Biodegradable Plastic Using Different Plasticizers

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Abstract: This experiment was conducted to compare the properties of biodegradable plastic made out of potato (Solanum Tuberosum) starch, using different plasticizers. Four setups were made for different plasticizers. The plasticizers used were urea, glue, and glycerol. Glycerol was used in different amounts in two of the setups.

The cost of production was kept at the bare minimum, as most of the materials used were readily available. The end product was a result of gelatinisation and baking of the starch obtained from potatoes. The appearance, flexibility and texture of the resultant pseudo-plastics were recorded. While most of the plasticizers yielded brittle but plastic-like end products, the product obtained for glycerol was more flexible and showed plastic like properties.

1. Introduction

Due to the overwhelming demand of commercial plastic, the environment is getting crammed with hazardous non-biodegradable materials. Thus, there is need for an alternative in the form of biodegradable plastics. Starch is highly useful in food industry, biomedical and cosmetic industries, and in the recent years research has been directed towards using starch as a thermoplastic material.

In this experiment, potato starch has been used to synthesize thermoplastic. In order to be able to process native starch to form a bio-plastic material, it is necessary to disrupt and melt the semi-crystalline granular structure of native starches [1]. This is generally done by heating the starch with a plasticizer. The transformation of granular starch into TPS (Thermoplastic Starch) is influenced by the processing conditions such as temperature and plasticizer content. Water and glycerol are the most commonly used plasticizers in TPS materials [2]. Glue and urea have been used as other possible plasticizers. The purpose was to compare the properties of the plastics synthesized using different plasticizers.

2. Theory and Previous Studies

Starch consists of long chains of glucose molecules. These molecules are of two types: Amylose (linear) and Amylopectin (branched). They aggregate into small particles called granules.

The difference between starches from different plants is that they have different granular sizes and different ratios of Amylose and Amylopectin molecules. This means plastic films made with different starches may have different properties. Amylose molecules form a more ordered and stronger plastic film than the amylopectin molecules that are difficult to align.

In this experiment, only potato starch has been used. It has 20:80 Amylose-Amylopectin ratio. The process that takes place while making plastic out of starch is described as under: When heated in the presence of water, starch undergoes a number of irreversible changes, commonly referred to as gelatinisation. The granules are observed to swell, absorb water, lose crystallinity, lose birefringence, and leach amylose [3,4,5]. In order to gelatinise starch, a plasticizer is necessary since the glass transition temperature and the melting temperature of pure dry starch are higher than its decomposition temperature [6,7]. Water is the most commonly used plasticizer, but it may cause brittleness [8]. Glycerol, glue, and urea were used in turns, in addition to water to increase the flexibility of plastic...
3. Materials and methods
Four setups were made with 2 g starch, 2.4 ml of HCl/NaOH and 20 ml water and the following plasticizers.

<table>
<thead>
<tr>
<th>S. No</th>
<th>Plasticizer</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Glycerol</td>
<td>1.6 g</td>
</tr>
<tr>
<td>2</td>
<td>Glycerol</td>
<td>0.8 g</td>
</tr>
<tr>
<td>3</td>
<td>Urea</td>
<td>1.4 g</td>
</tr>
<tr>
<td>4</td>
<td>Glue</td>
<td>1.0 ml</td>
</tr>
</tbody>
</table>

4. Procedure
1) Extracted starch from potatoes by peeling and shredding them first, and then washing out the starch with water.
2) Took 2 g of starch and added 20 ml of water to it, then added 2.4 ml of 0.1 N HCl.
3) Added the plasticizer corresponding to the amount shown in the table.
4) Added 0.1 N NaOH to neutralize the HCl.
5) Poured the viscous solution on a small piece of tile or a petri dish.
6) Repeated the process for the remaining three plasticizers.
7) Baked the specimens for 20 minutes at 60-70 degrees Celsius.
8) Air dried for two weeks.
9) Noted the texture and appearance.

5. Results and Discussion
Following are the results and related discussion for each of the samples:

a) Plasticizer: Urea
After the sample was dried completely, most of it could not be removed from the tile. The little that could be removed was hard and brittle. Thus the test for urea as a plasticizer was inconclusive.

b) Plasticizer: Glue
The sample was hard to remove from the tile but was relatively easy as compared to the one with urea. The plastic obtained was brittle but had very high tensile strength as the pieces could not be broken easily.

Fig. 4 Plasticizer: Glue

(c) Plasticizer: Glycerol 1.6 ml
Even after drying and baking for two weeks the sample remained sticky and attracted dust. It could be easily removed from the tile in a plastic-like fashion. The sample was a very flexible thin film but had very low tensile strength. When it was washed with alcohol to remove the stickiness, it became in flexible and brittle.

Fig. 5 Plasticizer: Glycerol 1.6 ml

d) Plasticizer: Glycerol 0.8 ml
This could be very easily removed. It was completely dry and showed characteristics of a typical plastic film, like flexibility, high tensile strength, impermeability etc.

Fig. 7: Plasticizer: Glycerol 0.8 ml
All the samples dissolved in water on keeping them immersed overnight.

Fig. 8: A dry, pseudo-plastic film was obtained

6. Conclusions

The four different setups that were made using different plasticizers yielded different results. As seen from the results, glycerol proved to be a better plasticizer than urea and glue. Glycerol when used in excess yielded a sticky plastic film with low tensile strength but in moderate amounts, the product was nearly a perfect plastic-like film. Since all of the products formed were water soluble, they can be considered biodegradable. Further research is being carried out to find a plasticizer that could provide high tensile strength at low cost of production.

7. References

[8] Rulande P.G. Rutgers, Gena Nashed, Peter A. Sopade: The Plasticisation effect of glycerol and water on the gelatinisation of wheat starch. Division of Chemical Engineering, University of Queensland, St Lucia, QLD 4072, Australia 297-301.