# Technology transforms plastic waste bottles into polymers for lithium-ion batteries

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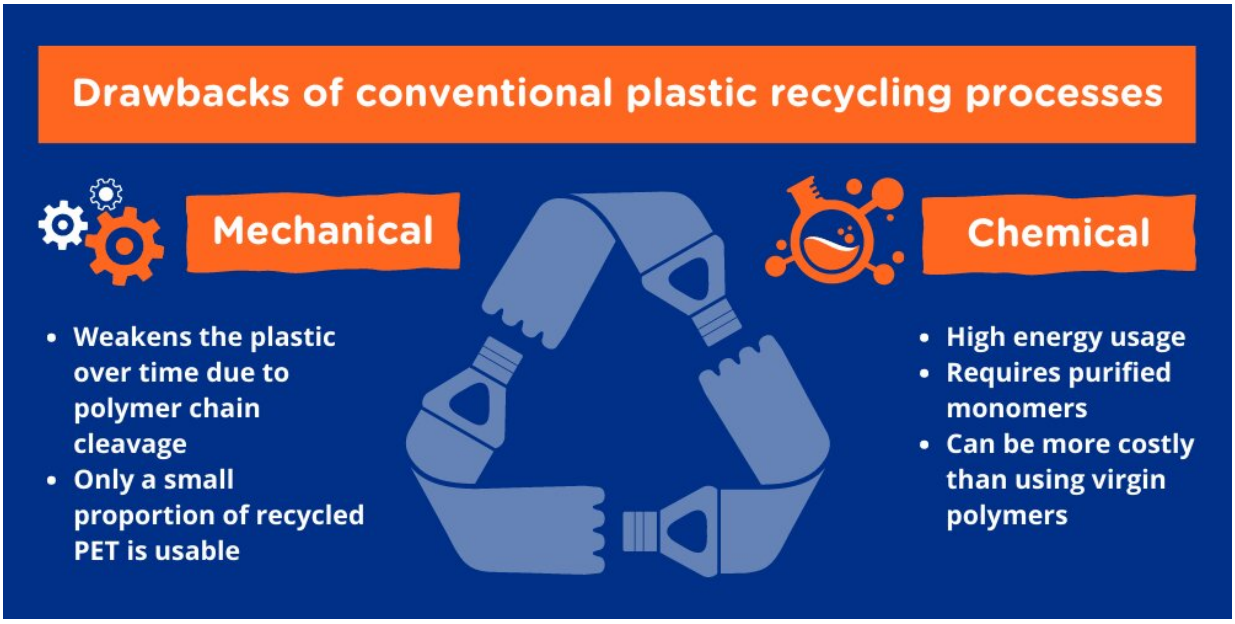



Mechanical and Chemical Processes. Credit: A*STAR

A team of A*STAR scientists has successfully upcycled waste polyethylene terephthalate (PET) plastic into polymer electrolytes, which are key components for safer lithium-ion batteries (LiBs). The study is the first known report of a working lithium-ion battery assembled using polymers upcycled from PET plastics, which are used to make plastic bottles.

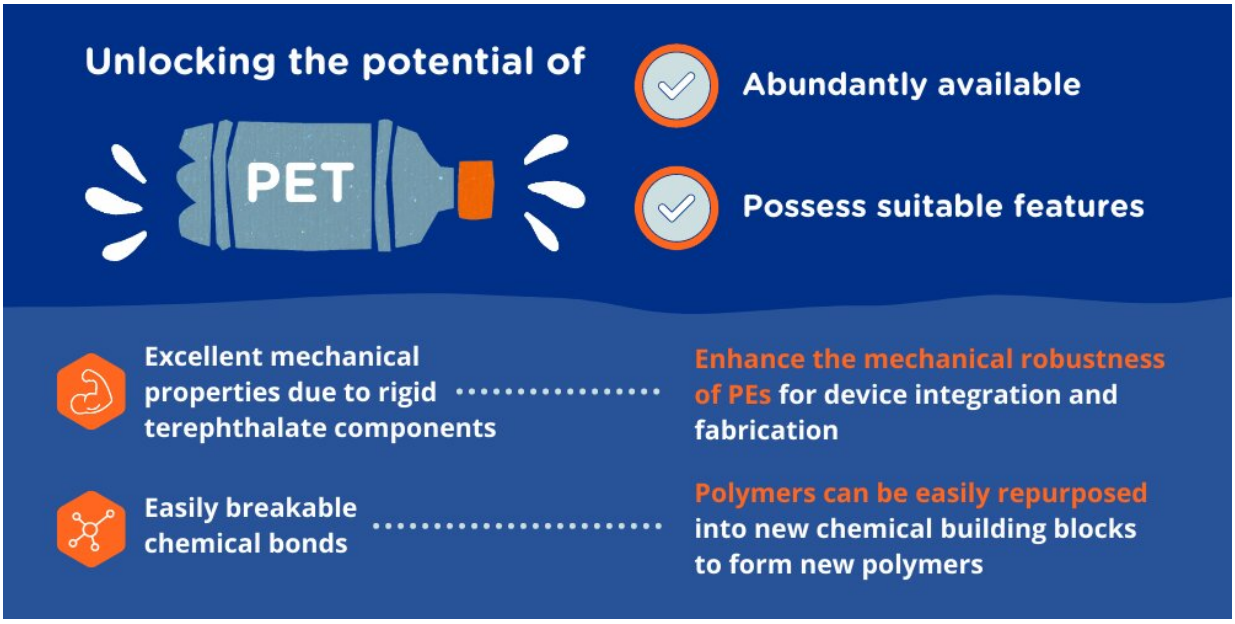
The study was published in *Journal of Materials Chemistry A* in November 2022.

Plastic waste is a mounting problem in the world today, and it is set to grow bigger with the rising demand for plastics. 460 million tons of plastics were produced globally in 2019, but only 9% are recycled, with the remainder either being incinerated or disposed in landfills and the environment.

Plastic waste is conventionally recycled through mechanical and chemical processes, which have their drawbacks. For mechanical recycling, only a small proportion of recycled PET can eventually be used, as their physical properties degrade with each round of recycling due to polymer chain cleavage. Chemical recycling involves high energy usage, requires purified monomers and can be more costly compared to using virgin polymers.

"Upcycling waste plastics is a new strategy to give these ubiquitous yet commonly discarded materials a new lease of life to transform them into value-added new products for novel applications. PET plastics offer great potential for upcycling due to their well-established existing waste collection infrastructure and relatively uncomplicated waste streams," said Dr. Derrick Fam, Deputy Head of the Polymer Composites department at A*STAR's Institute of Materials Research and Engineering (IMRE), who led this study together with Dr. Jason Lim, Deputy Head of the Soft Materials department at IMRE.

"There is a rise in demand for sustainably-sourced materials for lithium-ion batteries due to greater electrification. However, the use of waste PET plastics as a resource for polymer electrolytes has never been achieved till now. This represents our first attempt to upcycle waste PET plastics for this application," said Dr. Lim.




PET plastics possess various suitable features for upcycling. Credit: A*STAR

## Unlocking the potential of pet: Capitalizing on existing properties

Amongst the different types of plastic, polyethylene terephthalate (PET) is one of the most abundant plastics produced today, amounting to 31 million tons in 2019.

PET plastics possess existing features that make them suitable to be upcycled into polymer electrolytes (PEs). They are made up of rigid terephthalate components, which contribute to their excellent mechanical properties and can be tapped on to enhance PEs' mechanical robustness, which in turn facilitates device integration and fabrication.

In addition, they possess easily breakable chemical bonds which allow these polymers to be repurposed into new chemical building blocks with

ease. These can then be reconstituted into new polymers for fresh applications.

## From bottles to batteries: Revolutionizing battery design

Waste PET bottles were used by the team to design polyurethane-based PEs. Compared to conventional liquid electrolytes currently used in LiBs, PEs are promising alternative components in batteries that have the potential to eliminate safety hazards such as the risks of electrolyte leakage, uncontrolled heating, volume expansion, dendrite growth and fire hazards.

After assessing the viability of the PET-derived polymers as solid polymer electrolytes, the team further evaluated their ionic conductivity and cycling performance when used as gel polymer electrolytes for LiBs.

Findings from the study showed the potential of the polyurethanes derived from waste PET as polymer electrolytes for LiBs. They achieved a room temperature conductivity of $10^{-4}$ S/cm as a gel-polymer electrolyte (GPE), which is comparable to existing commercial systems containing liquid electrolytes. The team also successfully assembled a working LiB using these polymers, and showed that cells can be repeatedly charged and discharged up to 150 cycles.

Their promising performance paves the way for a future powered by more sustainable energy, where PET plastic waste can be transformed into PE materials for batteries, creating a circular economy while combating the mounting plastic waste issue. The team will also look to advance the technology for upcycling of waste plastics on a larger scale to create components for eco-friendly batteries. This initiative is in line with A*STAR's efforts to develop sustainable solutions for energy

efficiency and waste management.

**More information:** Ming Yan Tan et al, Upcycling waste poly(ethylene terephthalate) into polymer electrolytes, *Journal of Materials Chemistry A* (2022). DOI: 10.1039/D2TA06692K

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