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Caterpillars inspire new drug delivery system

By S De Silva

Science & Technology, Singapore (Commonwealth Union) – In nature, some molecules can join together to make complex structures on their own. An example is the hard outer layer of bugs, called the cuticle, which has a lot of proteins that can join together.

Self-assembly, or how these molecules join together, is a cheap, good for the environment, and fast way to make very small structures. These structures can be used in many different industries, like medicine and making machines that can make more of themselves, these examples were taken into account by scientists from Nanyang Technological University.

The scientists found a way to use the self-assembling proteins from the cuticle of a type of moth caterpillar to make tiny capsules. These capsules could be used to give people medicine or messenger RNA (mRNA). The mRNA is a molecule that tells cells to make proteins.

The Asian corn borer moth lives in places like China and Australia. It is a problem for farmers because its caterpillars eat and damage corn crops. The cuticle on the head of the caterpillar protects it and gives it special abilities.

Scientists studied the proteins in the covering of Asian corn borer caterpillar heads. They wanted to find small chains of building blocks called peptides. These peptides could stick together to make organized shapes on their own. They looked at the proteins for peptides that had the same pattern of building blocks repeating three or more times, with each pattern being at least five building blocks long. Because of how these building blocks interacted with each other, peptides with this feature could likely join together by themselves.

The researchers found three peptides that could come together to make tiny capsules with empty spaces inside from their investigation.

The study was led by Associate Professor Yu Jing from the NTU, School of Materials Science and Engineering, former NTU Distinguished University Prof Gao Huajian (now a Xinghua University Prof at Tsinghua University), Professor Liu Tian from Dalian University of Technology, and Prof Yang Qing from the Chinese Academy of Agricultural Sciences.

The researchers are seeking a patent for their new idea, based on their discoveries published in Nature Nanotechnology in April 2024.

They pointed out that these tiny capsules are better than usual ways of giving medicine because they're not harmful and can effectively carry different types of medicine.

The tiny pieces called peptides join together like building blocks due to differences in the chemicals around them. It's similar to how Lego pieces fit together to make something strong as described by the scientists of the study.

They copied natural peptides from caterpillars and mixed them in water. Then they added a chemical called acetone to start the process of pieces joining together.

The scientists found that the joining happens in two steps. First, when acetone is added, the peptide mix forms tiny drops. Then, as acetone moves into the drops and water moves out, it creates a change in how concentrated the mix is. This change makes the peptides stick together and form flat sheets, which eventually become round, hollow capsules. This whole process happens in just 10 minutes.

The scientists could also further work on how big the capsules were by adjusting the amount of a chemical known as isophorone diisocyanate. This chemical helps hold the capsules together.

"To the best of our knowledge, this is the first time that peptide nanocapsules have been created without templates, paving the way for a customisable drug delivery system," explained Associate Professor Yu.

"Our peptide nanocapsules open the door to various potential biomedical applications, such as drug delivery and gene therapy."

The scientists showcased the versatility of nanocapsules in capturing and transporting various payloads like chemotherapy drugs and antibodies. Through adjustments in peptide chains, they could repurpose the nanocapsules for mRNA delivery as well. Furthermore, these drugs and mRNA-loaded nanocapsules exhibited non-toxic properties and were efficiently assimilated by diverse cell types.

"By understanding the behaviour of self-assembling peptides in nature, we can engineer them to deliver a wide variety of drugs and therapeutic compounds," explained Dr Li Haopeng, who is a research fellow from the NTU, School of Materials Science and Engineering as well as the first author of the study.

The researchers hope to move forward with the study using the assistance of AI.

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