

Molecular Recognition System Controlled by Thermosensitive Complexation Using Cyclodextrin-Conjugated Poly(ϵ -lysine)s

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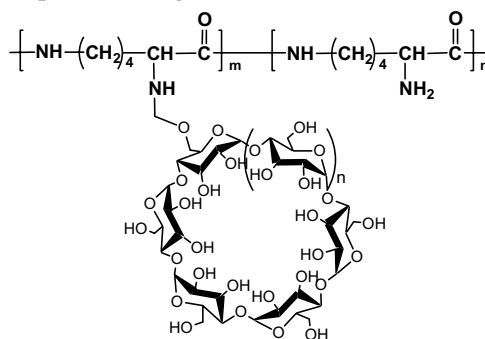
Abstract

Molecular recognition in chemistry and biology is a kind of host-guest phenomena, which concerns inclusion complexes formed through noncovalently controlled interactions between the host and guest. Possessing well-defined hydrophobic cavities of cyclodextrins (CDs), which can bind various organic, inorganic, and biological molecules to form stable inclusion complexes or supramolecular species, have been employed as excellent hosts in supramolecular chemistry and chiral selectors in separation science and technology. Hence, a great deal of efforts has been devoted to the design and syntheses of novel CD derivatives that display enhanced molecular binding abilities and selectivities for specific substrates.

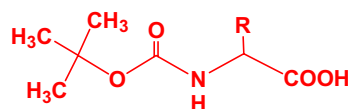
Recently, our group has developed a supramolecular assembly formed between β -CD-conjugated poly(ϵ -lysine) (β -CDPL) and 3-(trimethylsilyl)propionic acid (TPA).ⁱ This system underwent pH-induced phase transition because the main-chain containing ionic groups, in addition, it showed temperature-induced phase transition owing to the reversible inclusion complexation and dissociation. The induction time of β -CDPL/TPA system was found to be very short (within 100 ms) due to cooperative intermolecular interactions such as inclusion complexation and ionic interactions. However, despite their apparent simplicity, the affecting factors determining the recognition mechanism and assembly formation are not yet elucidated.

In this study, we prepared α - and β -CDPLs for molecular recognition of various types of amino acids, protected with N - α -Boc- or N - α -CBZ- groups. The chemical

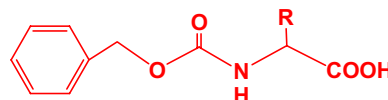
composition of CDPLs was confirmed by ^1H NMR and FT-IR spectrometries, and the degree of substitution (DS) for α - and β -CDPLs were 38 and 45%, respectively. The representative chemical structure was depicted in Figure 1.



(a) Cyclodextrin-conjugated poly(ϵ -lysine) (CDPL)
($n=1$: α -, $n=2$: β -)



(b) N - α -Boc protected amino acids



(c) N - α -CBZ protected amino acids

Figure 1. Chemical structures for CDPLs (a), N - α -Boc protected amino acids (b), and N - α -CBZ protected amino acids (c). The R group varied depending on the structure of amino acids.

The inclusion complexation was confirmed by ^1H NMR and 2D-ROESY NMR spectroscopic measurements. These systems showed stimuli-responsive

properties with pH and temperature changes. By observing UV-vis light transmittance, reversible phase transitions of the supramolecular assembling system occurred very rapidly in response to minute changes of temperature. As shown in Figure 2, the thermosensitivity of the systems could be modulated by changing the combinations in host-guest molecules as well as the concentration of the solutions at their optimum pH.

This molecular recognition process is the result of several interactions (van der Waals, hydrogen bonding, hydrophobic interactions, ionic interactions, etc.), which are dependent on the nature and structure of the groups present on each component of the complex. In this point of view, the used amino acids are containing a bulky hydrophobic part to form inclusion complex with the conjugated CDs. In addition, the ionic interaction between amino-groups of PL and carboxyl group of amino acids also can contribute as a major role to the phase transitions of the system. Such a supramolecular assembling system is of importance not only in basic studies such as a model for molecular recognitions and enzyme-substrate interactions of biological systems but also for practical applications such as separation operations in biotechnology, sensors, and actuators.

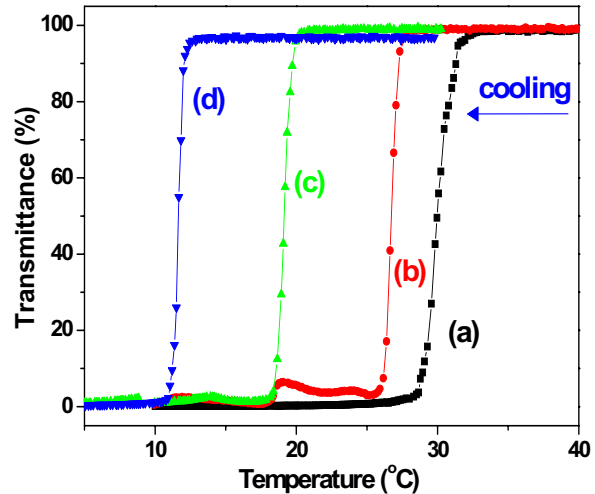


Figure 2. Thermosensitive transmittance changes in supramolecular assemblies; (a) Boc-Asp(Obzl)/ α -CDPL at pH 3.0 (2 wt%), (b) Z-Pro/ β -CDPL at pH 6.5 (1 wt%), (c) Z- γ -Abu/ β -CDPL at pH 6.0 (1 wt%), and (d) Boc-Ile/ β -CDPL at pH 4.0 (1 wt%).

[¹] (a) Choi, H. S.; Huh, K. M.; Ooya, T.; Yui, N. *J. Am. Chem. Soc.* **2003**, *125*, 6350. (b) Choi, H. S.; Ooya, T.; Sasaki, S.; Yui, N. *Macromolecules* **2003**, *36*, 5342. (c) Choi, H. S.; Huh, K. M.; Ooya, T.; Yui, N. *J. Phys. Chem. B* **2004**, *in press*.