Supporting Information

High efficient conversion of carbohydrates into 5-hydroxymethylfurfural using the bi-functional $CrPO_4$ catalyst

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1. HPLC analysis

In this work, high performance liquid chromatograph (HPLC) with Zorbax SB-C_{18} chromatograph column and UV detector was used to analyze the HMF.

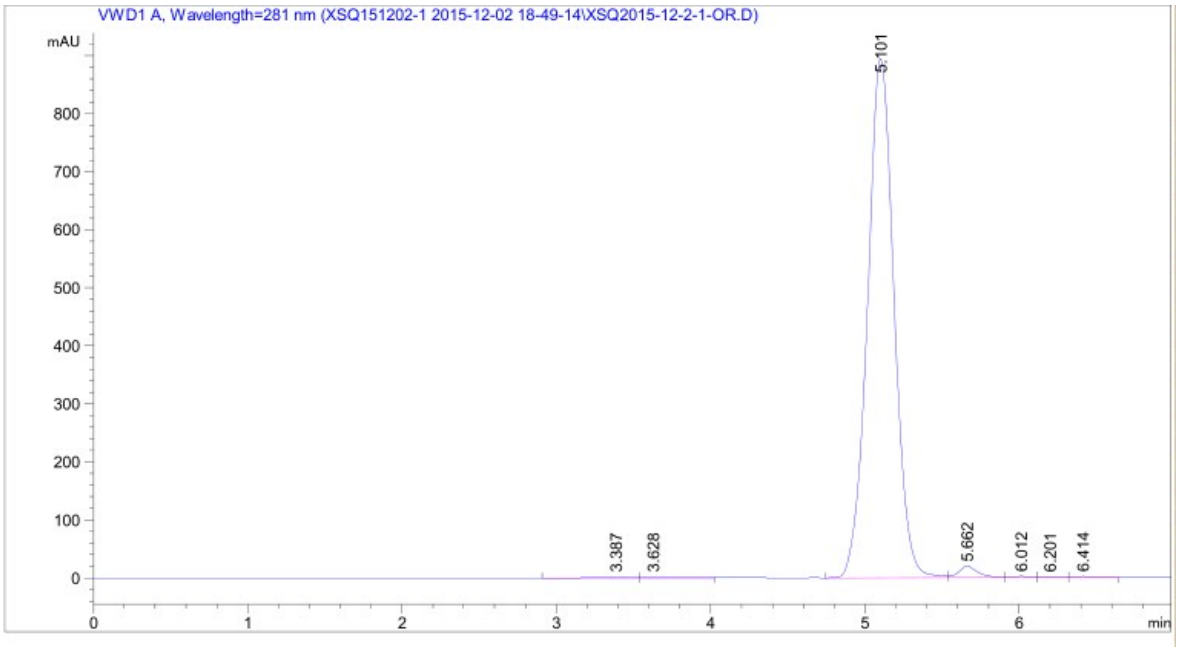

Figure S1 HPLC analysis of the liquid product produced from the catalytic conversion of fructose. The reaction conditions were as follows: 1.0 g fructose, 0.125 g $CrPO_4$, 10 mL H_2O, 30 mL THF, reaction temperature: 140 ℃, reaction time: 15 min. The detection conditions were as follows: UV detector with the wavelength was set to 281 nm and the mixture of water and methanol were used as the mobile phase.

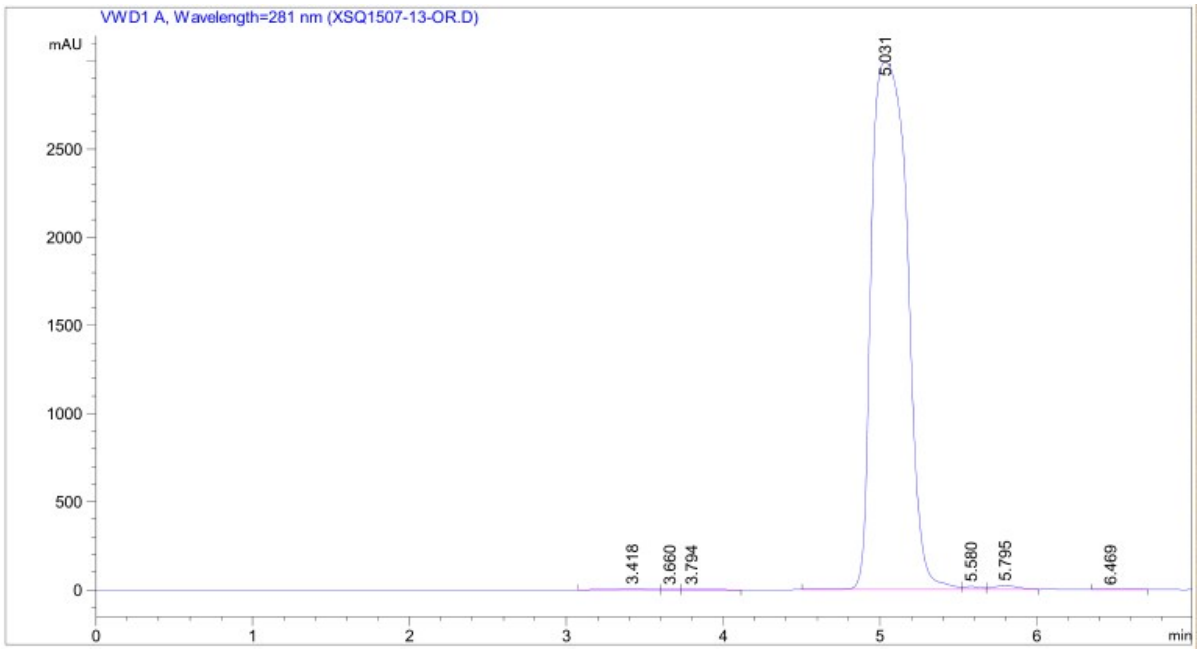

Figure S2 HPLC result of HMF standard chemical.

2. GC-MS

The liquid products were analyzed by a GC chromatography (Agilent Technologies 7890A) equipped with a capillary column (Agilent PH-5; 0.32 mm × 30 m) and flame ionization detector (FID) under ramping temperature from 40 to 280 ℃. Mass spectrometric analysis of the liquid products was performed with a 5975C inert MSD mass analyzer (Agilent Technologies) employing Triple-Axis Detector. GC Retention time of HMF was 22.15 min by injecting standard HMF compound.

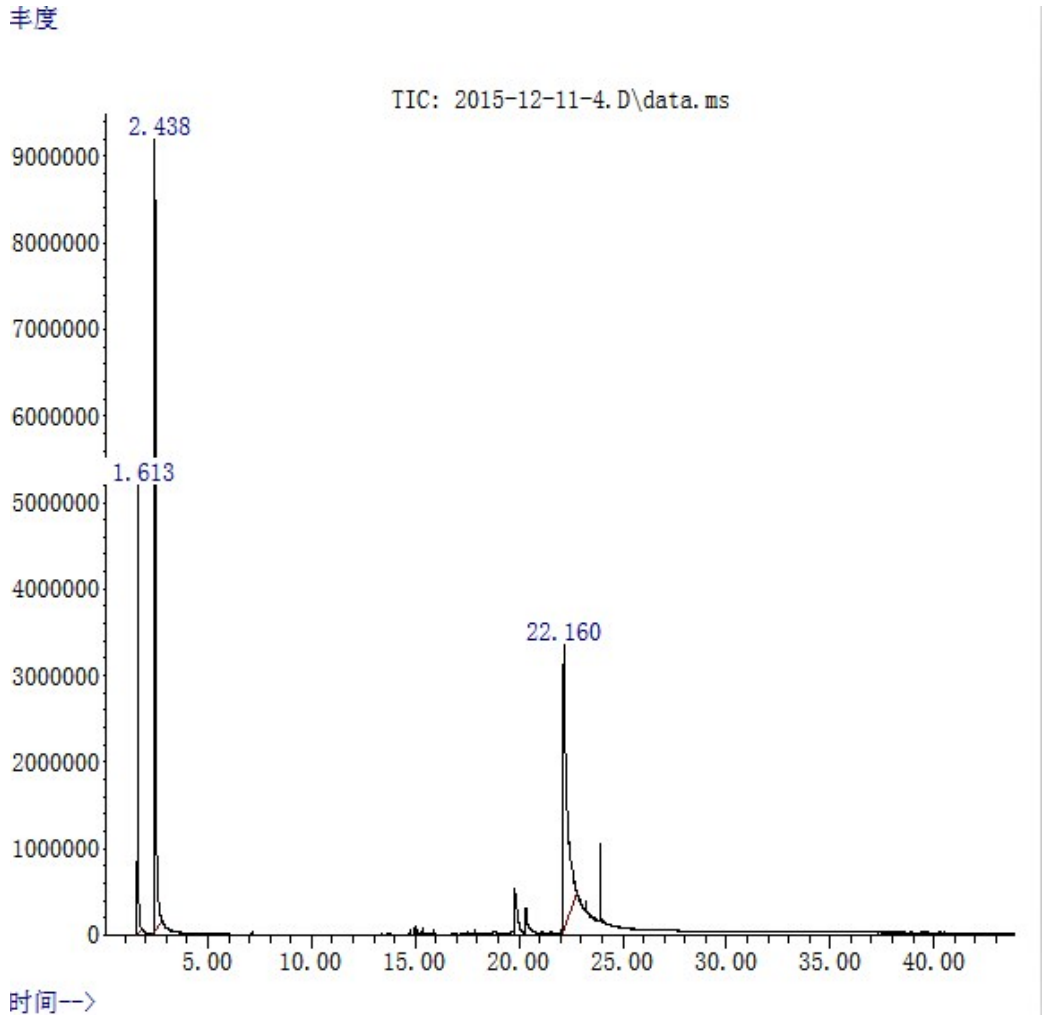

Figure S3 GC-MS plot for the liquid products produced from the catalytic conversion of fructose. The reaction conditions were as follows: 1.0 g fructose, 0.125 g $CrPO_4$, 10 mL H_2O, 30 mL THF, reaction temperature: 140 ℃, reaction time: 15 min.

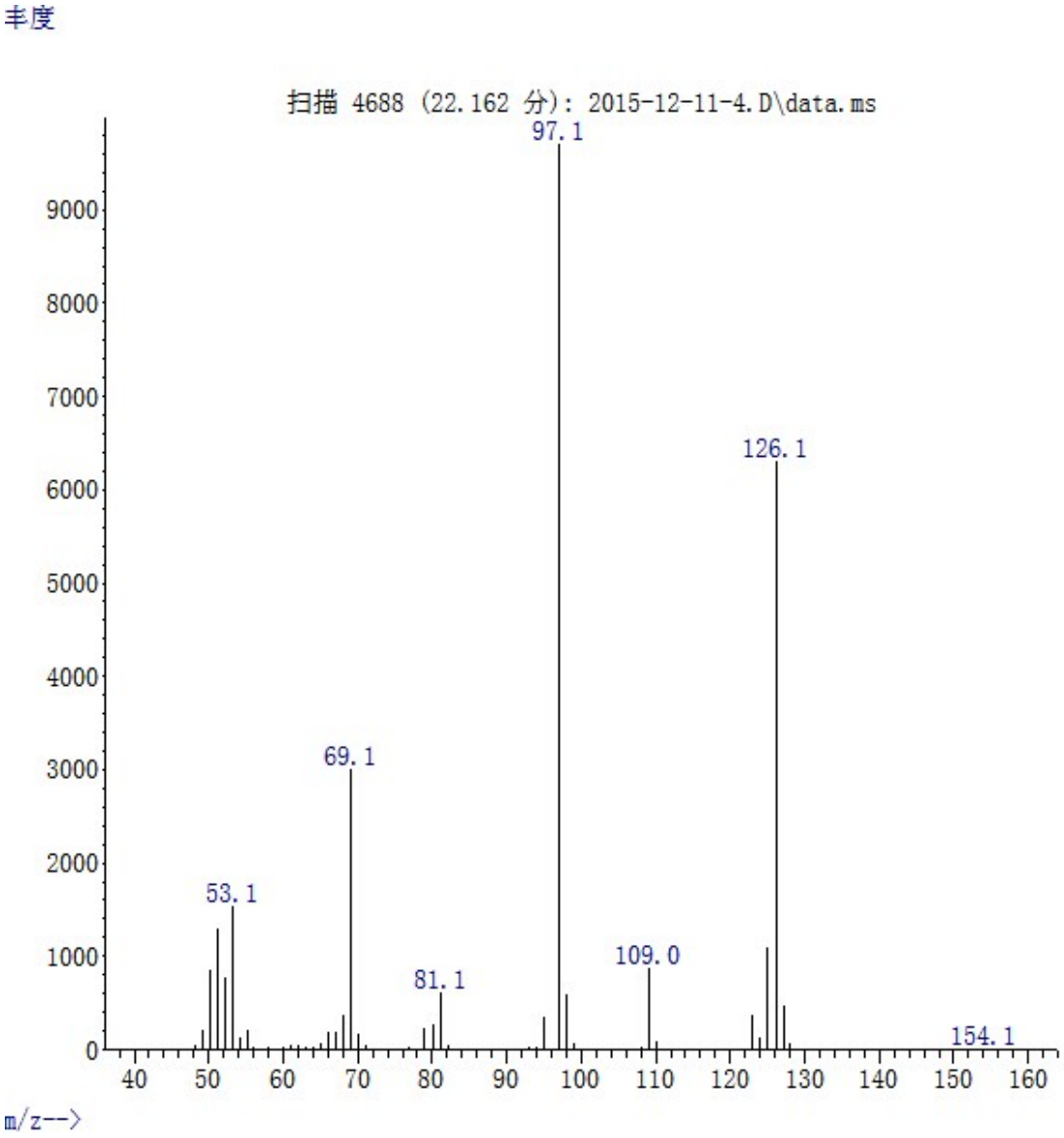

Figure S4 GC-MS/MS of the liquid products produced from the catalytic conversion of fructose. The reaction conditions were as follows: 1.0 g fructose, 0.125 g $CrPO_4$, 10 mL H_2O, 30 mL THF, reaction temperature: 140 ℃, reaction time: 15 min.

3. NMR spectrum

NMR (Bruker Biospin AVANCE III, 300 MHz) Analytic was used to analyze the liquid product produced from the catalytic conversion of fructose. Sample is dissolved in the D_2O-d_6.

1. HMF

^{1}H NMR (D_2O-d_6, 300 MHz): (ppm) 2.0, 4.64, 6.50, 7.18, 9.61;

^{13}C NMR (D_2O-d_6, 75 MHz): (ppm) 57.1, 111.6, 122.0, 153.1, 157.7, 178.1;

2. Levulinic acid

^{1}H NMR (D_2O-d_6, 300 MHz): (ppm) 2.09, 2.51, 2.72;

^{13}C NMR (D_2O-d_6, 75 MHz): (ppm): 29.9, 30.6, 39.3, 177.3, 207.7;

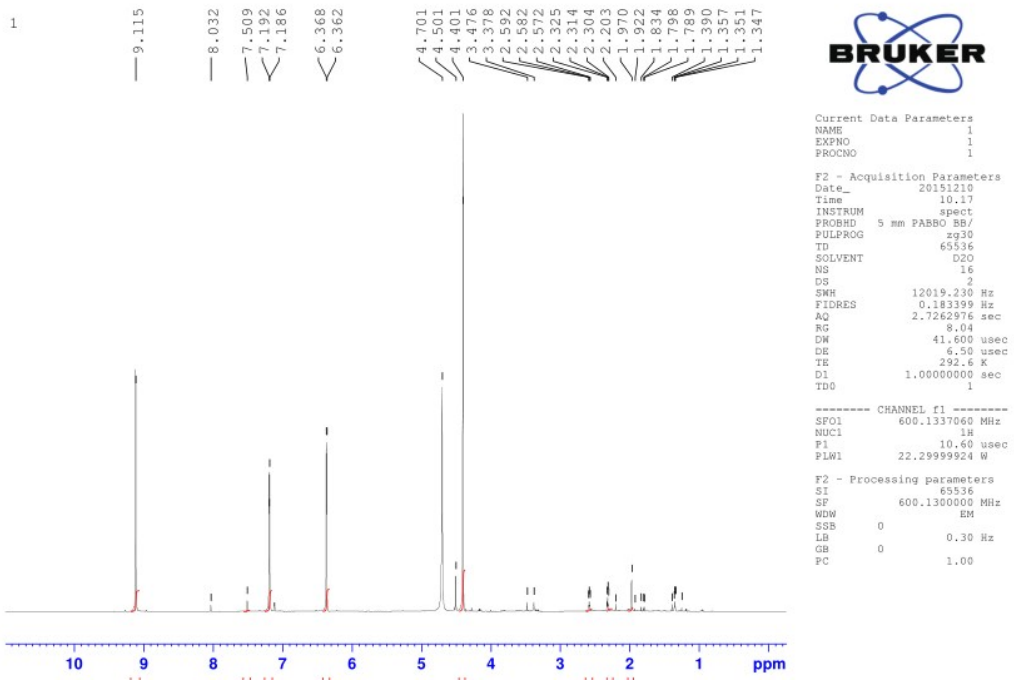

Figure S5 ^{1}H NMR of the liquid products in the THF phase produced from the catalytic conversion of fructose. The reaction conditions were as follows: 1.0 g fructose, 0.125 g $CrPO_4$, 10 mL H_2O, 30 mL THF, reaction temperature: 140 ℃, reaction time: 15 min.

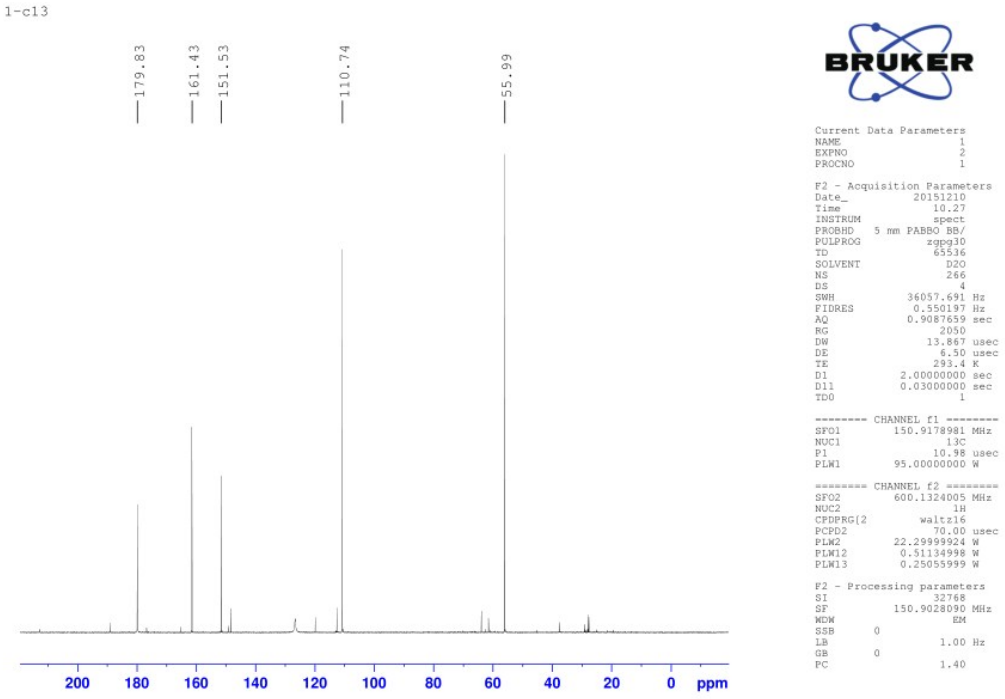

Figure S6 ^{13}C NMR of the liquid products in the THF phase produced from the catalytic conversion of fructose. The reaction conditions were as follows: 1.0 g fructose, 0.125 g $CrPO_4$, 10 mL H_2O, 30 mL THF, reaction temperature: 140 ℃, reaction time: 15 min.

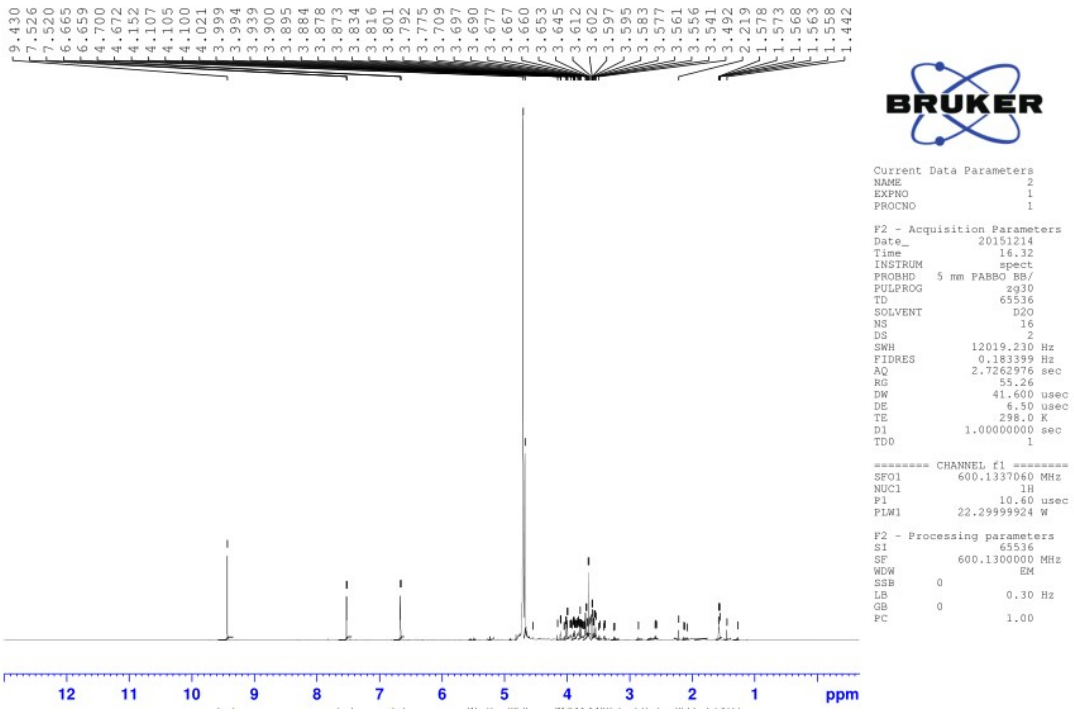

Figure S7 ^{1}H NMR of the liquid products in the water phase produced from the catalytic conversion of fructose. The reaction conditions were as follows: 1.0 g fructose, 0.125 g $CrPO_4$, 10 mL H_2O, 30 mL THF, reaction temperature: 140 ℃, reaction time: 15 min.

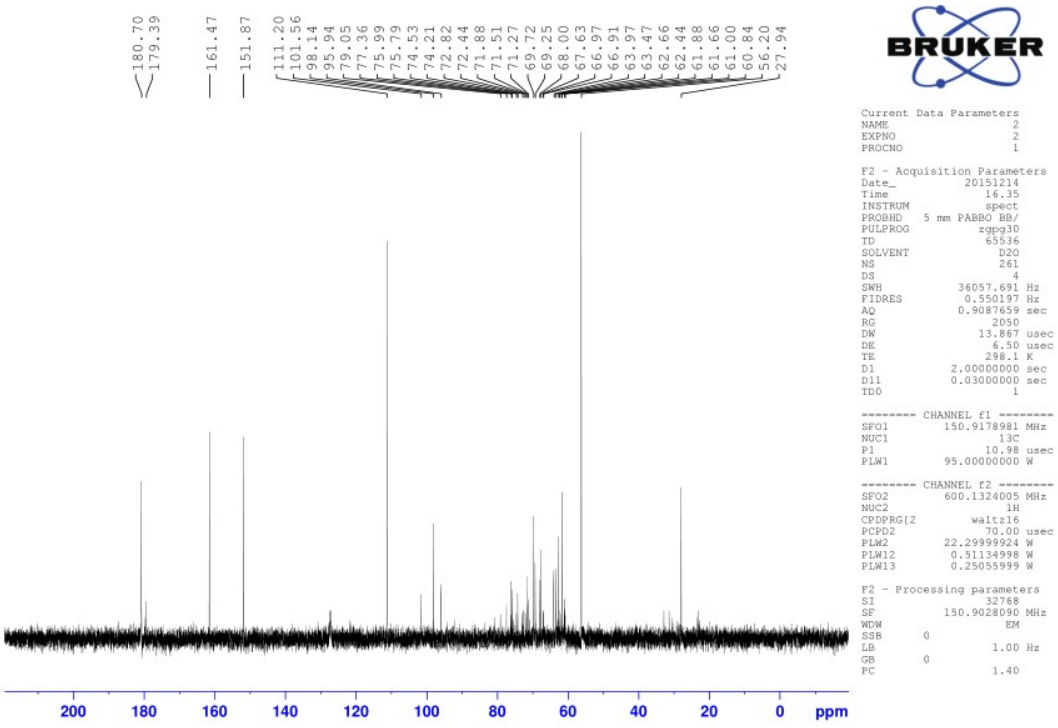

Figure S8 ^{13}C NMR of the liquid products in the water phase produced from the catalytic conversion of fructose. The reaction conditions were as follows: 1.0 g fructose, 0.125 g $CrPO_4$, 10 mL H_2O, 30 mL THF, reaction temperature: 140 ℃, reaction time: 15 min.