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For immediate release

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Yokohama Rubber, together with Shinshu University, develops rubber material with crack resistance from nanoparticle-based tough polymers that can be recycled without deterioration

Hiratsuka, Japan—The Yokohama Rubber Co., Ltd., announced today the development of a highly crack-resistant rubber material made from nanoparticle-based polymers[*1] that do not use any additives, such as organic solvents and reinforcing agents. The development is the result of a collaborative effort with a research group led by Associate Professor Daisuke Suzuki of Shinshu University's Graduate School of Textile Science and Technology and RISM (Research Initiative for Supra-Materials). Further research based on knowledge gained during the collaborative research project is expected to lead to the development of safer and more durable tires and rubber products that are people- and environment-friendly. The developed rubber material can be easily recycled without deterioration and therefore is expected to contribute to the realization of a circular economy.

The research project used nanoparticle-based polymers (hereafter, "nanoparticles") synthesized via mini-emulsion polymerization[*2], a well-known polymerization method, and a nanoparticle dispersed aqueous solution to create a nanoparticle film[*3] (rubber material) formed by evaporating the water from the dispersed aqueous solution. Inserting rotaxane molecules[*4], also known as supramolecular compounds[*5], into these nanoparticles as a crosslinking agent enhances their resistance to crack propagation without using other additives, such as reinforcing agents. This nanoparticle film also contributes to the rubber material's high elasticity.

In addition, nanoparticle films composed of nanoparticles only can be decomposed simply by immersing them in a water-ethanol solution, namely a low environmental-impact process. Since this water-ethanol solution can be returned to the dispersed aqueous solution that is composed of nanoparticles and water simply by evaporating the highly volatile ethanol, the nanoparticle film can be easily regenerated without any deterioration.

The research results were published in *Langmuir*, an American Chemical Society journal, on June 17 (Japan time).

Yokohama Transformation 2023 (YX2023), Yokohama Rubber's medium-term management plan for fiscal years 2021–2023, includes sustainability initiatives that are based on the concept of "Caring for the Future." Yokohama Rubber believes that conducting business activities aligned with its sustainability initiatives will help resolve social issues and lead to the continued increase of its corporate value. Yokohama Rubber also is implementing environment-related initiatives based on a three-pillar strategy focused on achieving carbon neutrality, a circular economy, and living in harmony with nature and has established a roadmap for achieving medium-to-long term goals in each of these pillars. Yokohama Rubber's efforts to promote the realization of a circular economy include the development of tires using sustainable materials.

*1: Nanoparticle-based polymers are polymer particles smaller than a microscale (1 micrometer = 1/1,000,000th of a meter).

*2: A type of emulsion polymerization that refers to the polymerization of monomers and initiators after micronizing them in water by using ultrasonic irradiation.

*3: A nanoparticle film is an aggregation of nanoparticle polymers.

*4: Rotaxane molecule refers to a molecular architecture in which a linear (dumbbell-shaped) molecule is threaded through one or more macrocycle molecules, interlocking the macrocyles and trapping them along the linear molecule.

*5: A molecular architecture formed by combining multiple molecules aligned highly orderly by relatively weak interactions. Combining multiple molecules makes it possible to control their functions and create new functions.

Nanoparticle film formation process

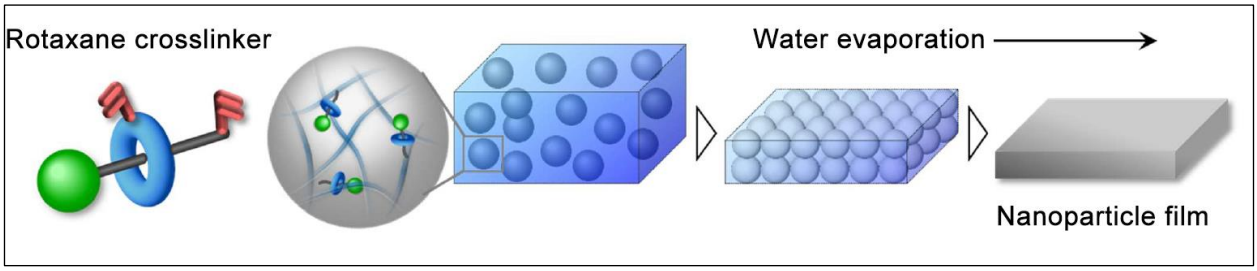

Illustration of a tear test from a cut in a nanoparticle film