Design and Synthesis of Silica Supported Nanoporous Gold-Palladium Bimetallic Catalyst for Alkyl Benzene Oxidation

Subrata Saha a, Md. Eaqub Ali a*, Azman Maamor a, b, Wan Jeffrey Basirun a, b

aNanotechnology and Catalysis Research Center (NANOCAT), University of Malaya, 50603 Kuala Lumpur, Malaysia.

bDepartment of Chemistry, University of Malaya, 50603 Kuala Lumpur, Malaysia.

asubratasaha341@yahoo.com, aseaqubali@gmail.com, azaman2111@um.edu.my, awjjeffreyb@yahoo.com

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Abstract. Gold palladium (Au-Pd) bimetallic catalysts are very promising for various reactions including oxidative catalysis. Mesoporous silica supported Au-Pd catalysts have large surface area, controlled hydrophobic and file-cities and are thus highly efficient for the oxidation of alkyl benzene to selective products. Alkyl Benzene oxidation is important for the productions of drugs, perfumes, polymers, insecticides and pesticides. Unfortunately, the efficient oxidation of alkyl benzene has been remaining a challenging task due to lack of suitable catalysts. Functionalized mesoporous silica with ordered surface and uniform porosity is an exciting template for the synthesis of supported catalysts. Metal precursors could be co-impregnated on the highly ordered surface of ammonium functionalized silica. This method facilitates great dispersion of the Au-Pd clusters with tiny and controlled particle size. Here, we described a two-step adsorption–reduction method along with various ratios of metal loadings for the synthesis of silica supported nanoporous Au-Pd catalyst for alkyl benzene oxidation.

Introduction

Nanotechnology has opened a new door to the innovation and modified design of novel catalysts for multifarious industrial applications with potentials to covert the highest amount of reactants to selective products, reducing cost and environmental burden. Gold has been a valuable choice in catalysis research since the pioneering work of Haruta et al[7] and Hutchings[8]. Highly dispersed gold catalyst on various supports were synthesized and investigated for numerous applications. However, controlling the structural uniformity and morphology has been remaining a challenging task since gold nanoparticles (AuNPs) are adsorbed on the external surfaces of oxide particles or enclosed in within the oxide structures. Externally attached AuNPs have strong inclination to aggregate causing low melting point and high surface and the lack of space for the reactants in the matrix pores the catalysis takes place. The catalytic reaction by bulk AuNPs often proceeds in a very slow rate compare to the other noble metals such as Pd, Pt, and Ru. Tremendous catalytic activity could be obtained with AuNPs if the particle size is maintained 2-10 nm [5]. Considering the potentiality and promise, many researches have pursued to invent an effective method to synthesis and increase the catalytic activity of by alloying-dealloying, or doping with different metals such as Fe, Pt, and Pd on various supports. To choose a second metal with gold, palladium is an ideal candidate since it causes electronic effect and resists metal sintering. The catalytic activity of gold is increased by several folds due to Au-Pd synergy at the bimetallic interface. The current industrial practice of alkyl substituted benzene oxidation is not up to the expected mark because of the uses of toxic chemical such as KMnO4 which has deleterious effects on health and environment. Some catalysts such as silica gel supported cobalt Schiff base complex [3], Ag/SBA-15 [1], Fe/ SiO2 orAl2O3 [6], SBA-15 supported Au NPs [2], have been explored. Some of them shows good results but are time consuming as well as involves harsh reaction conditions, dry and inert media, limitations in choosing oxidants. In addition, both conversation and selectivity have to be significantly improved.