Silicon chemistry

Hybrid skin for stable agents

Spherical vesicles formed from lipid bilayer membranes with an outer silica network show excellent morphological stability

Cerasomes – spherical vesicles with a lipid bilayer membrane and ceramic surface and an internal aqueous compartment – have exciting potential for use in biomedical and electronic devices. These organic–inorganic hybrid structures are made from the spontaneous self-assembly of amphiphilic molecules (attracted to both water and fat) to form a bilayer structure, followed by condensation reactions on the structure's exterior to form a silica-based network.

NAIST researchers Jun-ichi Kikuchi, Kazuma Yasuhara and Keishiro Tahara are investigating new ways to make and modify these hybrid materials to create gene delivery agents or magnetic structures that can be manipulated by external magnetic fields[1].

They have prepared and characterized cerasomes formed from lipids with different molecular components — including those with cationic groups (positive ions) — and shown how their structure and stability, across a pH range and in the presence of surfactants, are influenced by the cerasomes' composition and the reaction conditions used to make them.

The molecular components of a cerasome -forming lipid comprise a hydrophobic tail, a connector unit (for example, an amide or urea function), and an ethyoxysilyl group, which must be removed by hydrolysis before assembly of the lipid can occur. The cerasomes are between several tens of nanometers and microns in diameter, and can exist as single-walled or multiwalled vesicles.

Cerasomes, a close relative of phospholipid -containing vesicles (namely liposomes), differ as a result of the siloxane framework that covalently links several of the amphiphilic lipids together. "The cerasomes behave as biomembrane models, but they have a much enhanced morphological stability compared with conventional liposomes," says Kikuchi. The siloxane framework that connects the surface together is the key stabilizing factor and, in addition, imparts the chemical and biophysical characteristics of silica particles to the cerasomes.

The surface of these hybrid structures can be easily adapted to a range of chemical species including organic molecules, titanium dioxide, hydroxyapatite, and metals, which opens up many possible functions. For example, the titanium-dioxide-coated cerasomes are photocatalytically active, and the hydroxyapatite coating enhances the biocompatibility of the vesicles.

The metal-coated cerasomes, or metallosomes, are formed by electroless plating of palladium or gold onto the outer silica surface. "Metallosomes have practical advantages as a new type of organic–inorganic–metallic material in various applications, including energy conversion and information processing," says Kikuchi. "For example, the magnetic cerasome can behave as a molecular vehicle manipulated by an external magnetic field."

In addition, cationic cerasomes have been developed as gene delivery agents with high transfecting capabilities and low toxicity in various cell lines[2]. The clinical translation of these cerasomes is a future goal in this area.

References

1. Kikuchi, J.-I. & Yasuhara, K. Cerasomes: A new family of artificial cell membranes with ceramic surface. Advances in Biomimetics, Marko Cavrak (ed.), ISBN: 978-953-307-191-6, InTech, DOI: 10.5772/14167 (2011).
2. Tahara, K., Moriuchi, T., Tsukui, M., Hirota, A., Maeno, T. *et al.* Ceramic coating of liposomal gene carrier for minimizing toxicity to primary hippocampal neurons. *Chemistry Letters* **42,** 1265-1267 (2013).

NAIST chemists have prepared and characterized cerasomes formed from lipids with different molecular components.

More information about the group's research can be found at the Biomimetic Materials Science Laboratory webpage:
http://mswebs.naist.jp/english/courses/1417/