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Microwave-assisted catalytic conversion of cellulose into 5-hydroxymethylfurfural in ionic liquids

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HIGHLIGHTS

- We show an efficient way for the conversion of cellulose into HMF in ionic liquid.
- HMF was obtained in a high yield of 51.4% from cellulose with $ZrCl_4$ under MI.
- [Bmim]Cl, $ZrCl_4$, and MI show synergetic effects on the high yield of HMF.
- This catalytic system could be reused for several times without losing activity.

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ABSTRACT

Microwave-assisted direct conversion of cellulose into HMF in ionic liquids catalyzed by $ZrCl_4$ has been investigated in search of an efficient and environment-friendly process. Firstly, some representative metal chlorides were used to catalyze the conversion of glucose into HMF, and it was demonstrated that $ZrCl_4$ was superior to other catalysts. Then direct conversion of cellulose into HMF was catalyzed by $ZrCl_4$ under microwave irradiation (MI). Under optimal conditions, a high HMF yield up to 51.4% was obtained from cellulose in 3.5 min under MI at 400 W. Controllable experiments indicated that both ionic liquids, MI and $ZrCl_4$ showed synergetic effects on the efficient conversion of cellulose into HMF. This work provides a meaningful method for the conversion of carbohydrates into fine chemicals.

1. Introduction

With growing concerns on global warming and diminishing resources of fossil fuels, much attention has been devoted to the exploration of alternatives for fossil resources to supply chemicals and energy [1–3]. Cellulose, which is the most abundant biomass, has been received intensive research for the production of function materials and chemicals [4–6]. However, cellulose routinely co-exists with lignin in lignocellulosic biomass, and cellulose forms a highly crystalline structure due to the presence of the extensive intra- and inter-molecular hydrogen bonds and Van der Waals interactions. Therefore, it still remains a challenge for the chemical transformation of cellulose into sugars and valuable fine chemicals, as cellulose was insoluble in many conventional solvents due to its chemical structure [7,8].

In the past decade, some ionic liquids (ILs) have been shown to be good solvents for the dissolution of cellulose, as ILs having high hydrogen bond acceptor strength and high polarity can dissolve cellulose [9,10]. The utilization of cellulose in ILs has aroused enormous interest since the discovery of the dissolution of cellulose in ILs. In our previous work, hydrolysis of cellulose without pre-treatment was carried out in ILs to produce reduced sugars catalyzed by acid catalysts and satisfied yields of reduced sugars were achieved [11,12]. However, separation of reduced sugars from the ILs system was tedious and energy consumption. Therefore, it would be encouraged to promote the in situ conversion of cellulose into

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