready source of such microstructures that allow us to further study how stem cell development can be directed—the 'holy grail' of regenerative medicine and more recently, lab-grown meat. There are important biomaterials and scaffold design rules and lessons we can learn from these e-waste plastic scraps."

Going forward, the NTU team aims to further develop resource-effective remanufacturing processes to upcycle e-waste plastics that would support other high-value biotechnological applications.

This would help to promote sustainable practices in research and innovative waste-to-resource solutions for the industry, say the scientists.

Provided by Nanyang Technological University

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