Design of Supramolecular-structured Polyrotaxane Derivatives as Novel Blood Compatible Polymers and Their Evaluation for Biomedical Applications

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This dissertation deals with the design of supramolecular-structured PRx derivatives as novel blood compatible polymers and their evaluation for biomedical applications. A polyrotaxane (PRx), a representative supramolecular architecture, consists of cyclic molecules (typically, cyclodextrins, CDs) with high potency for chemical modification and polymeric chains capped with bulky-end groups. “A synergistic concept”, hypothesized to design PRx derivatives as novel blood compatible polymers, is as follows: The unique properties of functional groups ($-SO_3$ and $-PEG-SO_3$) and the physicochemical interactions of the supramolecular-structured PRxs with blood or cell would synergistically play an important role in enhancing blood compatibility. As based on the hypothesis, PRxs in which α-cyclodextrins (α-CDs) are threaded onto poly(ethylene glycol) (PEG)-*block*-poly(propylene glycol) (PPG)-*block*-PEG triblock copolymers (Pluronic^{TM}) capped with bulky-end groups were prepared and chemically-modified by the introduction of sulfonate-containing groups to hydroxyl groups of α-CDs. PRx derivatives was then applied to surface modification of conventional biomedical polymer. PRx derivatives containing the sulfonate groups showed the synergistically enhanced anticoagulant activity. The incorporation of PRx derivatives lead to the enhanced hydrophilicity by the change of surface properties onto the polyurethane (PU) substrate. Modified PUs showed the stable entrapment of PRx derivatives and the enhanced mechanical properties after exposure to water as compared with PU control.

Some of incorporated PRx derivatives repelled the proteins from closely approaching the surface areas, prevented platelets from activation by thrombin, and were effective as bacteria repellents. The important factors that contribute to the obtained results are estimated to be 1) the higher density of induced functional groups by the unique supramolecular structure of PRx and 2) the higher mobility (effective inhibition of steric hindrance by higher density) of functional groups by a spacer (e.g. PEG in $PEG-SO_3$). These characteristics of PRx derivatives are expected to be useful in the design of the novel supramolecular structure-based biomaterials, in the surface modification of biomedical polymers, and in further applications for blood compatible device fabrication.