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Self-assembly: Flower power

Cyclic polymers form thermally stable flower-like micelles.

Taking inspiration from single-celled organisms that live in extreme conditions such as hot springs, researchers in Japan[1] have created molecular structures that could be used as a temperature-activated drug delivery system.

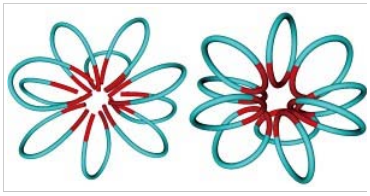

Fig. 1: Schematic illustration of the linear (left) and ring-shaped (right) micelles.

Some 'extremophile' organisms can withstand searing temperatures, possibly because their cell membranes contain ring-shaped lipid molecules. These are believed to be more resistant to heat than similar molecules stretched out into a linear chain.

Satoshi Honda, Takuya Yamamoto and Yasuyuki Tezuka of the Tokyo Institute of Technology have now replicated this effect using artificial lipids made from two types of polymer, poly(butyl acrylate) and poly(ethylene oxide), joined together to make linear chains or rings. When these polymers are dissolved in water, they self-assemble into structures called micelles, which look somewhat like flower heads but measure just 20 nm across (Fig. 1).

The scientists found that when these micelle solutions were warmed, both forms eventually broke down and accumulated into larger agglomerates, turning the water cloudy. But while micelle solutions formed from the linear polymer became cloudy at 24–27 °C (depending on concentrations), the micelles of cyclic polymers did not break down and cloud the solution until the temperature reached 71–74 °C.

Although such structural changes have previously been shown to cause a few degrees difference in the cloud points of related micelles, “the present result is the first example of such a large shift,” says Yamamoto.

The scientists believe that the large gap between the cloud points of the two micelles is caused by the difference in structure. In the linear polymer molecule, one end can break free from the micelle and form a bridge with a neighboring micelle, speeding up aggregation. The ring-shaped polymers, however, do not unravel so easily, making them more thermally stable.

Mixing varying amounts of the two types of polymers allowed the scientists to tune the cloud point of the overall mixture to any temperature between 24 and 74 °C. This means that the micelles could be used to develop a temperature-responsive drug delivery system for cancer treatment, says Yamamoto. “Drugs encapsulated in micelles are released when the micelle collapses at the cloud point,” he says.

Reference

1. Honda, S., Yamamoto, T.* & Tezuka, Y. Topology-directed control on thermal stability: micelles formed from linear and cyclized amphiphilic block copolymers. *J. Am. Chem. Soc.* **132**, 10251 (2010). | article

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This research highlight has been approved by the author of the original article and all empirical data contained within has been provided by said author.

Top Home

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