Journal of
Nanotechnology and Smart Materials

Editorial Open Access

Biomass-based Nanocomposites and Mesoporous Materials

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Received Date: December 05, 2013, **Accepted Date:** December 28, 2013, **Published Date: January 20**, 2014

Citation: Tae Jin Kim (2013) Biomass-based Nanocomposites and Mesoporous Materials. J Nanotech Smart Mater 1:1.

The conversion of lignocellulosic biomass into fuels and chemicals has been rigorously investigated as a response to the depletion of petroleum resources, increasing demand for in oil and secure access to energy[1-4]. It has been estimated that by 2030 lignocellulosic biomass could supply a substantial portion of the international chemical and transportation fuel market [5]. Lignocellulosic biomass is usually composed of three components: 35-50 wt% cellulose, 20-40 wt% hemicellulose, and 10-25 wt% lignin. While lignocellulose is cheap and abundant forms of biomass, it is difficult to convert to target materials due to the high crystallinity structure and oxygen/carbon ratio. In order to increase the biomass conversion and upgrade bio-oil into fuels (green diesel) and chemicals, oxygen reduction and chemical bonding rearrangement are crucial. Lignocellulose can be depolymerized to C_5/C_6 fragment by hydrolysis using an acid catalyst such as HCl or H_2SO_4. Furfuryl alcohol (FA; $C_5H_6O_2$) and hydroxymethylfurfural (HMF, $C_6H_6O_3$), which can be produced from hemicellulose and cellulose, respectively, by dehydration and decomposition, have been identified as are considered to be a key furan derivatives [6].

At higher FA concentrations in the aqueous phase with acid catalysts, FA monomer easily converts to polymeric materials[7,8]. Polymeric Furfuryl alcohol (PFA) is compatible with petroleum-based organic polymers. Microporous carbon spheres and membrane were synthesized with biomass-based chemicals and have been used for preparing corrosion-protective materials, electrode materials, synthesizing nanocomposite, nanoporou carbons and glassy carbon [9-11]. For instance, carbonized poly(furfuryl alcohol) membrane showed ~94% salt rejection for water desalination [12]. Recently, H. Wang and J. Yao published review paper in the journal of Ind. Eng. Chem. Res regarding the use of furfuryl alcohol polymer in carbon nanostructure and nanocomposite [13]. Authors highlighted that renewable biomass based poly(furfuryl alcohol)(PFA) is very attractive precursor for carbon materials and it would be a key template for fabrication of nanostructured materials.

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A wide number of characterization techniques have been used to explored the reaction mechanism, intermediate species, and structure morphology during the furan derivatives polymerization reaction; FT-IR [7,12,14,15,23,25], Raman [7,25], UV-vis [7,23] SEM [12,14-19,24,25], TEM [19-21,25], and NMR [22,23]. Theoretical studies have been also carried out to investigate the thermodynamic properties and support experimental results. [26] For instance, combined with the theory calculation, chemical bonding, such as exocyclic and endocyclic C=C, vibration information provided and proved a hypothesized polymerization mechanisms [26]. To enhance a functionality of polymer material, metal nanoparticles contained and metal-based porous materials were developed and can be applied to active catalysts. [27,28]

In summary, biomass derived nano-materials are promising option for replacing a current petrochemical based ones and targeted products' yield can be improved with an effective novel catalysts.

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