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Industrial way to make sugars from plant biomass

Research highlights

First report of a continuous slurry process for the conversion of cellulosic biomass to sugars using a solid catalyst. Cellulose, the main component of plant biomass, is hydrolyzed to β-1,4-glucans and glucose in the process using a solid carbon catalyst. Carbon captures cellulose and efficiently converts it to sugars in a slurry reactor. The new process gives 28 times higher productivity compared to a conventional batch system. We hope that our process is easily adopted by chemical industry for biomass conversion.

Outline

Cellulose present in plant biomass is a useful source for synthesis of useful chemicals. The industrial conversion of cellulose is difficult due to its low reactivity and high processing costs. In their recent study, the group of Prof. Fukuoka and Dr. Shrotri report the design of a process for hydrolysis of cellulose in a slurry reactor with high yield and productivity. Using an inexpensive carbon material, they prepared an active catalyst by oxidizing it with air. The cellulose was adsorbed on carbon surface by ball milling to increase its reactivity. Using a continuous slurry reactor designed in their lab they produce β-1,4-glucans and glucose with high yield. More importantly, due to low reaction time they can achieve 28 times higher productivity compared with conventional batch processes in their lab. This process is expected to reduce the cost of cellulose conversion to produce valuable chemicals.

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Publication

Title: Cellulose hydrolysis using oxidized carbon catalyst in a plug flow slurry process
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Brief summary of the research

(Background)

Plant biomass is abundantly available as waste and it has great potential to be an alternative to fossil fuels for chemical synthesis. Cellulose in plant biomass is converted to glucose, which is a potential feedstock for many chemicals. Solid acid catalysts are promising for this reaction as they can be easily separated and have low environmental impact. However, the interaction between solid catalyst and solid

cellulose is poor, resulting in low yield and productivity. Yield of glucose can be improved by using a batch reactor to enhance catalyst-cellulose contact. Nevertheless, it is not possible to achieve an economic process for cellulose conversion with high productivity in a batch process. Therefore, it is necessary to develop a continuous process that can provide high productivity for cellulose conversion using solid acid catalysts.

(Method to overcome the issue)

A plug flow continuous slurry reactor was designed to achieve high productivity for cellulose conversion. Acidic carbon catalyst and cellulose were milled together before reaction to overcome the limited interaction between them. Carbon materials show high affinity to attach with cellulose molecules caused by strong interaction between them. The carbon catalyst was prepared by oxidation of an inexpensive activated carbon in the presence of air.

(Results)

Hydrolysis of cellulose in slurry flow process was successful without clogging in the reactor system. High yield of glucose or β-1,4-glucans were obtained by simply altering the reaction conditions. Glucose is a potential feedstock for chemical industry and β-1,4-glucans are high value products useful as health food. The productivity of glucose synthesis in this process was 28 times higher than the batch process. Therefore, the cost of cellulose conversion using this process can be reduced and multiple value added products can be obtained. Notably this process can also convert raw biomass to monomeric sugars with high yield.

(Perspective)

Cellulose conversion at industrial scale is severely hampered by lack of an efficient process. This research demonstrates a strategy to overcome the challenges in designing a continues slurry process for cellulose conversion. Once the cellulose is adsorbed on carbon surface, high productivity can be achieved. This report opens the way for cellulose conversion at industrial scale using carbon catalyst.

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Graphical summary