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Microwave-assisted 2,5-furandicarboxylic acid production using ruthenium on activated carbon

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PURPOSE OF THE ABSTRACT

5-hydroxymethylfurfural (HMF), a renewable resource from lignocellulosic biomass conversion, is considered as one of the most valued additive chemicals.[1] 2,5-Furandicarboxylic?acid (FDCA), one of the oxidation products of HMF, can serve as a monomer in a variety of polymeric materials. In particular, it is known to be an excellent replacement for terephthalic?acid in many polyesters such as polyethylene terephthalate(PET).[2-4] FDCA was also listed as one of the 12 key value-added chemicals from biomass by the US Department of Energy.[5] HMF can be oxidized to FDCA through two possible pathways: (i) the hydroxyl group can be first oxidized to an aldehyde resulting in 2,5-diformylfuran (DFF) or (ii) the aldehyde?can be oxidized first to form 5-hydroxymethyl-2-furancarboxylic acid (HMFCA). Then, DFF or HMFCA is subsequently oxidized to 5-formyl-2-furancarboxylic acid (FFCA) and then finally to FDCA. Traditional HMF oxidation to FDCA typically relies on chemical oxidants or noble metal catalysts in high temperature with high O2 pressure.[6,7]

In the present study, commercial 5%Ru/C as catalyst for HMF oxidation was used. Instead of using oxygen gas, H2O2 as the liquid oxidant was selected to decrease the mass transfer resistance and provide high reactivity. This system is operated under atmospheric pressure and temperature below 100 oC in microwave conditions. It was found that a basic environment and H2O2 was added drop wisely to the system could strongly improve the catalytic conversion of HMF. The catalyst gave an impressive FFCA yield of 83 % and fully HMF conversion in only 5 min at microwave power equal to 8W in the presence of 0.3 mmol HMF as substrate. Various reaction parameters such as catalyst types, reaction time and the base types and amount as well as different H2O2 wt% have been optimized. The strong base like sodium hydroxide will strongly accelerate FFCA to FDCA. The yield of FDCA achieved 88% with another adding of sodium hydroxide (NaOH /HMF=8 mole ratio) in only 30min under MW conditions. The reactions are in low temperature, atmospheric pressure, and short reaction time with high catalytic efficiency, and the catalysts are easy to synthesize, which make this reaction system more feasible for industrial FDCA production in the future.

FIGURES

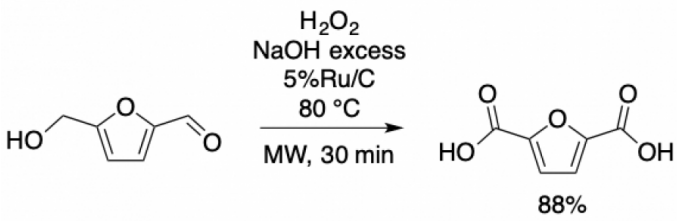

FIGURE 1

Batch microwave-assisted oxidation of HMF to FDCA

Batch microwave-assisted oxidation of HMF to FDCA

FIGURE 2

KEYWORDS

heterogeneous catalysis | biomass | oxidation | microwave

BIBLIOGRAPHY