碳奈米材料之多種超結構合成

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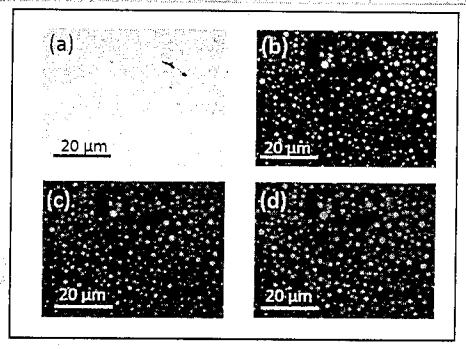

市場及需求:

奈米材料的自組裝可有效調控原有奈米材料的物理和化學性質，因此是一種製備多功能奈米材料的重要技術。由於自組裝的結果容易受到奈米材料間各種作用力的影響，因此須嚴格控制其表面的官能基、粒子大小和形狀、溶液組成和溫度等。市面上，仍然缺乏可製備大量、高品質且價格低廉的自組裝碳奈米材料(含碳量子點)技術。本發明以簡單的步驟與便宜的起始物製造大量且具獨特物理和化學性質的碳奈米超結構，故極具市場吸引力。

技術摘要(含成果):

本發明目的為開發簡單且便宜的製程來大量製備不同形狀和性質的碳奈米(包括碳量子點)超結構。為達本發明目的，利用有機小分子(包括有機酸、酯類和醇類等)為起始物，在 150–450 度的溫度下反應，製備膠狀碳奈米(包括碳量子點)超結構。在鹼性酒精溶液中，將表面部分疏水的官能基(如酯類)轉換為親水關能基(如羥基)，進而得到在不同相位具有不同官能基的雙面神碳奈米材料。再藉由控制溶液參數(溫度、酸鹼值和離子強度等)，可進一步將雙面神碳奈米材料製備成微脂體與水凝膠等不同的碳奈米材料超結構。

優勢:

碳奈米材料(如碳量子點)具有相當不錯的生物相容性、高的螢光量子產率、好的光學與化學穩定性和容易經由表面修飾功能化等優點。此外，它可藉由簡單的水熱法和微波消化等方法，從有機小分子、聚合物、碳材料或樹葉等各式各樣的天然物來合成。由於其具有極佳光學和電催化特性，已被證實可應用於生物醫學和能源等。雖然許多奈米材料超結構已被應用於生物醫學、機械與能源等領域，但碳奈米材料(包括碳量子點)超結構仍尚未被應用於相關領域中。本發明中所揭露之膠狀、水凝膠、微脂體等類型的碳奈米材料超結構尚未被揭露。本發明是以簡單、低耗能且安全的合成方法，從便宜的起始物合成大量、高品質、穩定且具特殊物理和化學性質的碳奈米超結構，故極具市場吸引力。

競爭產品:

雖然已有下列產品於市面上販售，但並不具有本發明所合成之碳奈米(含碳量子

點)超結構所具有的特殊光學性質和多功能(吸水、黏性、溫度感應和化學感應)等優異性質。目前市面上並沒有具類似多功能超結構和物質存在，故本發明所合成之超結構極具市場競爭力。

市場上已有許多黏性膠狀物應用於工業、醫學與一般生活用品中。大多黏性膠狀物皆溶於揮發性高且具毒性之有機溶劑中。

水凝膠產品大多為聚合物或共聚合物，已被廣泛應用於傷口敷料、隱形眼鏡、藥物載體、玩具甚至食品等等。

被廣泛應用於藥物和生物染劑之微脂體，大多是以脂質或是高分子共聚物所配製而成。

專利現況:

本發明研究成果母案已受美國專利(Application Number:15/440353)核准，由於核准內容主要為過程(Process)，為了增加保護範圍，希望能提出延續案與分案。本研究團隊已有超過二十年研究經驗，著力於開發新穎且綠色的奈米材料合成方法。本實驗室在碳量子點合成和應用居於世界領先群之一，我們領先全球提出利用小分子與咖啡渣等做為起始物製備碳量子點之概念，相關研究已被廣泛應用，亦已申請一項專利(專利編號 TWI525175)。本團隊研究成果豐碩，於頂尖國際期刊發表近三百篇文章，文章被引用總數超過一萬次。成員積極參與國際會議並執行多項國際合作案等。

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Fabrication of various superstructures of carbon dots

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Experience:

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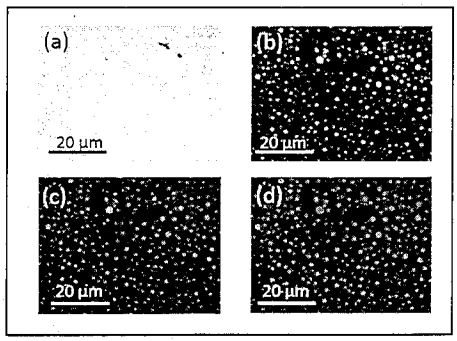

Market Needs:

Self-assembly of nanomaterials allows control of physical and chemical properties of nanomaterials, and thus it is an important technique for preparation of multifunctional nanomaterials. Self-assembly of nanomaterials depends on various interactions among nanomaterials, which are easily affected by several factors such as surface ligands, size and morphology of nanomaterials, and local environment such as pH values, ionic strength, and solution compositions. However, there are no techniques for large-scale preparation of high quality of self-assembled superstructures of carbon nanomaterials (including carbon nanodots). This invention provides a simple method to prepare large-scale superstructures of carbon nanomaterials (including carbon nanodots) with unique physical and chemical properties from low-cost carbon precursors.

Our Technology:

In this invention, we propose a simple method to prepare different superstructures of carbon nanomaterials (including carbon nanodots). To prepare superstructures of carbon nanomaterials (including carbon nanodots), organic precursors such as organic acids, esters, and alcohols were heated in a temperature range over 150–450 °C. In basic alcohol solution, the as-prepared glue-like superstructures of carbon nanomaterials undergo conversion of hydrophobic groups (e.g. esters) to hydrophilic groups (e.g. hydroxyl groups), leading to the formation of superstructures of Janus carbon nanomaterials that possess different functional groups on different sides (phases). Through further control of solution properties (temperature, pH values, ionic strength), the superstructures of Janus carbon nanomaterials were converted to form liposome-like or hydrogel-like superstructures of carbon nanomaterials.

Strength:

Carbon nanomaterials (e.g. carbon nanodots) have greater biocompatibility, high fluorescence quantum yield, excellent photo and chemical stability, as well as ease in conjugation. They can be easily prepared through various approaches such as hydrothermal reaction and microwave digestion from small organic molecules, polymers, bulk carbon materials, and natural resources such as

leaves. Having unique optical properties and electrochemical catalytic activity, carbon nanomaterials have been used in biomedical and energy related applications. Up to date, superstructures of carbon nanomaterials (including carbon nanodots) have not been applied in theses fields. In this invention, we proposed a simple, energy-saving, and safe strategy for the large-scale preparation of high-quality of superstructures of carbon nanomaterials with unique physical and chemical properties, which hold great potential in the market.

Competing Products:

Although similar products are commercially available as mentioned below, this invention still remains unique and competitive because the as-prepared superstructures of carbon nanomaterials (including carbon nanodots) possess unique optical properties and multi-functionality (hydrophilicity, viscosity, response to temperature and chemicals). There are no such materials commercially available, and thus the superstructures prepared in this invention hold great potential for commercialization.

Various kinds of viscous glues have been used for wide range of applications, including industrial, biomedical, and daily use. Most of the viscous glues are prepared in volatile and toxic organic solvents.

Hydrogels are polymers or copolymers, and they have been widely used in wounded dressing, contacts, drug delivery, toys, and food additives.

Liposomes widely used in medicines and bio-labeling are prepared from lipids or copolymers.

Intellectual Properties:

Part of the results claimed in this invention has been approved for US patent (Application Number:15/440353). In order to expand the extent of patent protection, we propose the continuing and division applications. Prof. Chang's group has shown their strong experience in the preparation of novel nanomaterials through green approaches. Prof. Chang's group is one of the world's leading research groups to prepare carbon nanodots. His group is pioneer in preparation of carbon nanodots from small molecules or used coffee grounds. One patent (Patent No. TWI525175) for preparation of carbon nanodots has been applied.

This research group has published around 300 papers in high-quality international journals, with total citation numbers greater than 10000. To promote science & technology worldwide, Prof. Chang's team has been actively involved in several international collaborative projects.

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