Reusable Mesoporous Solid-Based Pd Catalysts for C-C bonds formation in Water

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Abstract:

Environmentally benign, operationally simple, and robust reactions, particularly those employing reusable solid catalysts and water as a solvent, are of significant interest to the chemical industry. Here, heterogeneous palladium catalysts supported on ordered mesoporous carbonaceous nanocomposites including carbon-silica, CoO-C and quaternary ammonium phase transfer agent modified mesoporous carbonaceous resins, were applied to the water-mediated C-C bonds formation.

The mesoporous Pd/CoO-C catalyst showed a high yield of biphenyl (49 %) in the water-mediated Suzuki coupling reaction of chlorobenzene and phenylboronic acid. Product yields in the reaction of aryl chlorides containing electron-withdrawing groups attached to their benzene ring can reach approximately 90 %. Very small Pd clusters consisting of approximately 3 atoms and Pd-O bonds formed on the interface between CoO and Pd nanoparticles. The unsaturated coordinative Pd may be responsible for the activation of chlorobenzene in the absence of any additives or ligands. A nitrogen-containing functional group modified and ordered mesoporous resin material was also used to support a reusable solid Pd catalyst. The grafted quaternary N coordination with highly dispersed Pd NPs creates an electronically rich environment for surface atoms and causes a distinct enhancement in the stabilization and accessibility of these particles to organic substances in aqueous solution. The mesoporous Pd catalysts are active in the C-2 arylation of N-methylindole when water is used as the solvent without any other additive or the exclusion of air. The catalysis likely occurs on the Pd surface rather than in solution.

Thiol-functionalized mesoporous silica, which can trap soluble Pd species, was used to confirm the negligible leaching in solution and therefore heterogeneous reaction. These heterogeneous catalyst are stable, showing unobvious activity loss after ten catalytic runs.

Additionally, uniform mesopores and the hydrophobic nature of the carbon support may also facilitate the mass transfer of the reactant molecules and enrichment inside pores.

Biography:

Professor Ying Wan received her Ph.D. degree in Industrial Catalysis from the East China University of Science and Technology in 2002. Then, she joined Shanghai Normal University where she was promoted to a full professor in 2006. In 2005-2007, she carried out her postdoctoral research at Fudan University working with Professor Dongyuan Zhao. Currently, Professor Ying Wan is the leader of the Program for Innovative Research Team in University, China. Her research focuses on sintering-, and poisoning-resistance metal nanocatalysts supported on mesoporous carbons, and their applications in green organic synthesis and energy chemistry. She has contributed to about 70 peer-reviewed scientific publications with more than 7000-times citations and 3 books. She has been an Editorial Board Member of Chinese Journal of Catalysis since 2013, and serves as an associate editor of Journal of Porous Materials.

Recent Publications:

- Xiaojuan Zhu, Qishui Guo, Yafei Sun, Shangjun Chen, Jian-Qiang Wang, Mengmeng Wu, Wenzhao Fu, Yanqiang Tang, Xuezhi Duan, De Chen, Ying Wan* (2019) Optimising Surface d Charge of AuPd Nanoalloy Catalysts for Enhanced Catalytic Activity. Nature Communications 10:1428.
- Long Jiao, Chen Zhang, Chuannan Geng, Shichao Wu, Huan Li, Wei Lv,* Ying Tao, Zijin Chen, Guangmin Zhou, Jia Li, Guowei Ling, Ying Wan,* Quan-Hong Yang* (2019) Capture and Catalytic Conversion of Polysulfdes by In Situ Built TiO2-MXene Heterostructures for Lithium-Sulfur Batteries. Advanced Energy Materials. 1900219.
- Shangjun Chen, Haibin Fu, Li Zhang, Ying Wan* (2019) Nanospherical mesoporous carbon-supported gold as an efficient heterogeneous catalyst in the elimination of mass transport limitations. Applied Catalysis B: Environmental 248:22-30.
- Hui Li, Hong Shen, Chun Pei, Shangjun Chen,* and Ying Wan* (2019) A Self-Assembly Process for the Immobilization of N-Modified Au Nanoparticles in Ordered Mesoporous Carbon with Large Pores. ChemCatChem 11:1 -11.
- Shangjun Chen, Li Meng, Bingxu Chen, Wenyao Chen, Xuezhi Duan, Xing Huang, Bingsen Zhang, Haibin Fu, Ying Wan* (2017) Poison Tolerance to the Selective Hydrogenation of Cinnamaldehyde in Water over an Ordered Mesoporous Carbonaceous Composite Supported Pd Catalyst. ACS Catalysis 7:2074-2087.

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