Rational Design of High-Performance Continuous-Flow Microreactors Based on Gold Nanoclusters and Graphene for Catalysis

By: Liu, YB (Liu, Yanbiao)[1,3,4]; Liu, X (Liu, Xiang)[1]; Yang, SN (Yang, Shengnan)[1]; Li, F (Li, Fang)[1,3]; Shen, CS (Shen, Chensi)[1,3]; Huang, MH (Huang, Manhong)[1,3]; Li, JJ (Li, Junjing)[4]; Nasaruddin, RR (Nasaruddin, Ricca Rahman)[2]; Xie, JP (Xie, Jianping)[2]

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Abstract

In this work, we rationally designed a high-performance microreactor system for continuous-flow catalysis. The membrane consists of ultrasmall gold nanoclusters (AuNCs) and two-dimensional graphene. The Au cores of the NCs act as catalysts, while their ligands have two functions: (1) protecting the Au cores to avoid agglomeration and (2) providing a well-defined surfactant assembly to disperse graphene in aqueous solution. Hydrogenation of 4-nitro-phenol (4-NP) was employed as model reaction to evaluate catalytic activity. The catalytic membrane microreactor demonstrated excellent catalytic activity and stability, where complete 4-NP conversion was readily achieved via a single pass through the membrane. This desirable performance was maintained over 12 h of continuous operation, although a certain amount of organic buildup on the membrane was observed. The catalytic membrane microreactor outperforms conventional batch reactors due to its improved mass transport. 4-NP-spiked real water samples were also completely converted. This study provides new insights for the rational design of membrane reactors for industrial applications.

Keywords

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Author Information

Reprint Address: Liu, YB (reprint author)

+ Donghua Univ, Coll Environm Sci & Engn, Minist Environm Protect, Text Pollut Controlling Engn Ctr, 2999 North Renmin Rd, Shanghai 201620, Peoples R China.

Reprint Address: Xie, JP (reprint author)

+ Natl Univ Singapore, Dept Chem & Biomol Engn, 4 Engn Dr 4, Singapore 117585, Singapore.

Reprint Address: Liu, YB (reprint author)

Shanghai Inst Pollut Control & Ecol Secur, 1239 Siping Rd, Shanghai 200092, Peoples R China.

Reprint Address: Liu, YB (reprint author)

+ Tianjin Polytech Univ, State Key Lab Separat Membranes & Membrane Proc, 399 Binshuixi Ave, Tianjin 300387, Peoples R China.

Addresses:

+ [1] Donghua Univ, Coll Environm Sci & Engn, Minist Environm Protect, Text Pollut Controlling Engn Ctr, 2999 North Renmin Rd, Shanghai 201620, Peoples R China

+ [2] Natl Univ Singapore, Dept Chem & Biomol Engn, 4 Engn Dr 4, Singapore 117585, Singapore

[3] Shanghai Inst Pollut Control & Ecol Secur, 1239 Siping Rd, Shanghai 200092, Peoples R China

+ [4] Tianjin Polytech Univ, State Key Lab Separat Membranes & Membrane Proc, 399 Binshuixi Ave, Tianjin 300387, Peoples R China

E-mail Addresses: yanbiaoliu@dhu.edu.cn; chexiej@nus.edu.sg

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1. A novel Ru-polyethersulfone (PES) catalytic membrane for highly efficient and selective hydrogenation of furfural to furfuryl alcohol — **Times Cited:** 2
   By: Bagnato, G.; Figoli, A.; Ursino, C.; et al.
   JOURNAL OF MATERIALS CHEMISTRY A Volume: 6 Issue: 12 Pages: 4955-4965 Published: MAR 28 2018

2. Hybrid Amyloid Membranes for Continuous Flow Catalysis — **Times Cited:** 34
   By: Bolisetty, Sreenath; Arcari, Mario; Adamcik, Jozef; et al.
   LANGMUIR Volume: 31 Issue: 51 Pages: 13867-13873 Published: DEC 29 2015

3. Applications of Continuous-Flow Photochemistry in Organic Synthesis, Material Science, and Water Treatment — **Times Cited:** 337
   By: Cambie, Dario; Bottecchia, Cecilia; Straathof, Natan J. W.; et al.
   CHEMICAL REVIEWS Volume: 116 Issue: 17 Pages: 10276-10341 Published: SEP 14 2016

4. Gold nanoparticles stabilized by amphiphilic hyperbranched polymers for catalytic reduction of 4-nitrophenol — **Times Cited:** 45
   By: Dai, Yu; Yu, Peng; Zhang, Xiaojin; et al.
   JOURNAL OF CATALYSIS Volume: 337 Pages: 65-71 Published: MAY 2016

5. TPPS supported on core-shell PMMA nanoparticles: the development of continuous-flow membrane-mediated electrocoagulation as a photocatalyst processing method in aqueous media — **Times Cited:** 9
   By: Dambruoso, Paolo; Ballestri, Marco; Ferroni, Claudia; et al.
   GREEN CHEMISTRY Volume: 17 Issue: 3 Pages: 1907-1917 Published: 2015

6. From Symmetry Breaking to Unraveling the Origin of the Chirality of Ligated Au13Cu2 Nanoclusters — **Times Cited:** 12
   By: Deng, Guocheng; Malola, Sami; Yan, Juanzhu; et al.
   ANGEWANDTE CHEMIE-INTERNATIONAL EDITION Volume: 57 Issue: 13 Pages: 3421-3425 Published: MAR 19 2018

7. Recent advances on membranes and membrane reactors for hydrogen production — **Times Cited:** 283
   By: Gallucci, Fausto; Fernandez, Ekain; Corengia, Pablo; et al.
   CHEMICAL ENGINEERING SCIENCE Volume: 92 Pages: 40-66 Published: APR 5 2013