Efficient production of dimethylfuran (DMF) from hydroxylmethylfurfural (HMF) using catalytic hydrogenation reaction

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ABSTRACT
In a time of steady decline in oil reserves, instability in oil prices, strong environmental legislation and global warming concerns, researchers and oil companies are actively seeking cost - effective processes to convert renewable biomass resources into biofuels and other value-added chemicals. Dimethylfuran (DMF) has attracted attention as a dense energy compound with similar gasoline fuel properties. Hydroxymethylfurfural (HMF), a versatile platform chemical that can serve as an intermediate for different chemical products and biofuels, is one of the main biomass-derived compounds. (Biradar) This paper describes Hydroxymethylfurfural catalytic hydrogenation to Dimethylfuran (DMF) in different reaction conditions. Hydrogenation from HMF to DMF has been studied with a batch Hydrosynthasis autoclave reactor for conventional Ru / C and Pd / C. Optimum conditions were achieved through the experiment at different temperatures and reaction times.

Keywords: Hydroxymethylfurfural (HMF); Dimethylfuran (DMF);

INTRODUCTION

The main objective of this work is to identify and compare the most efficient 5-HMF hydrogen donor system to produce 2, 5-DMF in order to achieve the highest yield and selectivity and to respond to changes in reaction conditions. The main objectives investigated in the current study were, Identifying the most appropriate hydrogen donor and catalyst system for maximum conversion and yield. And To investigate the efficiency and performance of commercial catalysts in all hydrogen donor systems under different reaction parameters by evaluating; Effect of reaction temperature and reaction time, Effect of catalyst on the reaction. (Jungho Jae)

METHODOLOGY

15 ml of HMF sample, which was converted from glucose, has been used to the DMF production. 15 ml of sample contains Dimethyl sulfoxide as a solvent. Another 50 ml of Isopropyl alcohol was added to the sample as a solvent. The catalytic hydrogenation was investigated as function of different reaction variables namely; reaction temperature and time. Results are presented in terms of the reactant (5-HMF) conversion, and the product (2,5-DMF) yield for both Pd/C and Ru/C catalyst.

The results obtained from the experiments investigating the parameters were presented in terms of HMF conversion and DMF yield. It is important to note that we used the moles of compounds to calculate conversion and yield. It should be noted here that HMF conversion and DMF yield were based on external standard method and

calculated using the spectrophotometer data. (Yue YangORCID logoa)

$$\text{HMF Conversion (\%)} = \frac{(\textit{Initial moles of HMF} - \textit{Final moles of HMF})}{\textit{Initial moles of HMF}} \times 100$$

$$\text{DMF Yield (\%)} = \frac{\textit{Moles of DMF in products}}{\textit{Initial moles of HMF}} \times 100$$

RESULTS AND DISCUSSION

1. Effect of Reaction Temperature

The effect of temperature was investigated between 1500C and 200 0C at 10 0C intervals. Figure 5.2 shows that 5-HMF conversion increased slowly first and then increased rapidly as temperature increased between 150 and 200 0C, increasing from 38.6 % at 150 0C to 61.5% at 200 0C with Pd/C catalyst and increasing from 34.2 % at 150 0C to 59.6% at 200 0C. With regard to 2,5-DMF yield, different trend to 5-HMF conversion was observed as the yield increased rapidly then leveled off.

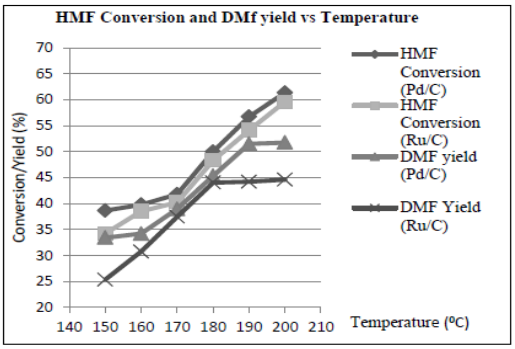

Figure 1-HMF conversion and DMF yield vs Temperature

2. Effect of Reaction Time

HMF conversion increases steadily with time. It is 48 % with Pd/C catalyst and 44% with Ru/C catalyst when the reaction time is 1 hour. It reached to a 71 % and 67% value with Pd/C and Ru/C separately. Therefore, it clearly indicates that the HMF conversion increases of reaction time. With regard to the HMF conversion, different type of results has been obtained for the DMF yield. Up to certain reaction time period, DMF yield has been increases, but after it reached to a certain level, it starts to decrease. It is 41 % with Pd/C catalyst and 39% with Ru/C catalyst when the reaction time is 1 hour. It reached to a 54 % with Pd/c in 3 hours and starts to decrease. And it reaches 53% of maximum with Ru/C in 4 hours and starts to decrease. The decrease in 2,5-DMF yield after 3/4 hours could be ascribed to further hydrogenation of 2,5-DMF to 2,5-DMTHF.

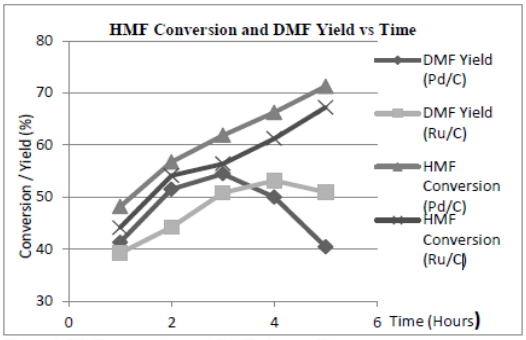

Figure 2-HMF conversion and DMF yield vs Time

CONCLUSION

From series of experiments we have identified, Pd/C is more suitable over Ru/C for the conversion of HMF to DMF. But the conversion of HMF and DMF yield are not very different. Optimum temperature for this reaction is 190 0C. Optimum reaction time for the reaction with Pd/C catalyst is 3 hours and with Ru/C is 4 hours.

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