Quantum dots: Nano-probes of the future

IBN has pioneered methods to enable these nanocrystals to be used as powerful tools in bio-imaging and drug targeting

SINGAPORE, May 12, 2005 – A team of researchers at the Institute of Bioengineering and Nanotechnology (IBN) has successfully addressed one of the biggest challenges facing the use of quantum dots in biomedical applications.

The group, led by IBN Executive Director Prof. Jackie Y. Ying, has invented methods that effectively give these unique materials water-soluble and non-toxic qualities, enabling them to be used as powerful fluorescent probes in biological labeling and diagnostics.

Quantum dots, also known as nano-crystals, are a special class of semiconductors that are extremely small in size (2-6 nanometers). These nanometer-sized particles are able to display any chosen color in the entire ultraviolet-visible spectrum through a simple change in their size or composition. They have shown great promise in wide-ranging applications, as solar cells and photodetectors.

More importantly, their strong and stable photoluminescent properties make them promising candidates for use in bio-imaging applications – they can emit different colors, based on pre-determined biological tags/signals. This means that scientists can attach quantum dots to a given protein or receptor to observe normal or abnormal cell functions. Unlike conventional organic dyes, quantum dots have enormous photostability, or the ability to fluoresce for several months. This allows them to track cell processes for longer periods of time and to shed more light on molecular interactions.

Nevertheless, the major disadvantages involving the use of quantum dots, particularly in biological applications, are their toxicity and insolubility (they would need to be soluble to be taken up by cells). Their surfaces would also need to be modified to enable the linking of bio-molecules. Previous efforts to tackle these problems involve synthetic methods that were too complicated or ineffective in maintaining the quantum dots’ stability or photoluminescent properties.
IBN scientists, however, have been able to pioneer a simple and efficient one-step procedure to render these quantum dots water-soluble and non-toxic.¹

According to Senior Research Scientist Dr. S. Tamil Selvan, IBN’s method of coating the particles with silica involves a simple water-in-oil reverse microemulsion procedure. The silica coating provides an effective non-toxic barrier and enables bio-molecules to adhere to the particles’ surface.

“This highly economical procedure produces robust and water-soluble quantum dots that have great potential to be used commercially in bio-imaging applications,” said Dr. Selvan.

The researchers have gone one step further by designing silica-coated composites of quantum dots and magnetic nanoparticles.²

The hybrid composite is created easily and economically using reverse microemulsion synthesis. “Besides exhibiting the attractive qualities of water-soluble quantum dots, these nano-scale composites display magnetic properties, which are useful in magnetic cell separation, magnetic resonance imaging (MRI) contrast enhancement and magnetic transport of anti-cancer drugs,” said Dr. Dong Kee Yi, a Post-doctoral Fellow at IBN.

“Quantum dots pave the way for new methods of observing cellular processes in cells and small animals,” said Prof Ying. “It is hoped that this technology would allow for the precise diagnosis and treatment of diseases like cancer.” Different genetic markers of a tumor can be ‘color-coded’ with quantum dots, for instance, to enable the accurate identification, localization and treatment of cancer cells.

“IBN’s silica coating techniques are not limited to semiconductor quantum dots,” added Prof Ying. “They could also be used on a variety of hydrophobic materials such as metallic and magnetic particles, as demonstrated in our research.”


About the Institute of Bioengineering and Nanotechnology (IBN)
The Institute of Bioengineering and Nanotechnology (IBN) is a member of the Agency for Science, Technology and Research (A*STAR). Established in March 2003, the Institute’s mission is to establish a broad knowledge base and conduct innovative research at the interface of bioengineering and nanotechnology. Positioned at the frontiers of engineering, IBN is focused on creating knowledge and cultivating talent to develop technology platforms that will spur the growth of new industries. IBN also fosters an exciting, multidisciplinary research environment for the training of students and young researchers to spearhead biomedical advancement in Singapore.

For more information on IBN, please log on to www.ibn.a-star.edu.sg.

Note to the Editor:
The Institute of Bioengineering and Nanotechnology (IBN) is holding its Official Opening tomorrow (Friday, May 13, 2005), from 3pm to 4:45pm at the Biopolis. The Guest-of-Honor is Deputy Prime Minister Dr Tony Tan. Media interviews with IBN Executive Director Prof Jackie Y. Ying and IBN scientists can be arranged during the event. Details of the opening were sent to the media in an advisory dated April 29, 2005.

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