Functional design of polymeric materials based on movable cross-links and application for strain-sensor

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[Introduction] A design of cross-links affects mechanical properties of polymeric materials. The movable cross-links were found to be formed by the bulk polymerization between cyclodextrin (CD) monomer and main chain monomer[1,2]. Herein, we designed the materials where movable cross-links connect between dissimilar polymers.

[Result] Movable cross-linked materials knitting dissimilar polymers (PS-CD(20,1)⊃PEA(79)) were obtained by the bulk polymerization of ethyl acrylate (EA) in presence of peracetylated γCD modified polystyrene. In tensile tests, the polymer blend materials (PS(20)/PEA(80): comparison) exhibited low toughness and heterogeneous domains on the order of 0.1 mm due to low miscibility (**Fig. 1**). PS-CD (20, 1)⊃PEA (79) showed a 170±30 times increase in toughness and 1.6±0.3 times increase in the Young's modulus of PS(20)/PEA(80). PS-CD(20, 1)⊃PEA(79) were white elastomers without heterogeneous domains on the order of 0.1 mm. DSC measurements reveals three-phase structure: PEA, PS and a mixed phase (**Fig. 2**). The PEA phase contributes to effective stress dispersion by the movable cross-links on account of its low T_g and high mobility. The PS phase contributes to a high Young's modulus as a hard domain with a high T_g (~100 °C). The movable cross-links connect the two phases and result in a mixed phase, enabling each phase to work together. In addition, compositing Ketjenblack EC600JD© (carbon-filler) achieved high electrical conductivity (7.5±0.3 S/m) and high strain-sensitivity (gauge factor at 100% strain = 120), enabling application for strain-sensor (**Fig. 3**).

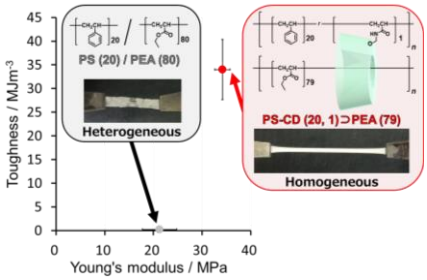

Fig. 1. Photographs and plots of Toughness *vs* Young's modulus for PS-CD (20, 1) ⊃ PEA(79) and PS(20)/PEA(80).

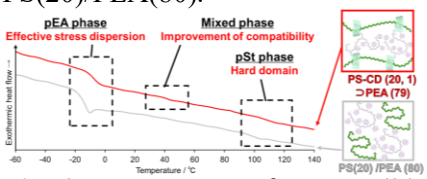

Fig. 2. DSC curves of PS-CD (20, 1)⊃PEA(79) and PS(20)/PEA(80).

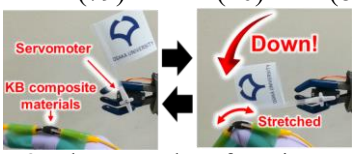

Fig. 3. Photographs of strain-sensor

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2) R. Ikura, A. Harada, Y. Takashima, et. at. *Polymer* **2020**, *196*, 122465.