STABILIZATION OF CARBOHYDRATES WITH FORMALDEHYDE DURING INTEGRATED BIOMASS DEPOLYMERIZATION

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Biomass-derived carbohydrates are important platform molecules for the production of renewable fuels and chemicals. The production of carbohydrates from lignocellulosic biomass requires the extraction of lignin and the cleavage of ether bonds in hemicellulose (mostly xylan) and cellulose chains while minimizing further degradation of the resulting carbohydrates.[1] Several routes have been developed to convert lignocellulosic biomass into sugars, including direct concentrated acid saccharification and enzymatic saccharification after biomass pretreatment.[2] However, these methods lead to incomplete biomass depolymerization (producing only polysaccharides) and high process costs due to mineral acid recovery and enzyme production. Lowering acid use to improve process economics requires the use of higher temperatures and generally leads to significant sugar degradation and low yields, which is why these strategies have generally been difficult to implement.

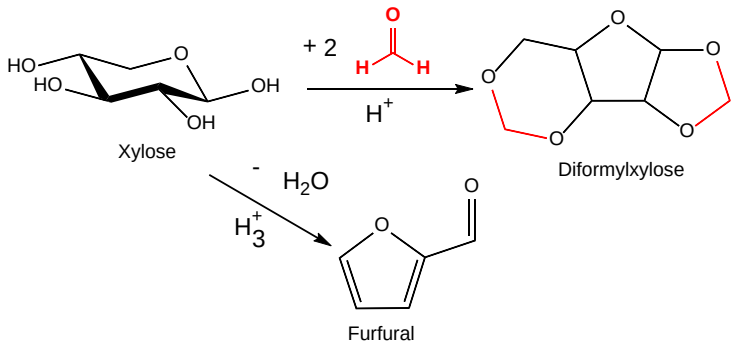

Figure 1. Xylose conversion to difromylxylose and furfural during biomass pretreatment with and without the addition of formaldehyde.

Recently, we have discovered that formaldehyde (FA) could be used to stabilize lignin and facilitate the conversion of extracted lignin to monomers at high yields (up to 97%). In the current work, we study the stabilization of carbohydrates by the addition of FA during integrated biomass depolymerization. The low water content and the acidic environment in the biomass pretreatment allow FA to react with xylose, forming diformylxylose at yields above 90% and minimizing xylose degradation into furfural. Diformylxylose could be used as is or converted back to xylose at high yields in aqueous environments. In comparison, reactions without formaldehyde lead to almost full xylose degradation into furfural with no xylose recovery. A similar process is observed with glucose. The development of a robust pathway for carbohydrate stabilization after depolymerization from polysaccharides could facilitate the use of conditions that were previously unfavorable due to carbohydrate degradation.

References

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2. Shuai L, Questell-Santiago YM, Luterbacher JS (2016) A mild biomass pretreatment using γ-valerolactone for concentrated sugar production. Green Chem 18:937–943. doi: 10.1039/C5GC02489G