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Emerging design of supramolecular biomaterials

1. **Regulation of cell functions by dynamic surfaces**
2. **Therapeutic applications of biocleavable polyrotaxanes for metabolic diseases**
3. **Nanomedicine applications of biomolecules by complexation with polyrotaxanes**
4. **Design of smart dental materials based on biocleavable polyrotaxanes**

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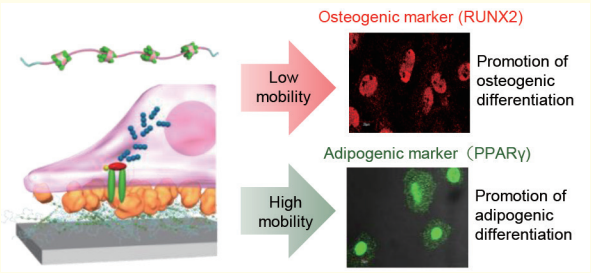
We are developing biomedical applications using supramolecular polyrotaxanes, in which many cyclic molecules (cyclodextrins) are threaded onto a linear polymer that is capped at both terminals with bulky end-groups, as biomaterials. We are aiming to create biomaterials that can demonstrate unprecedented functions by utilizing various characteristics derived from the structure of polyrotaxanes, such as the mobility of cyclic molecules, the rigidity of the frameworks, responsive degradability and others.

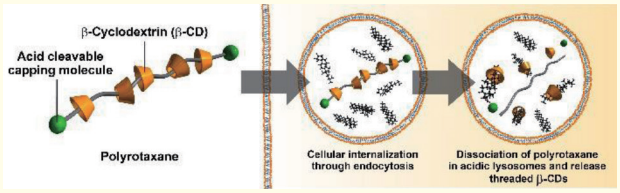
Regulation of cell functions by dynamic surfaces

Cyclic molecules threaded in polyrotaxanes are expected to move and rotate along a polymer axle. Focusing on the mobility of the cyclic molecules in polyrotaxanes, our group has designed biomaterials surfaces with dynamic properties by utilizing the movable architecture on the molecular level of polyrotaxanes. We have examined their effects on a variety of interactions with biological systems, such as proteins and cells. Interestingly, we have clarified that the molecular mobility on these surfaces is critical to directing the differentiation of stem cells.



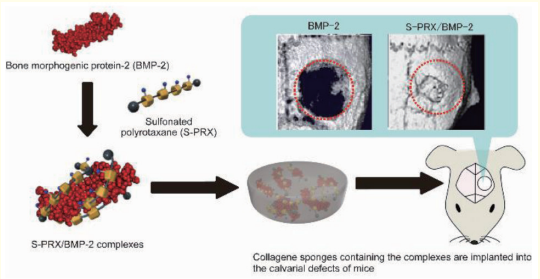
Therapeutic applications of biocleavable polyrotaxanes for metabolic diseases

Biocleavable polyrotaxanes that can release threaded β-cyclodextrins (β–CDs) in cellular environments have been developed as a therapeutic agent for various intractable diseases. The intracellular release of β–CDs from the polyrotaxanes leads the interaction with the intracellular lipids and cholesterol to modulate the cellular metabolic functions. Our group has found that the polyrotaxanes showed significant therapeutic effects in model mice of Niemann-Pick disease type C, which is a rare metabolic disorder in which cholesterols accumulate in lysosomes.



Nanomedicine applications of biomolecules by complexation with polyrotaxanes

Biopharmaceutical agents, such as nucleic acids and proteins, have recently attracted much attention as a new class of drug. To enhance the stability and biological activities of such biopharmaceutical agents, supramolecular polyelectrolyte complexes with polyrotaxanes have been designed, and their therapeutic efficacy has been evaluated *in vitro* and *in vivo*.



Design of smart dental materials based on biocleavable polyrotaxanes

In current dental treatment, a variety of photocurable resins are used, such as in composite resins and dental adhesives. However, these conventional resins and adhesives are difficult to remove after polymerization. Our group has developed photo-labile polyrotaxanes that can dissociate under UV-light irradiation and we have investigated their application as a component of dental adhesives for orthodontics. For instance, by using polyrotaxanes, it will become possible to remove orthodontic brackets by simple light irradiation.