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Hierarchical NiO as Superior Catalyst for Transfer Hydrogenation of Bio-based Aldehydes

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PURPOSE OF THE ABSTRACT

Furfural (FF), the acid-hydrolysis product of C5-based carbohydrates, is recognized a highly promising feedstock in the manufacture of a broad spectrum of fuels and valuable chemicals via upgrading strategies such as, e.g., hydrogenation, hydrogenolysis and aldolization [1]. Furfuryl alcohol (FAOL), as a typical representative reduction derivative of FF, is a versatile precursor in the synthesis of synthetic fibers, resins, adhesives and vitamin C and act as an intermediate linking C5-carbohydrates to the down-stream products of bio-based furan derivatives, e.g. levulinic acid and gamma-valerolactone (Scheme 1).

Generally, two synthetic strategies are adopted to catalytic hydrogenation of FF to FAOL. The first apply high-pressure hydrogen gas as H-donor with transition metal catalysts, preferably noble metals [2]. This strategy is efficient but demands special precautions for handling hydrogen which is highly flammable and explosive, thus limiting its general applicability. The second strategy - catalytic transfer hydrogenation (CTH) - employ formic acid or alcohol as H-donor, and is much simpler and safer in terms of operation. Specifically, the acid-free, cheap and easily accessibility of alcohol, in combination with its potential dual role as a solvent and H-donor, make utilization of alcohol as H-donor attractive [3]. Many heterogeneous catalysts are reported for CTH of FF to FAOL with alcohol, but although substantial progression have been made most catalytic systems are generally subjected to undesired harsh reaction conditions, long reaction times and require large catalyst dosage to work efficiently. In addition, most of the reported catalysts involve tedious preparation procedures limiting their practical application.

In previous work, we have demonstrated that commercially available nanoparticles of nickel ferrite [4] as well as NiO [5] catalyze the CTH of FF to FAOL with 2-propanol quite well. In this study, we prepared hierarchically structured NiO catalysts for the reaction by a facile and environmental-friendly method [6]. The catalysts were thoroughly characterized by multiple techniques and demonstrated to be highly catalytic activity and reusable for CTH of FF to FAOL with 2-propanol as H-donor under unprecedented mild reaction conditions. Importantly, the catalytic systems proved also applicable to CTH of various other bio-derived aldehydes and thus potentially attractive for industrial biomass valorization.

FIGURES

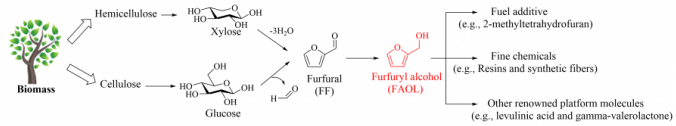

FIGURE 1

Scheme 1

Biomass upgrading route to platform molecules via furfural and furfuryl alcohol.

FIGURE 2

KEYWORDS

Catalytic transfer hydrogenation | Furfural | Hierarchical nickel oxide | Biomass valorization

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