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Production of bioplastic from rice straw cellulose

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Abstract
Rice straw (*Oryza sativa*) is the stem of rice plant left after the grains is separated from harvested paddy. It has fairly high cellulose (37.71%) content. Reasonably high cellulose content has potential to be used as bio plastic material. This work was aimed to fabricate bio plastic from the rice straw, with addition of carboxymethyl cellulose (CMC) and glycerol. Straw was also cut into 2-3 cm length and being dried under the sun. Cellulose was separated by digestion and the bioplastic were produced by blending dried pulp with varying concentration of CMC, and glycerol (1.5-3 gram CMC and 1 ml -2 ml glycerol. /100 gm cellulose).Swelling test (both in water and oil) and biodegradability test were conducted to study the performance of the bioplastics. Effects showed that bioplastics were dissolved easily in water. Throughout oil swelling check, it showed that higher glycerol content material will increase the oil resistant function of the bioplastic. In the meantime, the CMC content material has no impact during the oil swelling check. The exceptional composition of the bioplastic is with the CMC and glycerol contents of 1.382% and 0.323% respectively, with the bottom oil swelling check end result of 68%. Biodegradability of the bioplastics is low at high CMC and glycerol contents. The first-rate composition with maximum weight loss of the bioplastics was achieved by the bioplastic with 0.469% of CMC content and 0.939% of glycerol.

Keywords: Rice straw, CMC, glycerol, bioplastic, oil, water, swelling, biodegradability

Introduction

The world has produced over 9 billion tons of plastic since 1950s. One hundred and sixty five million heaps of it has trashed our ocean, with nearly 9 million extra heaps getting into the oceans each year. Considering only about 9 percent of plastic gets recycled, a good deal of the rest pollutes the environment or sits in landfills, in which it can take up to 500 years to decompose while leaching poisonous chemical compounds into the ground. The global wishes to find a solution that offers us continued access to plastic but avoid these serious problems.

Bioplastic are partly or wholly made from biological substances and not from crude oil, represent an effective way to maintain the big blessings of conventional plastics, overcoming their disadvantages. India is the world's second-largest producer of rice, and the largest exporter of rice in the world. Production increased from 53.6 million tons in FY 1980 to 120 million tons in FY2020-21 [1].

Rice straw (*Oryza sativa*) is the stem of rice plant after the grains is removed from harvested paddy. It contain 37.71% of cellulose, 21.99% of hemicellulose, and 16.62% of lignin. A reasonably high cellulose content is potential to be used as bioplastic material. Cellulose from rice straw continues to be not extensively used. On the whole, rice straw becomes waste after the grain rice is taken. The advantage of this polymer is renewable and biodegradable. Consistent with these properties, this polymer can be used as bioplastic, the plastic material that may be decomposed through microorganisms, became an environmentally friendly compound [2].

Bioplastics are plastics that can be utilized like conventional plastics, however it can be broken down by the activity of Microorganisms and the end product will be water and carbon dioxide. It is released into the climate without leaving poisonous buildups. Use of Bioplastic is one of the techniques to reduce the usage of conventional plastic that is non-degradable and carcinogenic. Bioplastic is usually used as a plastic packaging, similarly, bioplastic also have potential to be used in a clinical and Pharmaceutical area like surgical thread, swabs, wound dressing, and so on [3].

Bioplastics are assembled into two gatherings and four unique families, for example gathering of agro-polymers, comprising of polysaccharides, proteins, and so on, and gathering of biopolyester (biodegradable polyester), for example, polylactic corrosive (PLA), polyhydroxy alkanoate (PHA), fragrant and aliphatic co-polyester.

Agro-polymers are biomass products obtained from agricultural materials. Biopolymer can be grouped according to source. PHA group is obtained from microorganism activity by means of extraction. Another group is biopolyester acquired from the use of biotechnology, specifically by ordinary blend of naturally gotten monomers, called polylactides. Examples of polylactides are poly lactic acid. The final group is derived from petrochemical products synthesized conventionally from synthetic monomers (polycaprolactones, polyester Amides etc) [4].

Biodegradable polymers are polymers that are suitable to putrefy into CO_2, CH_4, H_2O, inorganic composites or biomass through enzymatic responses by microorganisms. Some polymers can be decomposed at certain places with different decomposing speed [5].

Cellulose as one of the plastic constituent polymers contains high levels of fiber. The mechanical strength of cellulose fibers is influenced by the size of the fiber diameter. The greater the diameter of the fiber, the lower the value of the tensile strength and modulus of elasticity and vice versa [6].

Carboxymethyl cellulose (CMC) is a derivative of cellulose and is often used in the food industry, or used in food to prevent degradation [7]. There are four important functions of CMC, i.e., as thickener, stabilizer, gelling agent and emulsifier. In the hydrocolloid emulsion system, CMC does not function as an emulsifier but rather as a compound that provides stability [8]. Glycerol is a chemical that is widely used in the pharmaceutical, cosmetic and food industries. It is non-toxic, edible, and biodegradable so it has important benefits to the environment. The functions of Glycerol are to absorb water, as a crystallizing agent and a plasticizer. Plasticizer is a compound that has ability to increase flexibility, strength, and distortion of a biopolymer matrix by reducing the electrostatic charge and at the same time increasing flexibility, crack resistance, and dielectric constant [9].

This research was aimed to produce bioplastic from rice straw cellulose and to study the effect of glycerol and CMC on its water resistance, and biodegradability.

Methodology

Extraction of cellulose from rice straw

Prior to bioplastic fabrication, cellulose was uprooted from rice straw that was attained by removing leaves from paddy rice. Then Straw was cut into 2-3 cm length and dried under the sun. A cooking solution of 50% (w/w) ethanol and 8% (w/w) NaOH solution as catalyst was made and rice straw was cooked in this digester. Ratio between dried rice straw and ethanol solution was 10:1 (gram: ml).Digester was operated for 60 minutes at 120 °C. The residue and filtrate from the digester were separated with a sieve. The residue was washed with 50 (w/ w) ethanol solution followed by hot water until the filtrate was clear and neutral. The ‘clean’ residue was then dried in an oven at 70 °C for 24 hours. The dried residue, i.e. pulp, was then pulverized using a blender to reduce the size of the straw and break down the cellulosic fibers.

Cellulose analysis

The pulp was dried in an oven at 105 ºC for 1 hour. Ten grams of dried pulp was soddened using 50 ml of 17.5% (w/w) NaOH solution in an erlenmeyer for 1 minute. 30 ml of 17.5% (w/w) NaOH solution was poured into the erlenmeyer and then the mixture was stirred continuously for15 minutes and rested for 3 minutes. 17.5% (w/w) NaOH solution was then added sequently into the mixture at 2.5, 5, and 7.5 minutes. Volume of NaOH solution added for each time was 30 ml. The mixture was the kept in rest for 30 minutes. Add 500 mL of water and keep it for 30 minutes, then the mixture was filtered using whatman filter paper. A precipitate was formed and is washed with 250 ml of water. This washing step was repeated for 5 times. The precipitated solid left on the filter paper was transferred to another flask and then was washed using 1500 mL of water. 2N Acetic acid solution was poured to the precipitated solid and the mixture was stirred for 5 minutes. Washing step was repeated until the solid was not in acidic condition (Neutral). The remaining precipitate was then dried in an oven at 105 ºC until the weight of the solid remained constant.

Sample Name	CMC [gram]	Glycerol [%mass]
C1G1	0.5	1.183
C2G1	1	1.178
C3G1	1.5	2.323

Bioplastic synthesis

Bioplastics were prepared with 5 gram and 10 gram of rice straw cellulose which was dissolved in 100 ml & 200 ml of water respectively with varying levels of the glycerol and CMC content. The amount of glycerol added to the mixture were 1ml, and 2 ml, while the CMC amount were 1.5 gram and 3 gram. Prior the molding, the solutions were filtered to remove coarse solids. Bioplastics were molded on plastic-wrapped ceramic and dried in room Temperature for 2x12 hours. Size of each bioplastic sample (sheet) was 2.5 cm x 5 cm.

Analysis

Water, oil swelling test and biodegradability tests were conducted for samples. In water swelling test, samples were submerged into the water and in oil swelling test, samples were submerged into the oil. In biodegradability test, samples were buried under dry soil.

During water swelling test, all bioplastic samples decompose immediately when they were submerged in water. Duration for oil swelling test and biodegradability test were 6 and 15 days, independently. In oil swelling test, samples were weight in diurnal base. For biodegradability test, the weights of samples were measured in every 5 days.

Results and Discussion

During water swelling test, all bioplastic samples putrefy incontinently when they were submerged in water.

This happened because the bioplastic binding agent, i.e. CMC, is hydrophilic and its molecules were also easily dispersed in water.

In general, the higher glycerol content of bioplastic the resistance toward oil was higher. It was recorded that the amount of oil absorbed by the bioplastics reduced significantly in higher glycerol content.

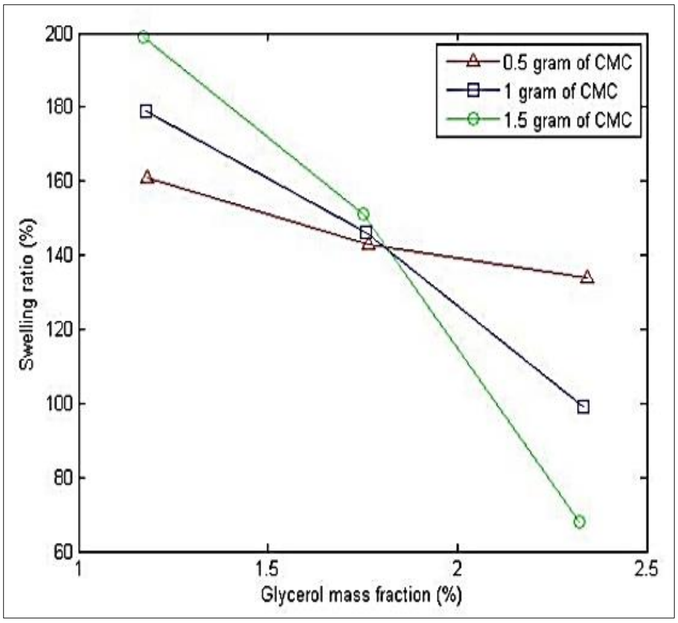

Fig 1: Oil swelling test

Those peculiarities occurred as glycerol is a plasticizer that has character as oil resistant. The impact of CMC content was seen during the fabrication of bioplastic. The higher CMC content, the bioplastics became thicker, as well as the other way around.

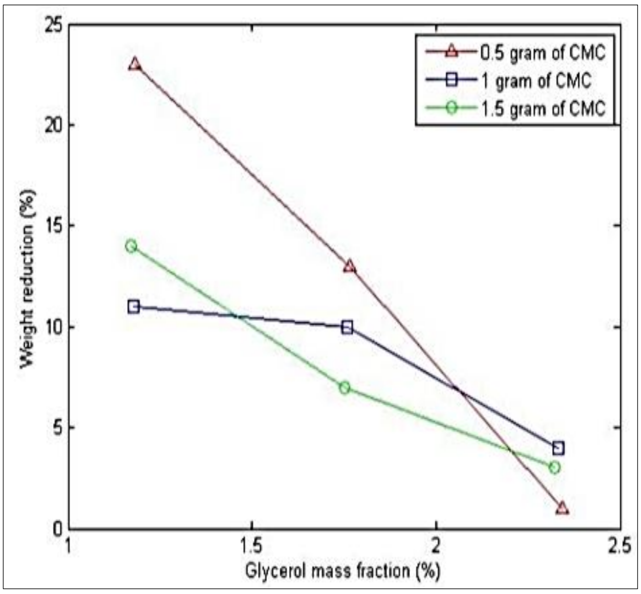

Fig 2: Biodegradability test under dry soil

Degradation test was noticed for 15 days on entombment of the bioplastic tests in dry soil. On gauging the sample on the fifteenth day, it was observed that all samples presently have not experienced weight decrease. This implies that there were undecomposed samples following the 15 days internment.
In general, the higher the density of the sample, the more difficult to be decomposed.

Conclusion

Based on the results of research that has been done can be concluded as follows:

1. Bioplastics can be fabricated from rice straw cellulose with expansion of CMC and glycerol.
2. Bioplastics with added substances, for example, CMC and glycerol are not waterproof.
3. At the same CMC content, the oil opposition of the bioplastic was higher in bioplastic with higher glycerol Content.
4. CMC and glycerol content that created bioplastic with most elevated oil obstruction (68%) were 1.382% and 2.323%, individually.
5. Lower the CMC and glycerol content, the bioplastics were simpler to be debased. Best bioplastic with extreme weight reduction was accomplished at CMC and glycerol content of 0.469% and 0.939%, respectively.

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