# 물과 기름 분리 및 오염물을 쉽게 정화할 수 있는 나노캡슐 개발


- 주저자 : 이하진(서울서부)
- 교신저자 : 최원산(한밭대)교수



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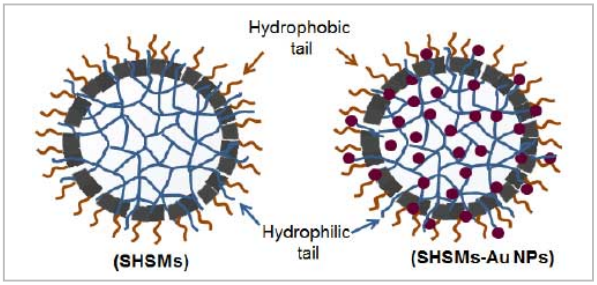
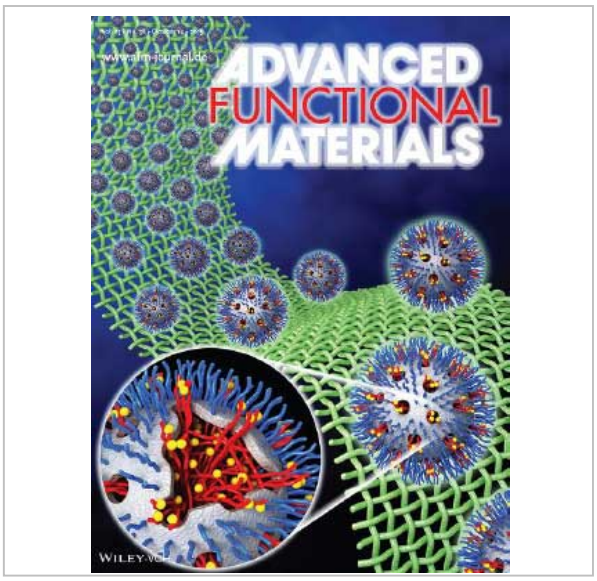
## 연구내용

친수성(hydrophilic)과 소수성(hydrophobicity)은 한 표면에 양립할 수 없다는 기존의 이론을 깨고, 친수·소수 물질이 한 표면에 공존할 수 있음을 이번 연구를 통해 실험적으로 증명하였음.
이를 기반으로 친수성 코어와 양쪽성(친수성/소수성) 쉘의 구조를 갖는 '실리카 마이셀 ' 에 촉매제를 탑재하여 물과 기름의 분리 및 물과 기름 속에 포함된 오염 물질을 쉽게 정화할 수 있는 기술을 개발하는데 성공 하였음. (기존 기술의 10배 이상 성능 향상, 20회까지 재활용이 가능)




[그림 1] 양쪽성(친수성/초소수성) 쉘구조의 실리카마이셀




[그림 2] Advanced FuntionalMaterials 2015, 25권 38호 BackcoverPicture

## 기대효과

이번 연구성과는 물/기름의 분리와 오염수 처리 뿐만이 아니라 소수성 유기용매 하에서 일어나는 1차 알코올의 브롬화 반응 및 친수성 용매에서 일어나는 글루코스산화제의 담지 반응에도 매우 높은 효율을 보여 환경 및 생명과학 분야에서의 활발한 응용이 가능함.

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FULL PAPER

**Inorganic Micelles (Hydrophilic Core@Amphiprotic Shell) for Multiple Applications**

*Md. Shahinul Islam, Won San Choi,* Sun Ha Kim, Oc Hee Han, and Ha-jin Lee**


A facile approach for synthesizing superhydrophobic hollow silica micelles (SHSMs) with hydrophilic cores and amphiprotic (superhydrophobic/hydrophilic) shell structures that act as "all-in-one" smart nanomaterials is presented. The particles possess hydrophilic cores consisting of silica and a polyelectrolyte (PE) network and an amphiprotic shell consisting of supehydrophobic long-chained hydrocarbons and hydrophilic PEs. Due to the unique hydrophilic cores and amphiprotic shells, the particles exhibit extraordinary performance in terms of amphiprotic catalytic reactions in organic and aqueous solutions, oil/water separation and pollutant purification, and as ultrahigh loading capacity of enzymes with significant stability and efficient recyclability. The amphiprotic functionalities of the SHSMs have the potential to allow for a rich range of applications to be explored.


1. Introduction

Oil/water separation and micellar catalysts that utilize the hydrophilic/hydrophobic interface have consistently attracted attention for a long time. Due to the increasing requirements for environmental and water remediation, the selective separation of oil spills (or organic solvents) from water using polymer membranes/febrics,[1,2] metal meshes,[3,4] and sponges[5,6] has been the subject of extensive research in recent years. There are several methods for fabricating oil/water separation materials.[3–13] These methods include the fabrication of surfaces with superhydrophobicity and superoleophilicity for the separation of oil from water. However, these methods cannot remove/purify soluble pollutants in water. Most efforts have been devoted to separating oil from water and have not focused on pollutants in water. Very little attention has been focused on the purification of water-soluble pollutants after oil/water separation.[8] Thus, there is considerable interest in developing novel and facile methods for the simultaneous separation of oil from water and purification of water-soluble pollutants.

The practical application of organic micelle catalysts that utilize hydrophilic/hydrophobic interfaces has been limited by several disadvantages. For example, the stability of organic micelles depends on many parameters, such as the solvent polarity, critical micelle concentration, and reaction conditions, such as pH, water/oil ratio, and temperature.[10,11] Due to the narrow range of stability of organic micelles, the synthesis of inorganic micelles that have hydrophilic/hydrophobic interfaces, large surface areas, high porosities, tunable surfaces, and high recyclability has recently attracted some attention.[12,13] For example, Lin and co-workers reported a simple route to hierarchically assembling micelles and inorganic nanoparticles.[14] Yang and co-workers prepared functionalized mesoporous silica spheres consisting of a hydrophobic core and a hydrophilic micellar shell.[15] As a first example, Alivisatos and co-workers recently reported resin templates based on the synthesis of inorganic micelles with a hydrophilic cavity and a hydrophobic surface and its application as a catalyst in the bromination of alcohol.[16] There is still considerable interest in developing novel methods for the exploration of interior/exterior-functionalized, superhydrophobic, and nanostructured inorganic micelles. To fulfill the requirements of oil/water separation and inorganic micellar catalysis mentioned above, the development of hierarchical nanomaterials that have a hydrophilic interior and superhydrophobic/hydrophilic (amphipetic) exterior is highly desirable, offering significant potential for multiple applications. To the best of our knowledge, this report is the first example of the synthesis of nanomaterials that have a hydrophilic core and amphiprotic shell for multiple applications, such as amphiprotic catalytic reactions, oil/water separation and pollutant purification, and enzyme immobilization with significant stability and efficient recyclability.

Herein, we present the preparation and multiple applications of superhydrophobic hollow $SiO_2$ micelles (SHSMs) with hydrophilic cores and amphiprotic (superhydrophobic/hydrophilic) shell structures that act as "all-in-one" smart nanomaterials. Our SHSMs are better than hydrophilic@hydrophobic micelles prepared using previously reported methods for several reasons: (i) the polyallylamine hydrochloride (PAH) chains were extended and survived from the core to the shell even


Dr. Md. S. Islam, S. H. Kim, Dr. O. H. Han, Dr. H.-J. Lee
Western Seoul Center
Korea Basic Science Institute (KBSI)
Seoul 03759, South Korea
E-mail: hajinlee@kbsi.re.kr
Prof. W. S. Choi
Department of Chemical and Biological Engineering
Hanbat National University
Daejeon 34158, South Korea
E-mail: choiws@hanbat.ac.kr
S. H. Kim
Department of Chemistry
Kyungpook National University
Daegu 41566, South Korea
Prof. O. H. Han, Prof. H.-J. Lee
Department of Chemistry and Nano Sciences
Ewah Womans University
Seoul 03760, South Korea



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