Empowering biomass wastes through catalysis: Sustainable synthesis of high-value chemicals and fuels

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Biomass is any hydrocarbon that mainly consists of carbon, hydrogen, oxygen and nitrogen, and is mainly composed of cellulose, hemicelluloses and lignin.[1] The catalytic valorization of biomass wastes is a promising technology that can link the traditional refinery and renewable sources. Considering the availability of forestry and agricultural feedstocks, aquatic plants and algae, as well as municipal and industrial wastes, there is a great worldwide potential for the production of highly valuable chemicals and fuels from biomass. For example, sorbitol and ethylene glycol (EG) are extremely important chemicals that are extensively used in food, pharmaceutical, and chemical industries. Great progress was obtained in their selective production over a variety of highly efficient heterogeneous catalysts.

The conversion of cellulose into sorbitol was studied by coupling hydrolysis of cellulose to glucose and its subsequent hydrogenation. Sorbitol yields up to 70 and 48 % were attained from the one-pot conversion of cellulose and cellulosic wastes (e.g., tissue paper, cotton wool, cotton textile), respectively, over carbon nanotubes (CNT) supported Ru catalysts.[2] Then, Ru catalysts supported on glucose-derived carbons were synthesized, allowing to achieve a remarkable 100 % conversion of cellulose with a sorbitol yield of 64 % in just 3 h, which outstood previous results.[3]

Alternatively, Ru–W bimetallic catalysts supported on glucose-derived carbons were used for the direct conversion of cellulose to EG, allowing to achieve yields close to 50 % in just 3 h.[4] Furthermore, CNT-supported Ru-W catalysts were tested for the production of EG from various forestry, agricultural and urban wastes, such as woods (pine, oak, eucalyptus, etc.), leaves (eucalyptus, lemon), pine cones, cork, corncob, grass, flowers, peanut shells, coffee grounds, cotton wool and paper. The highest yields could be directly obtained from eucalyptus wood and cotton wool (41 %).[5] More recently, a cheaper metal such as Ni was found to successfully replace the Ru noble metal for cellulose conversion into EG. [6] An EG yield over 50 % was reached in just 5 h over Ni-W/CNT, which greatly surpassed the previous obtained using Ru-W/CNT. Additionally, the catalyst was tested for the conversion of cotton wool, eucalyptus wood and corncob, resulting in EG yields of 43, 28 and 36 %, respectively.[6]

These results are very encouraging for large scale applications, and the accumulated knowledge from these extensive studies will be a valuable guide for tuning the reaction selectivity and meeting the market demand.

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