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Editorial

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Carbon-Based Supported Catalysts for Biomass Conversion

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Introduction

The use of a supported heterogeneous catalyst makes the process more efficient and economically feasible in many applications. The support materials provide a physical surface for dispersion or binding of active catalyst components. The final catalytic properties depend on the combination of the type of catalyst components and supportive material [1,2]. Lignocellulosic biomass is an alternative to petroleum for the production of biofuels and chemicals and is increasingly recognized as a valuable material; however, the high cost of conversion technologies hinders its use as an economical alternative to petroleum. One way to make the conversion process economical is to use catalysts during conversion reactions. For instance, furfural production from biomass has attracted a lot of attention in the last several years. Commercially, furfural is produced using mineral acids such as sulfuric acid and hydrochloric acid as homogeneous catalysts. Metal chlorides such as $CrCl_2$, $ZnCl_2$, $MgCl_2$, $FeCl_3$, and $AlCl_3$ demonstrated the ability to catalyze xylose dehydration to produce furfural as alternative. However, both types of catalysts are homogeneous and have some limitations in terms of difficulties in separation and recyclability and high environmental and safety risks as use of mineral acids [3]. In the recent report on economic analysis data for furfural production from biomass suggested that considering raw material, equipment, production and purification costs; cost of furfural production could be significantly reduced due to use of heterogeneous acid catalyst rather than homogeneous acid catalyst [4]. Therefore, supported metal chlorides heterogeneous catalysts could be promising way for improving the reaction and separation efficiencies and enhancing the production yield of furfural. Carbon materials have been extensively applied as efficient catalyst supports for many reactions because of their good mechanical strength, high chemical stability, a large surface area, tailorable porous structure and surface chemistry. Metal and precious metal catalysts are widely used in the supported forms on porous materials for many applications. The use of carbon as the support for metals, rather than other supports (e.g,. silica, alumina) facilitates recovery of the metal, which is achieved by simply burning the catalyst [5]. How activity of the catalysts can be increased by supportive carbon materials?

(1) Selection of porous structured carbon materials as supports could increase the activity.

(2) Surface chemistry of the carbon materials could have important role in increasing the activity of the supported catalyst.

Carbon materials can be classified according to their pore diameters as microporous (pore size < 2 nm), mesoporous (2 nm < pore size < 50 nm), and/or macroporous (pore size > 50 nm) [6]. Mesoporous carbon materials have large surface areas and highly oxygen-functionalized surfaces. High quality of mesoporous carbons (well-ordered mesoporous structure) could be promising supportive material for various catalysts that can be used in conversion of biomass materials to a wide range of value-added products. For instance, deposition of metal particles (tungsten and tungsten species, precious metals, etc.) on mesoporous carbon could effectively break down lignocellulosic biomass materials into smaller components or convert biomass compounds to specific products. The carbon supports for catalysts can be pre-functionalized to yield special functional groups, such as ether-, carboxylic acid-, thiol-, amino- and hydroxyl- and trimethoxysilyl- group for binding catalysts to the support [7]. The oxygen-containing functional groups (also denoted as surface oxides) in carbon materials had significant influence in their performance in many catalytic reactions [8]. Various chemicals such as nitric acid, hydrogen peroxide, ammonium persulfate and sodium hypochlorite can be used to form polar hydrophilic surface groups such as carboxylic acid and hydroxyl on the surface [9]. Oxidation conditions must be carefully chosen to prevent excessive corrosion and structural breakdown of the carbon skeleton. Different shaped graphene-based structures with new properties could be promising carbon-based supportive materials for especially metal catalysts deposition, and resulting catalysts could exhibit unique properties for synthesis of a specific product from biomass (e.g., more active sites and suitable gaps between graphene sheets for the entrance of biomass molecules). Carbon materials can also be supportive materials for a thin film of an ionic liquid film or other expensive solvents grafted on carbon supports. This application creates a specific reaction environment on the surface that locally mimics the characteristics of the bulk ionic liquid and prevents use of large volume of expensive solvents [10]. As a conclusion, there has been increasing demand for the development of stable and highly active carbon-based heterogeneous catalysts that can be used in biomass conversion technologies for efficient production of various value-added products. The research efforts made in this area could lead to new opportunities for reducing expensive production steps for many products derived from biomass.

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