Cannabis Sativa: Pretreatment and Fiber Content Analysis

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Abstract:

Cannabis Sativa commonly known as hemp, is one of the fastest growing plants whose refined products have immense commercial value. Refined hemp is included in various products: biofuels, biodegradable plastics, textiles, dietary supplements, paper, clothing and much more. Hemp fibers are also used in construction and manufacturing applications as a way to strengthen composite products. These qualities make hemp a high yielding, sustainable, and environmentally friendly crop with the potential to yield valuable raw materials for a large number of applications. Our research evaluates the pretreatment of hemp and the comparative analysis of the fiber content thereof. Our goal is to determine the suitability and the potential use of ionic liquid-based pretreatment (1-Butyl-3-methylimidazolium chloride) for the breakdown of hemp lignocellulosic biomass. The collected data is presented and discussed.

Introduction :

Hemp, a largely forgotten crop that was once popularly used as a major sustainable fiber for production. Hemp is from the Cannabis family, it contains 0.3% THC compared to Marijuana 17.1%, allowing it to be a safe and compelling raw material. This organic plant matter is able to replenish poor soil, thrive without much assistance and grow without the need for pesticides, fertilizers, and much water. It is considered a low input and low impact crop. The environmental impacts associated with the production of hemp fibers are smaller than those associated with most other crops; sugar beet, potato, which are considered high impact and high input crops. Hemp's adaptable species can be sustained in harsh environmental conditions. Having a growth cycle of 108-120 days, and the ability to grow four inches apart, allows for a high and rapid yield. These factors positively support hemp's resurgence in the textile, agricultural, pharmaceutical, and fuel industries.

Cannabis Sativa, hemp, is classified as second-generation biomass due to its composition of non-edible plant material such as lignocellulose, and pectin. Lignocellulose comprises three polymers cellulose, hemicellulose, and lignin. Together, they are responsible for the structural stability, high strength, and stiffness of hemp's cell walls.

The goals of this study are, 1; to determine how efficient the use of ionic liquids is for the pretreatment of hemp lignocellulosic material and, 2; evaluate the quality of fiber obtained thereof. Ionic liquids (ILs) are a unique class of non-volatile, nonflammable chemicals. Their properties can be altered through varying the identities of their constituent ions. Dissolving biomass in ILs has been reported to lead to a full release of all the functional groups and bonds from the matrix. These results have shown that lignocelluloses dissolved in ionic liquids are more susceptible to chemical attack by various reagents/catalysts.

Procedure

I. Biomass Preparation

The hemp was donated by SUNYrf. The hemp was chopped into three sizes (Ground ¼", Short ½", and Large 1") then washed in deionized water, and placed in an oven at 70 degrees Celsius for a total of three days to dry. Once dried, the "ground" samples were ground with mortar and pestle to resemble a fine powder. The "Short and Large" samples were cut using scissors to their respective sizes. Then 0.3g of each sample were weighed using an analytical balance and distributed into respective Erlenmeyer flask for pretreatment (nine flasks per hemp group).

II. Ionic Liquid(IL) Pretreatment

The pretreatment used for the hemp samples was 1-Butyl-3-methylimidazolium chloride. For each flask, 3.0 grams of 1-Butyl-3-methylimidazolium chloride was added along with a magnetic stirrer. The Ionic Liquid to biomass ratio, was 1:3 for each sample. All sample flasks were heated in mineral oil baths in crystallizing dishes at temperatures between 75-80 degrees Celsius. Each dish was placed on a hotplate for either 3, 6, or 9 hours. Once samples reached their target heating period, they were removed and left to cool.

III. Acid Hydrolysis

After the ionic liquid pretreatment, the samples containing ionic liquid and hemp, were filled with 10.0 mL of 0.5 Hydrochloric acid. The samples were then heated in mineral oil baths in crystallizing dishes for either 3, 6, or 9 hours at 80 degrees Celsius. Once heated, samples were removed from the heat and oil and left to cool for 30 minutes. After cooling, 10.0 mL of 0.5 M sodium hydroxide solution was added to each acidic sample as a neutralizer.

IV. Slide Preparation

From each step: raw, ionic liquid, and acid hydrolysis, hemp samples were collected for fiber examination. Hemp fragments were removed from each flask, rinsed with deionized water, and placed on glass slides to be examined using a stereomicroscope. Slide were labeled A for acid hydrolysis, IL for Ionic liquid, and RAW for raw samples.

V. Stereomicroscope

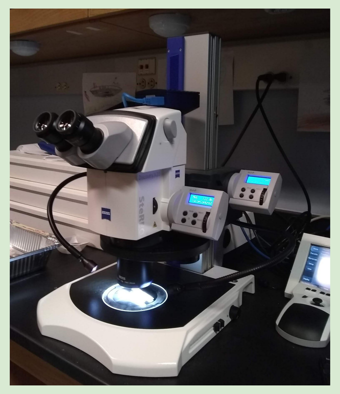


Figure 1. Image of Stereomicroscope

The microscope used for the data collection was ZEISS SteREO Discovery.V20. The objective lens applied for all images was the Achromat S 1.5x FWD 28mm. For optimal imagery, a z-stack was conducted based on the topography of each hemp fiber. Additionally, images underwent further processing methods such as "Extended View of Focus" to sharpen resolution, or "White Balance" to adjust light reflection, or both. Images displayed show two fields of vision of each hemp sample, a half and zoomed view. The optimal images for each sample are presented.

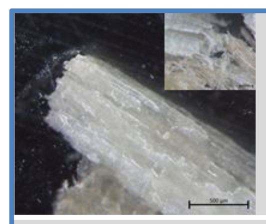


Figure 2. Image of raw hemp sample

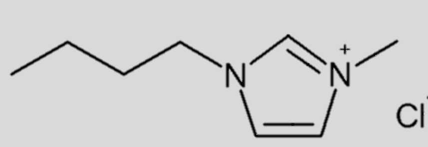


Figure 3. Chemical structure depiction of the Ionic Liquid compound 1-Butyl-3-methylimidazolium chloride

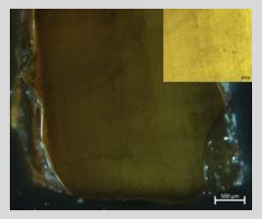
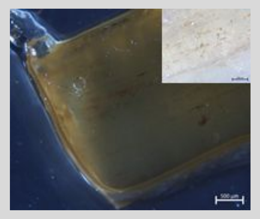
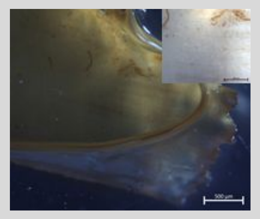
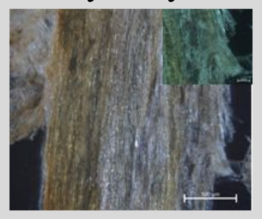
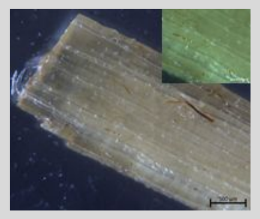
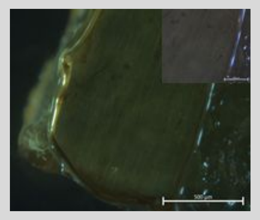
	Hours in Ionic Liquid	Hours in Acid Hydrolysis
Ground Hemp: 3hrs		
Ground Hemp: 6hrs		
Ground Hemp: 9hrs		Ground Hemp in Acid Hydrolysis 3-9 
Short Hemp: 3hrs		
Short Hemp: 6hrs		

Table 1. Stereomicroscope Images of hemp from Ionic Liquid, Acid Hydrolysis, and Raw stages.

Results and Future directions:

Pretreatment of the hemp fiber results in more fibrous material obtained in each case. These results suggest that the ionic liquid (1-Butyl-3-methylimidazolium chloride) used in this case may serve as a good pretreatment candidate for further studies on hemp.

Future directions will include imaging the remainder of the samples to gain a better understanding of the differences in fiber breakdown after ionic liquid and acid hydrolysis treatment. Further data investigating hemp fiber decomposition could be found using Thermal Gravimetric Analysis, where the mass of the sample will be measured over time as the temperature changes to provide information about the thermal decomposition/stability of hemp.

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Stay happy, you have incredible value- Barnabas Gikonyo