**Microwave as Suitable Alternative for Sugar Recovery From Brewer’s Spent Grain.**

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**Highlights**

* Fractionation of BSG by microwave using water and diluted sulfuric acid as solvents
* Higher sugar recoveries for microwave pretreatment assisted by diluted sulfuric acid
* Hemicellulosic sugar recovery of 71% for microwave assisted sulfuric acid (150 ºC, 10 min)
* Enzymatic hydrolysis yield of 41% for microwave assisted sulfuric acid (150 ºC, 10 min)

**1. Introduction**

Brewer’s spent grain (BSG), which is a low cost lignocellulosic industrial waste obtained from brewing industry, has traditionally been used as cattle feed due to its high content in carbohydrates and proteins. However, the high moisture content of BSG makes it susceptible to fast spoilage. The high content of cellulose and hemicellulose in BSG makes it attractive from the point of view of a biorefinery, being able to produce different products like biofuels, chemicals and high value added compounds [1].

Nevertheless, a pretreatment results essential, as BSG structure must be disrupted in order to fractionate it into its main components (cellulose, hemicellulose and lignin). As a result, the microwave assisted pretreatment has currently gained increasing interest in comparison with conventional heating. The basis of the microwave is the ability to apply an electromagnetic field directly about the heated object. Microwave pretreatment offers a great number of advantages, such as short reaction times, uniform and direct heating, simplicity of the process, higher removal of acetyl groups in hemicellulose and lower generation of inhibitory compounds (such as acetic and formic acids, furfural, 5- hydroxymethylfurfural and phenolic compounds). Moreover, the most important aspect is that microwave assisted pretreatment is an energetically efficient method, which does not cause environmental problems while also having a small capital cost [2,3]. What is more, microwave pretreatment can be assisted by acid catalysts. The use of dilute acid is considered as a powerful and effective pretreatment of lignocellulosic biomass [4]. Nevertheless, it is necessary the use of a corrosion resistant materials, and it is generated a hydrolysate whose pH must be adjusted to a value suitable for enzymatic hydrolysis. Therefore, in this work, a hydrothermal pretreatment is also used, which is less expensive and non-corrosive in comparison with acid or alkaline catalysts. The objective of this work was to fractionate BSG, removing the hemicellulose present and reaching in this way a cellulose-enriched solid. This study addresses the influence of extraction solvent (water and dilute sulfuric acid) on the recovery of sugars by microwave pretreatment.

**2. Methods**

Hydrothermal or dilute sulfuric acid pretreatment was performed in a Multiwave PRO SOLV reactor 50 Hz (Anton Paar GmbH, Austria, Europe). The solid concentration was 5% (w/v). Temperature and process time were selected as experimental factors. The temperature was set at 150 ºC and 170 ºC whereas the process time was set at 2.5, 5 and 10 min for each temperature. When dilute sulfuric acid pretreatment was employed, the sulfuric acid concentration was kept at 1% (w/v). Afterwards, the liquid fractions (or prehydrolysates) were separated from pretreated solids by vacuum filtration. Pretreated solids were subjected to enzymatic hydrolysis to compare the influence of extraction solvent. The contents in sugars (glucose, xylose, and arabinose) and potential fermentation inhibitors (acetic acid, formic acid, furfural and hydroxymethylfurfural (HMF) were determined by HPLC [1].

**3. Results and discussion**

When the hydrothermal pretreatment was used, high oligomeric sugars content (87-95%) was observed in the prehydrolysates whereas moderate hemicellulosic sugar recoveries, between 8 and 31%, were achieved. The maximum hemicellulosic sugar recoveries were observed at the most severe pretreatment conditions tested (170ºC, 10 min), being the influence of temperature more significant. Moreover, a maximum enzymatic hydrolysis yield of 20%, referred to glucose in the raw material (BSG), was reached under these pretreatment conditions.

Nevertheless, for the dilute sulfuric acid pretreatment, oligomeric sugar concentrations in the prehydrolysates were very low (< 3% of total sugars). Hemicellulosic sugar recoveries and enzymatic hydrolysis yields ranged between 62-71% and 35-41%, respectively, reaching the maximum value at 150ºC and 10 min.

**4. Conclusions**

In comparison with the microwave assisted hydrothermal pretreatment, the microwave assisted dilute sulfuric acid pretreatment is able to obtain higher hemicellulosic sugar recoveries (71 vs 31%) and enzymatic hydrolysis yield (20 vs 41%), referred to glucose in the raw material (BSG) under the experimental conditions analyzed. Further research will be focused on the optimization of pretreatment conditions of microwave assisted diluted sulfuric acid, in order to increase sugar recoveries.

**References**

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