USE OF IONIC LIQUIDS TO IMPROVE THE PRODUCTION OF HYDROXYMETHYLFURFURAL FROM RENEWABLE BIOMASS

Shengdong Zhu,* Yanjie Tong, Yezi Lv, and Yuanxin Wu

Based on its rich chemistry and broadly available raw material sources, hydroxymethylfurfural (HMF) has become one of the most promising platform compounds for chemicals and biofuels from renewable biomass, and its production has drawn much attention in recent years. However, it is currently still facing significant technical challenges to make it economically feasible in an industrial scale. Use of ionic liquids has provided a potential alternative to address such challenges. Some studies have shown that the use of ionic liquids and suitable catalysts can inhibit side reactions and decrease the formation of by-products, thus improving selectivity and yield during conversion of renewable biomass to HMF. Moreover, the use of ionic liquids also simplifies the HMF production procedures from crude biomass in a one-pot process.

Keywords: Hydroxymethylfurfural; Plantform compound; Chemicals & biofuels; Renewable biomass

Contact information: Key Laboratory for Green Chemical Process of Ministry of Education, Hubei Key Laboratory of Novel Chemical Reactor and Green Chemical Technology, School of Chemical Engineering and Pharmacy, Wuhan Institute of Technology, Wuhan 430073, PR China;
** Corresponding author: zhusd2003@21cn.com*

Hydroxymethylfurfural: A Promising Platform Compound for Chemicals and Biofuels from Renewable Biomass

Petroleum is currently being used as a major source for chemicals, materials, and fuels, but it poses great concerns in terms of its future utilization because of limitations in its supply, increasing costs, and the associated environmental issues. Renewable biomass is becoming a potential raw material source for these products in place of petroleum. To maintain sustainable development our society, shifting the current petroleum-based economy to a future carbohydrate economy is an inevitable historical choice. Hydroxymethylfurfural (HMF) has been identified as one of the most promising platform compounds to serve as a bridge between carbohydrate chemistry and petroleum-based chemistry in consideration of its rich chemistry and its broad raw material sourcing. The HMF molecule consists of a furan ring, containing both aldehyde and alcohol functional groups, which can undergo a variety of reactions and form a series of derivatives. Some typical derivatives and their applications are represented in Fig.1. As indicated in the figure, the derivatives can be widely used as monomers for new materials, fuels and fuel additives, solvents, pharmaceuticals, fine chemicals, and food additives. Moreover, the HMF can be synthesized from various saccharides in renewable biomass, such as fructose, glucose, sucrose, inulin, starch, and cellulose, which ensures a sufficiently inexpensive raw material supply. Among them, cellulose is the most favorable feedstock because it is the most abundant in the world and doesn't cause food supply problems. As a promising a platform compound, it is essential to lower the HMF production cost by adopting a

suitable technology. Although extensive research has been carried out, there are still technical bottlenecks in developing an efficient and economical-viable process for commercial production. To the best of our knowledge, improving HMF's synthesis selectivity and simplifying its production process are the greatest challenges in this regard.

Use of Ionic Liquids to Improve Hydroxymethylfurfural Synthesis Selectivity and to Simplify Its Production Process

Ionic liquids (ILs) are a group of new organic salts that exist as liquids at relatively low temperatures (<100 ^{o}C). Interest in ILs has grown steadily in recent years because their non-detectable vapor pressure, non-flammability, high thermo-stability, and unique solvent properties provide the possibility for clean manufacturing in the chemical and energy related industry, including production of HMF from renewable biomass. Use of ILs and suitable catalysts during the HMF synthesis can effectively inhibit some side reactions, for example HMF hydrolysis and some intermediate polymerization, greatly decreasing the formation of such byproducts as levulinic acid, formic acid, and humics. Thus ILs can significantly improve selectivity and increase the HMF yield. Recent report indicates that the HMF yield from cellulose reached 89% by use of $CrCl_2$ in [EMIM]Cl. Moreover, some ILs have strong solubility for carbohydrate biomass, which makes it possible to simplify the HMF production procedures from crude biomass in a one-pot process. Some recent studies have shown that the one-pot conversion of crude biomass, for example, untreated corn stover and pine wood to HMF, could achieve fair yields by using $CrCl_2$ in DMA/LiCl/[EMIM]Cl or $CrCl_3$ in [BMIM]Cl. Although great progress has been made, the production of HMF by using ILs is currently limited to laboratory scale. Many efforts are still needed to develop an efficient and economical-viable process for its industrial production. Anyway, the use of ILs has provided a potential alternative to break the technical bottleneck for HMF production from renewable biomass.

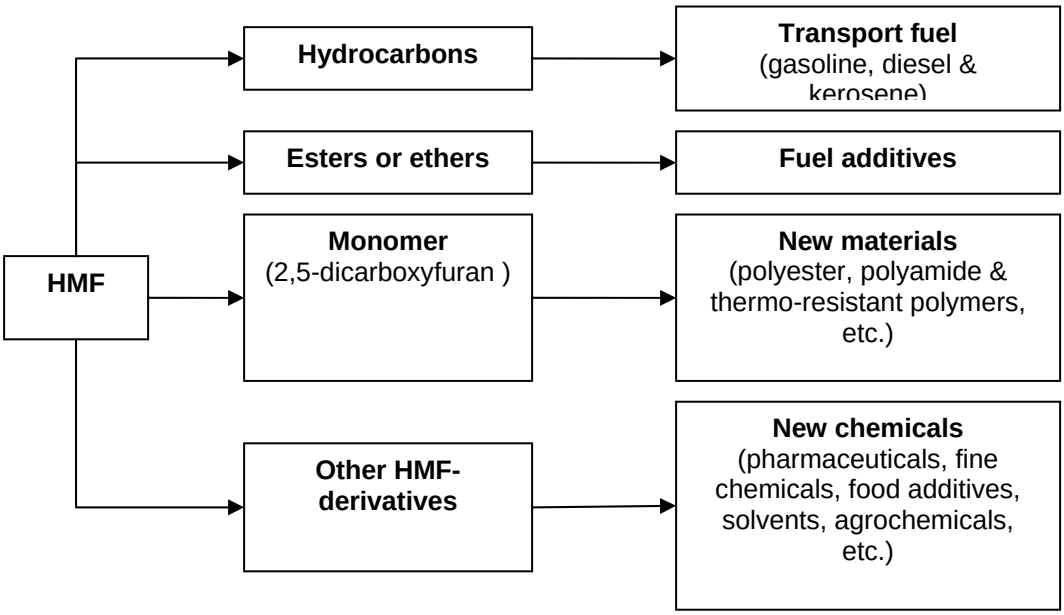

Fig. 1. Typical HMF derivatives and their applications

(This work was supported by the National Natural science Foundation of China No.21176196)