Supramolecular Plastics for a Sustainable Future

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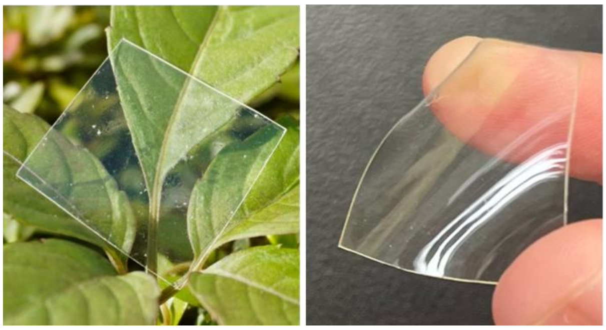
One of the major issues causing environmental destruction is plastic waste. Between the years 1950 and 2015, we produced 8.3 billion tons of plastic, yet less than 9 % was recycled. 6.3 billion tons became waste, either incinerated or discarded into the natural environment. When burned, plastic emits carbon dioxide, which accelerates global warming. When discarded, plastic degrades into microplastics, which spread not only in the oceans but also in the air and soil, harming ecosystems—including humans. Recent studies have reported that microplastics, once inside the human body, can pass through the blood-brain barrier and cause various diseases. While many strategies, such as improving plastic materials, have been explored to address the plastic waste problem, we believe a fundamentally new strategy is necessary. We focused attention on the concept of supramolecular polymers, which I have tightly committed from the beginning. At the end of November 2024, we reported supramolecular plastics [11], as a strategic extension of the concept of supramolecular polymers using salt-bridge-forming ionic monomer pairs. This new class of polymeric materials disassembles intomonomers when exposed to salts in the natural environment and is then metabolized by microorganisms. Unlike conventional plastics, supramolecular plastics do not generate microplastics. Despite their eco-friendly characteristics, these plastic materials possess mechanical properties that are comparable or even better than those of conventional plastics. What we have done with supramolecular plastics are listed below.



(1) Green synthesis by mixing two monomers in water at ambient temperatures, (2) monomers derived from natural resources are usable, (3) non-genotoxic, (4) colorless and glass-like transparency, (5) non-flammable with no emission of carbon dioxide, (6) exceptionally high mechanical strength, (7) ultra-high density (1.71 g/cm^3) achievable, (8) no weight loss up to 315 °C, (9) thermoplastic properties though with a three-dimensional crosslink, (10) self-healing ability to repair structural damage, (11) dissociate in seawater into monomers that are metabolizable, (12) dissociate in soil into monomers that are metabolizable, (13) contains P, N, and S useful for a soil conditioner, and (14) applicable to 3D printing technology.

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