Orange peel helps to recycle lithium-ion batteries

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Scientists have developed a novel method of using orange peel waste to extract and reuse precious metals from spent lithium-ion batteries in order to create new batteries.

The team demonstrated their concept using orange peel, which recovered precious metals from battery waste efficiently. They then made functional batteries from these recovered metals, creating minimal non-toxic waste in the process (Credit: NTU Singapore)

The team at Nanyang Technological University, Singapore (NTU Singapore) said their waste-to-resource approach tackles food waste and electronics waste, supporting the development of a circular economy.

In a statement, Professor Madhavi Srinivasan, co-director of the NTU Singapore-CEA Alliance for Research in Circular Economy (NTU SCARCE) lab, said: “Current industrial recycling processes of e-waste are energy-intensive and emit harmful pollutants and liquid waste, pointing to an urgent need for eco-friendly methods as the amount of e-waste grows. Our team has demonstrated that it is possible to do so with biodegradable substances.”

The findings were published in *Environmental Science & Technology* in July.

With industrial approaches to recycling battery waste generating harmful pollutants, hydrometallurgy – using water as a solvent for extraction – is increasingly being explored as a possible alternative. This process involves first shredding and crushing used batteries to form a crushed material called black mass. Researchers then extract valuable metals from black mass by dissolving it in a mix of strong acids or weak acids plus other chemicals like hydrogen peroxide under heat, before letting the metals precipitate.

While relatively more eco-friendly than conventional methods, the use of such strong chemicals on an industrial scale could generate a substantial amount of secondary pollutants.

The NTU team found that the combination of orange peel that has been oven-dried and ground into powder, plus citric acid, can achieve the same goal.

In lab experiments, the team found that their approach extracted around 90 per cent of cobalt, lithium, nickel, and manganese from spent lithium-ion batteries, which they said is a comparable efficacy to the approach using hydrogen peroxide.

Assistant Professor Dalton Tay of the NTU School of Materials Science and Engineering and School of Biological Sciences said: “The key lies in the cellulose found in orange peel, which is converted into sugars under heat during the extraction process. These sugars enhance the recovery of metals from battery waste. Naturally-occurring antioxidants found in orange peel, such as flavonoids and phenolic acids, could have contributed to this enhancement as well.”

Solid residues generated from this process were found to be non-toxic, suggesting that this method is environmentally sound, he added.

From the recovered materials, they then assembled new lithium-ion batteries, which showed a similar charge capacity to commercial ones. Further research is underway to optimise the charge-discharge cycling performance of these new batteries made from recovered materials.