# Slide-Ring Materials for Circular Economy

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The Circular Economy of polymers has attracted global interests recently. The conventional linear economy of mass production, mass consumption, and mass disposal should shift to a circular model in which polymers are used longer and disposal is recycled into resources. The speaker has been the leader of large national projects on the Circular Economy of polymers in Japan and various innovative polymers have been developed through cooperative collaboration among companies and academia.

In ImPACT (Impulsing Paradigm Change through Disruptive Technologies) program (2014-2018), we successfully developed various tough polymers for automobile, in which slide-ring (SR) materials with movable cross-links were partly used (Fig.1). In the SR materials, the necklace-like supramolecular polyrotaxanes are cross-linked and axis polymer chains in the polyrotaxane are topologically interlocked by figure-of-eight cross-links.[1)] Hence, these cross-links can pass along the polymer chains freely to equalize the tension of the threading polymer chains similarly to pulleys. Accordingly, the SR gel shows small Young's modulus, high elongation, high fracture toughness, and instant recoverability. [2)] The concept of the slide-ring gel is not limited to gels but also applied to elastomer, resins, and composites for paints, rubbers, soft actuator, and so on.[3)] As a typical example, the durability and fracture toughness of polyamide resins and carbon fiber reinforced plastics were improved drastically, and the remarkable scratch-resist properties were found.

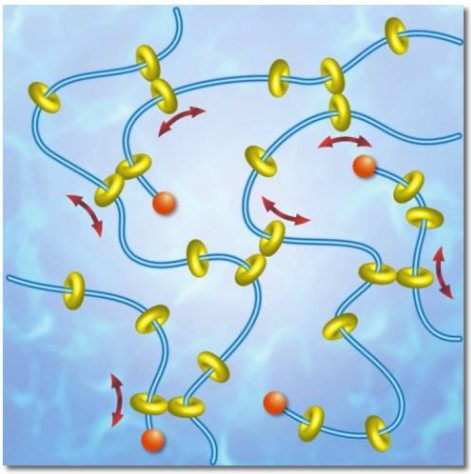

Fig.1 Schematic diagram of slide-ring materials.

We are now applying the SR materials to develop tough and degradable polymers in the Moonshot program (2020-2029), which is the successive national project of ImPACT to solve the world-wide microplastic problem in ocean as shown in Fig. 2. We need tough polymers at the point of use but if they spread in the environment by mistake, they should decompose safely as soon as possible by an on-demand switching. Our targeted products here are plastics, tires, fibers, fishing nets, and fishing goods whose raw materials come from non-food biomasses. In addition, we found that polyrotaxane drastically improved the mechanical properties, self-healing, chemical decomposition, and marine biogegradability of vitrimers.

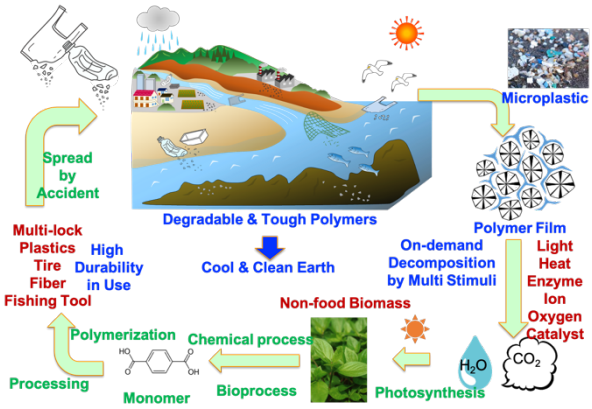


Fig.2 Moonshot program to create tough and degradable polymers.

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