Study on the synthesis and the mechanical properties of chitosinous thin films

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Introduction

Chitin is the second most abundant natural biopolymer. It was first discovered in 1811 by Professor Henri Braconnot. Chitin is a type of glucose-derived polymer which can be found in the exoskeletons of crustaceans. Especially for the crabs and shrimps, chitin can be extracted from their shells.

Extraction process of chitin

Yet the usages of chitin have to be discovered. Due to the low solubility of chitin in normal solvents, the application of chitin has been limited. Since various approaches for dissolving chitin have been discussed in recent researches, some applications and products have been invented based on this natural material. One of the application is to produce plastic products by chitin’s product which is chitosan.

The process of converting chitin to chitosan is known as deacetylation.

Conversion process of chitosan

In this project, the synthesis and the mechanical properties on chitosinous thin film have been studied. The potential applications are suggested additionally.

Motivation and objectives

Seeing that the portion of the plastic bag in MSW take an important role, the possibility of bio-inspired polymer to substitute the low bio-degradability polymer has been studied. According to the data from EPD in 2015, the daily disposed plastic bag is 649 tons. It is about 29.74% of the amount of disposed plastic.

Due to the low biodegradability of low-density polyethylene (one of the plastic used to manufacture the plastic bags), it lasts for a very long time in landfills. Besides, chitosinous plastic can be easily degraded and the duration required is much lower than low-density polyethylene.

Synthesis of thin film

Chitosan powder is soluble in the acidic solution. 98ml of 2wt% acetic acid were used to dissolve 2g chitosan powder. The solution is then spread on the substrate(glass or plastic) and air dry under ambient temperature for about 24 hours which depends on the humidity.

The traditional synthesis has an additional alkali treatment to neutralize the thin film. This process has been neglected. Chitosinous thin film without the alkali treatment can be dissolved in water without any additional chemical. It is good for the recycling process. With water only, the chitosinous thin film can be cast in to other products depending on the applications. The degraded chitosinous thin film is produced by adjusting the portion of long chain chitosinous and chitosinous oligosaccharide(short chain). The amount of chitosan in total is unchanged.

Experiment setup

The tensile strengths of thin films are measured by TINUS OLSEN HROKXT with laser extensometer from the laboratory of Department of Mechanical and Biomedical engineering.

Universal testing machine—TINUS OLSEN HROKXT(left) and setup(right)

To measure the load applied on the sample, the load cell in the machine recorded the load data. With measuring the thickness of the thin film by micrometer. The tensile strength of the thin film is obtained.

In terms of the strain, the traditional universal testing machine requires to attach strain gauge on the sample. For the laser extensometer, it can reduce the adhesive force provided by the stickers applied in the traditional strain gauge setup. The result of the test thus can be improved.

Application of the chitosinous polymer

Attached plates at the lock(left), Without plates at the lock(right)

Apart from the equipment, the clamp of the universal testing machine may destroy the thin film during locking the clamp. It is because the inner surface of the clamp is not smooth. Two flat plates have been installed to isolate the rough inner surface of the clamps.

<table>
<thead>
<tr>
<th>Low-density polyethylene</th>
<th>Chitosan(2wt%)</th>
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<tbody>
<tr>
<td>Tensile strength(MPa)</td>
<td>1.4</td>
</tr>
<tr>
<td>(MPa)</td>
<td>1.4</td>
</tr>
<tr>
<td>Strain</td>
<td>1.8</td>
</tr>
<tr>
<td>Bio-degradability</td>
<td>1.8</td>
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</tbody>
</table>

As a result, the development of high strength thin film was conducted in this project. Moreover, the long term strength of the thin film was studied. The tested films were not under any alkali treatment in order to reduce chemical being used in proposed recycling process.

Result

In the synthesis of the chitosinous thin films, it is observed that the minimum ratio of long-chain chitosan(CS) and chitosinous oligosaccharide(CO) is about 1:1.

In the mechanical testing, the pure chitosinous thin film has with higher tensile strength in general, the result revealed that the CO content affects the strain of the thin film. The strength of the thin films without alkali treatment is similar to thin films with alkali treatment.

Meanwhile, the Young’s modulus of the thin film decreases substantially with the increase of the CO content.

Since the strength of chitosinous thin film is much higher than low-density polyethylene bag, the chitosinous thin film can be functioned as plastic bag. However, the strain of the chitosinous thin film should be improved. It is found that the strain of the thin film is related to the water content. The further study of the strain of chitosinous thin film should be conducted. Moreover, the durability of the chitosinous thin film has yet been studied. The future study of the durability of the chitosinous should be conducted as well.