More sustainable recycling of plastics

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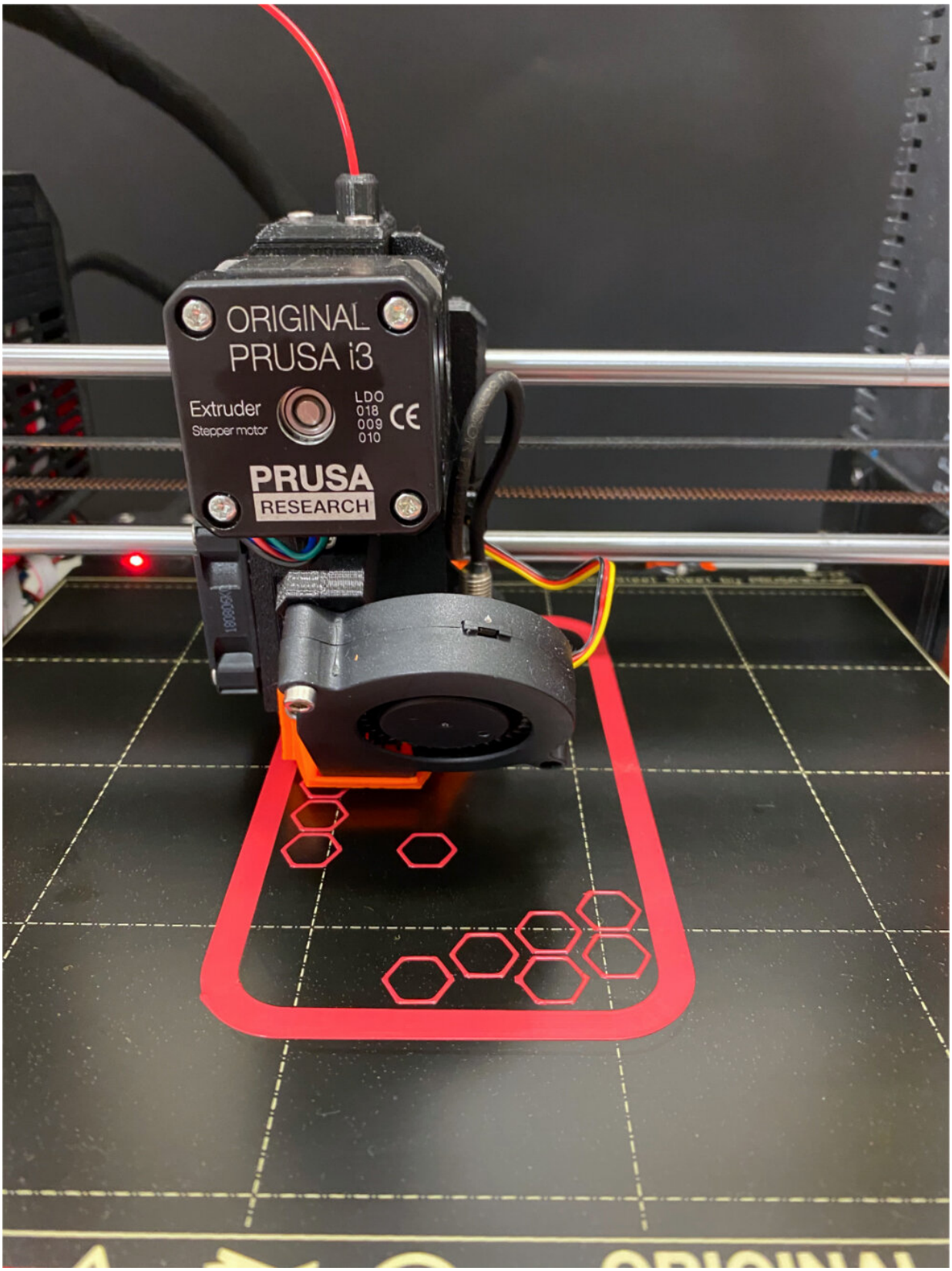
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Mobile phone case made with 3D printing, using recycled plastic. Credit: Copyright: AG Mecking, University of Konstanz

Plastics are among the most widely used materials, and they are vital components of all modern technologies. So far, it has been possible to recycle these valuable materials only to a limited extent. In order to offer novel solutions, chemists from Professor Stefan Mecking´s group at the University of Konstanz developed a more sustainable method for chemically recycling polyethylene-like plastics. The researchers use 'breaking-points' on a molecular level to disassemble the plastic back to its molecular components.

The new method works without extremely high temperatures, is therefore more energy-efficient and has a significantly higher recovery rate (approx. 96 per cent of the starting material) than established processes. These findings are published on 17 February 2021 in the scientific journal *Nature*.

Mechanical recycling vs. chemical recycling

"The direct re-utilization of plastics is often hampered by the fact that, in practice, mechanical recycling only functions to a limited degree—because the plastics are contaminated and mixed with additives, which impairs the properties of the recycled materials," Stefan Mecking explains.

'Chemical recycling' is an alternative: Via a chemical process, used plastic is broken down into its molecular building blocks, which can then be converted into new plastic.

Limitations of chemical recycling of polyethylene

Specifically in the case of polyethylene—the most widely used plastic—chemical recycling is difficult. On a molecular level, plastics are made up of long molecular chains. "Polymer chains of polyethylene are very stable and not easily reversed back into small molecules," Stefan Mecking explains. Temperatures exceeding 600° Celsius are required, making the procedure energy-consuming. At the same time, the recovery rate is limited (in some cases, to less than ten per cent of the starting material).

Mobile phone case made with 3D printing, using recycled plastic. Credit: Copyright: AG Mecking, University of Konstanz

How chemical recycling of polyethylene can be made more sustainable

Stefan Mecking and his team report on a method that makes a more energy-efficient chemical recycling of polyethylene-like plastics possible, coupled with a very high recovery rate of around 96 per cent of the starting materials. To do so, the chemists used "breaking-points" on a molecular level enabling a deconstruction of the chain into smaller molecular building blocks. "Key for our method are polymers with a low density of predetermined breaking-points in the polyethylene chain, so that the crystalline structure and material properties are not compromised," Stefan Mecking explains, adding, "This type of material is also very suitable for 3-D printing."

Mobile phone case made with 3D printing, using recycled plastic. Credit: Copyright: AG Mecking, University of Konstanz

Mecking´s research team demonstrated this chemical recycling on polyethylene-like plastics based on plant oil. The recycling stage requires temperatures of only about 120 degrees. Furthermore, the chemists also performed this recycling method on mixed plastics as they occur in waste streams. The properties of the recycled materials are on a par with those of the starting material. "Recyclability is an important aspect for future technologies based on plastics. Re-utilizing such valuable materials as efficiently as possible makes sense. With our research we want to contribute to making chemical recycling of plastics more sustainable and effective," Mecking concludes.

More information: Closed-loop recycling of polyethylene-like materials, *Nature* (2021). DOI: 10.1038/s41586-020-03149-9 , dx.doi.org/10.1038/s41586-020-03149-9

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