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# Thermal and Functional Group Analyses of Potato Starch and Corn Starch Biopolymer Film

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**Abstract**

Potato starch and corn starch are widely used to produce biopolymers because they contain amylose and amylopectin, the two main components responsible for polymer formation. In this study, potato and corn starch were used as raw materials to prepare biopolymers with glycerol added as a plasticizer to improve elasticity. Four biopolymer samples were prepared with different starch weights. A biopolymer sample was prepared from potato and corn starch at different starch contents were evaluated for their physical properties. The potato starch biopolymer with 2.0g showed the highest elasticity and transparency compared to the other samples. This difference is attributed to variations in the amylose and amylopectin content of each starch type. The thermal analysis results showed that the biopolymer sample with higher starch content has greater weight loss and lower thermal stability. Among the samples, potato starch biopolymers showed lower thermal stability compared to corn starch biopolymers, which may be attributed to their higher amylopectin content. The spectra of all samples showed similar functional groups, including C–O (1000–1300 $cm^{-1}$), C–H (700–900 $cm^{-1}$), C=O (1500–1800 $cm^{-1}$), C–H stretching (2800–3000 $cm^{-1}$), and O–H (3300–3500 $cm^{-1}$). The presence of the O–H group confirms amylose and amylopectin structures. The addition of glycerol introduced C=O groups associated with ester formation and slightly changed the intensity of certain peaks. These findings provide insight into how starch type and formulation composition influence the properties and stability of starch-based biopolymers, supporting their potential development as an environmentally friendly alternative material.

## 1. Introduction

Recently, growing researchers are focusing on areas of research to decrease the pollution that comes from synthetic bioplastics, which strongly affect the environment. There are 19-23 million tons of plastic found in aquatic environments every year, and it is one of the factors affecting aquatic ecosystems [1][2]. One of the common natural polymers that has been used in recent years is biopolymers. Biopolymers are one of the types of polymers that can be synthesized naturally by living organisms.

In this study, corn starch and potato starch are used as raw materials to create a biofilm polymer. Corn starch and potato starch are natural biopolymers that are in the same group as starch polymers. The presence of amylopectin and amylase in starch enhances the characteristics of the polysaccharide [3]. The properties of corn

and potato that are low cost, renewable, low toxicity, and biodegradable make it one of the highest sources of production of biopolymers [4]. The high content of amylose in potato will increase the mechanical and barrier characteristics of starch properties. Potato has also been used in the production of disposable tableware and agricultural films [5]. With all the characteristics of potato and corn, make it suitable for producing biodegradable polymer.

One of the important factors to focus on when producing biopolymers is their degradation to make sure the polymers are easily degraded without harming the environment [6]. This study is focused on evaluating and understanding the thermal degradation and the chemical properties of the sample. Thermogravimetric Analysis (TGA) was utilized to evaluate the thermal degradation, while the Fourier Transform Infrared Spectroscopy (FTIR) was used to identify the functional group and their chemical composition [8]. The samples that were analysed are biopolymers produced from potato and corn starch.

## 2. Materials and Methods

### 2.1 Material

Potato and corn starch were brought from a local grocery, glycerol and acetic acid were supplied from Merck, and distilled water was used to create a biopolymer

### 2.2 Preparation of Potato Starch and Corn Starch as Biopolymers

Fig. 1 with 1.5 g, and 2.0 g of potato and corn starch were individually mixed and stirred with 25ml of distilled water until the starch dissolved. Then, 1.7 ml of acetic acid and 2.7ml of glycerol were added to the solution. Each solution was heated up to $85^0$ c for 45 minutes. After 45 minutes, the solutions were poured into 10ml petri dishes and later were dried in the oven at $55^0$ for 24 hours. All the procedures were shown in Fig. 2. Then, the samples were characterized through the Thermogravimetric Analysis brand (TA instrument) model (Discovery TGA 550) and Fourier Transform Infrared Spectroscopy (FTIR) (spectrum two), (Perkin Elmer, USA). For TGA analysis, the samples were classified as follows: potato starch samples were labelled (a) for 2.0 g and (b) for 1.5 g, while corn starch samples were labelled (c) for 2.0 g and (d) for 1.5 g. For FTIR analysis, the raw potato starch, corn starch, and synthesized biopolymers were compared.

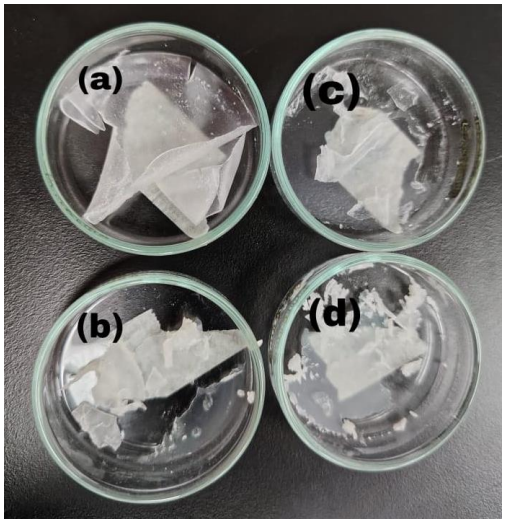


**Fig. 1** Biopolymer: (a) Potato starch 2.0 g, (b) potato starch 1.5 g, (c) corn starch 2.0 g, and (d) corn starch 1.5 g

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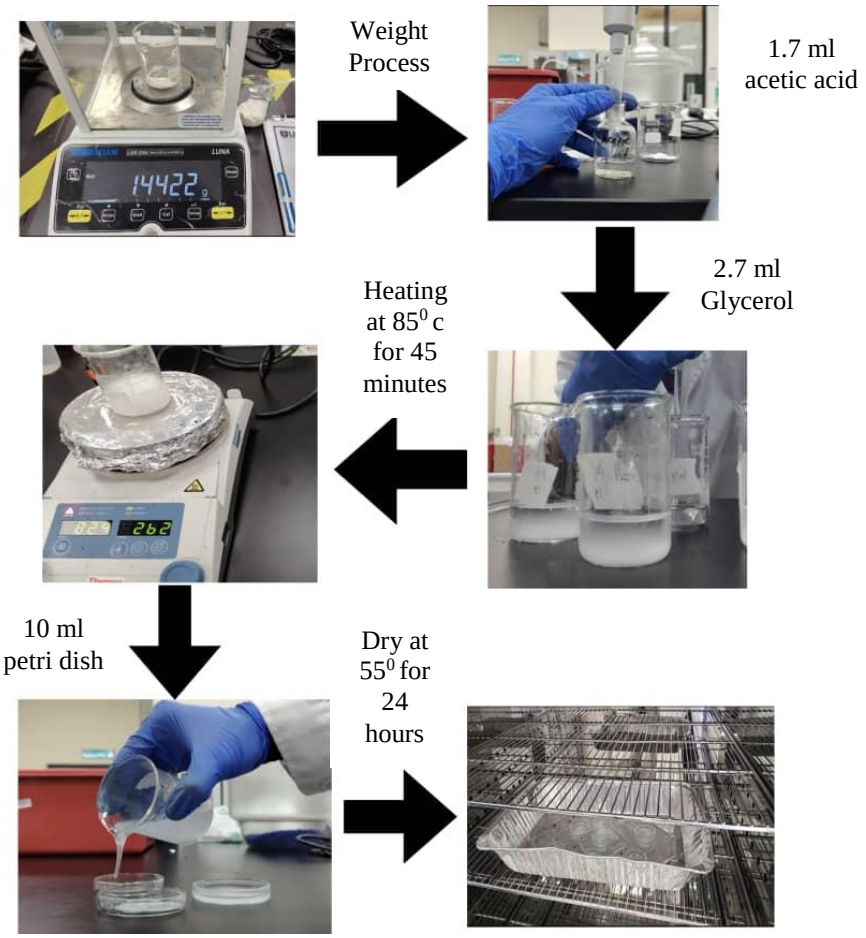


**Fig. 2** Flow diagram of biopolymer preparation

## 3. Result and Discussion

### 3.1 Characteristic Biopolymer

The biopolymer, which is potato starch 2.0 g, is the most elastic and more transparent biopolymer compared to the other polymers. The reason potato starch is more elastic is that the amount of amylose, phosphorus, and moisture content in both starches is different. Furthermore, the percentage contain for amylose, amylopectin, phosphorus, and moisture are shown in Table 1 for each starch [9] [10]. The amylose content is crucial because it increases the stiffness and gel strength; due to this, potato starches are more elastic because the amylose content is lower compared to corn starch [9]. Previous study [11] shows that increasing phosphorus in the influent increases the storage modulus (G').

**Table 1** Percentage content

| Type of Starch | Amyloses content | Amylopectin content (100 – Amylose) | Phosphorus content | Moisture content |
|---|---|---|---|---|
| Potato | 20.5% | 79.5% | 0.043% | 15.1% |
| Corn | 24.8% | 75.2% | 0.020% | 11% |

### 3.2 Thermogravimetric Analysis

Based on Fig. 3, the thermogravimetric analysis (TGA) results for each biopolymer degradation stage are summarized in Table 2. Three degradation stages were observed. The first degradation stage occurred between 25°C and 125°C, with an average weight loss of approximately 20–24%, mainly associated with moisture evaporation. The second degradation stage, which represents the main decomposition of the biopolymer, occurred below 260°C and showed an average weight loss of 34–49%. This stage exhibited the most significant weight loss due to the cleavage and breakdown of the polymer backbone. The final degradation stage occurred

above 250°C, with an average weight loss ranging from 4–39%. At this stage, the biopolymer underwent pyrolysis and gradually converted into carbon residue [5]. The results indicate that corn starch biopolymers have higher crystallinity compared to potato starch biopolymers, as they require higher temperatures for degradation. Differences in starch content (2.0 g and 1.5 g) also influenced the degradation behaviour, with biopolymers containing 2.0 g of starch requiring slightly higher temperatures to degrade than those containing 1.5 g. Variations in amylose and amylopectin composition contributed to differences in crystallinity and mechanical strength of the biopolymers [5] [10].

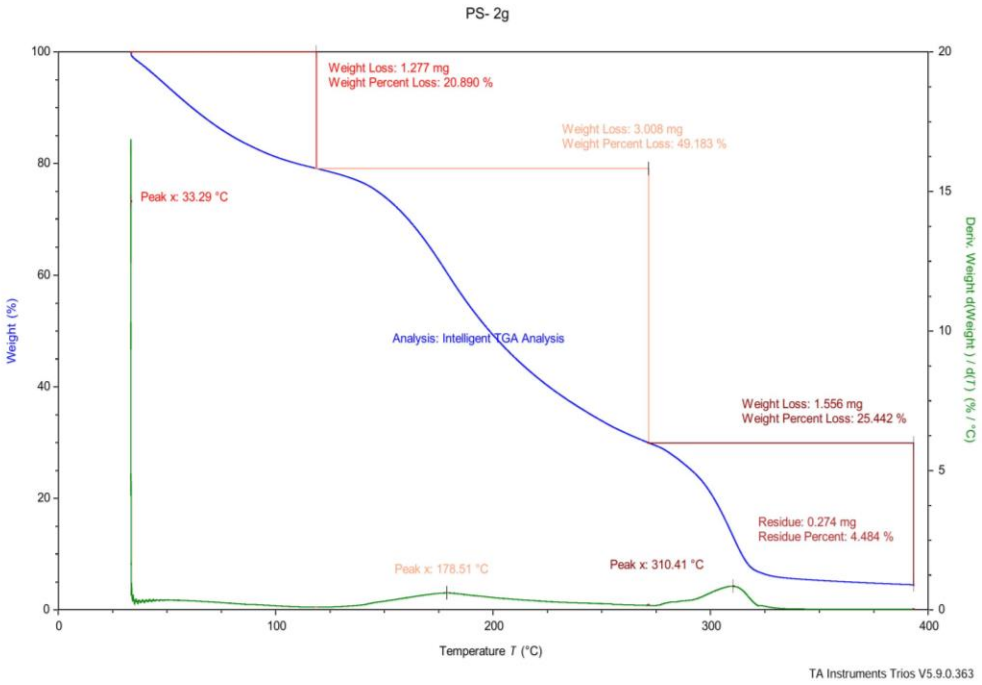


**Fig. 3** TGA result for potato starch 2.0 g

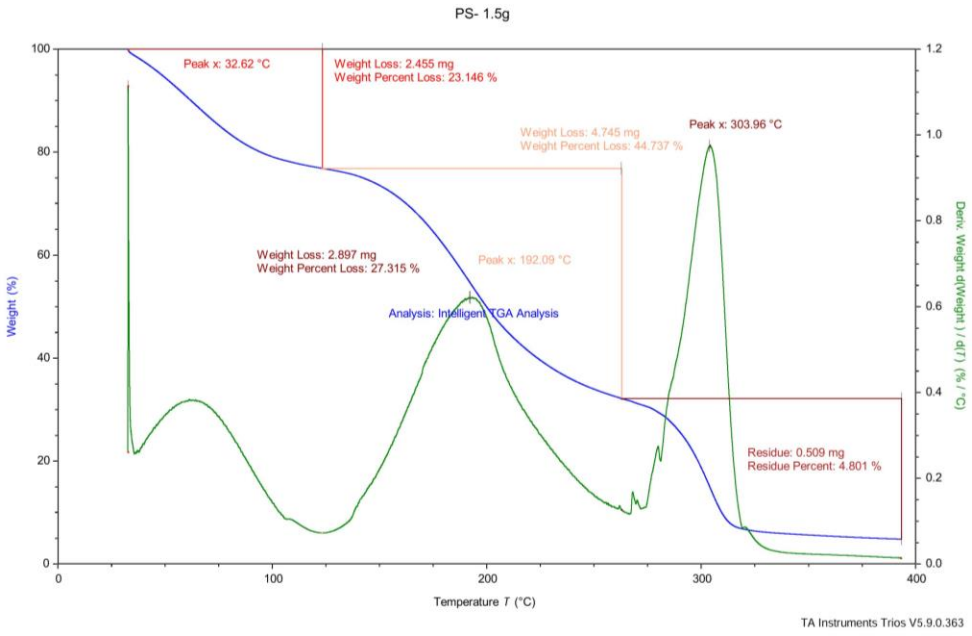


**Fig. 4** TGA result for potato starch 1.5 g

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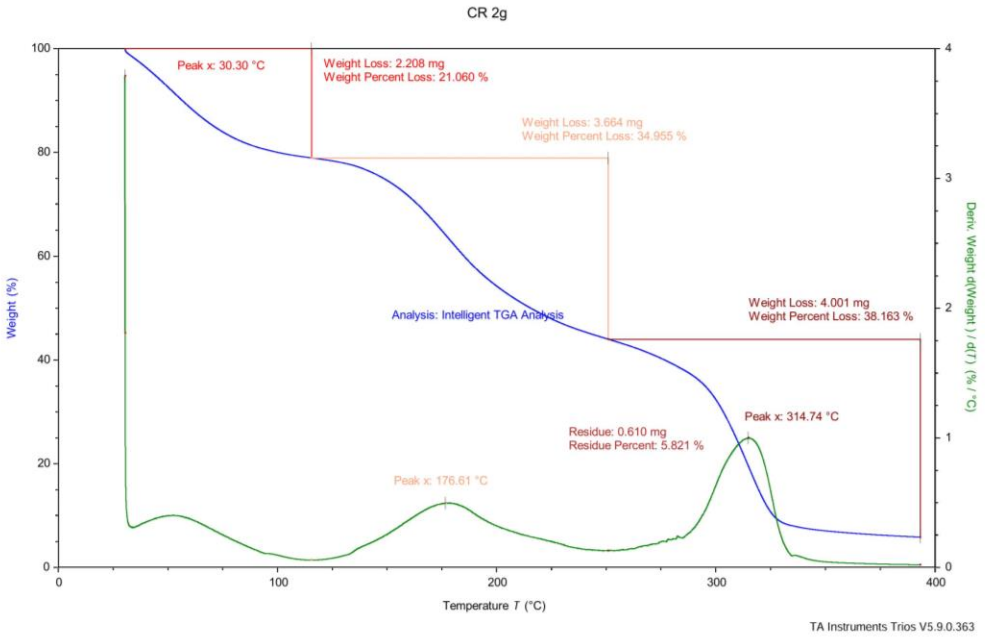


**Fig. 5** TGA result for corn starch 2.0 g

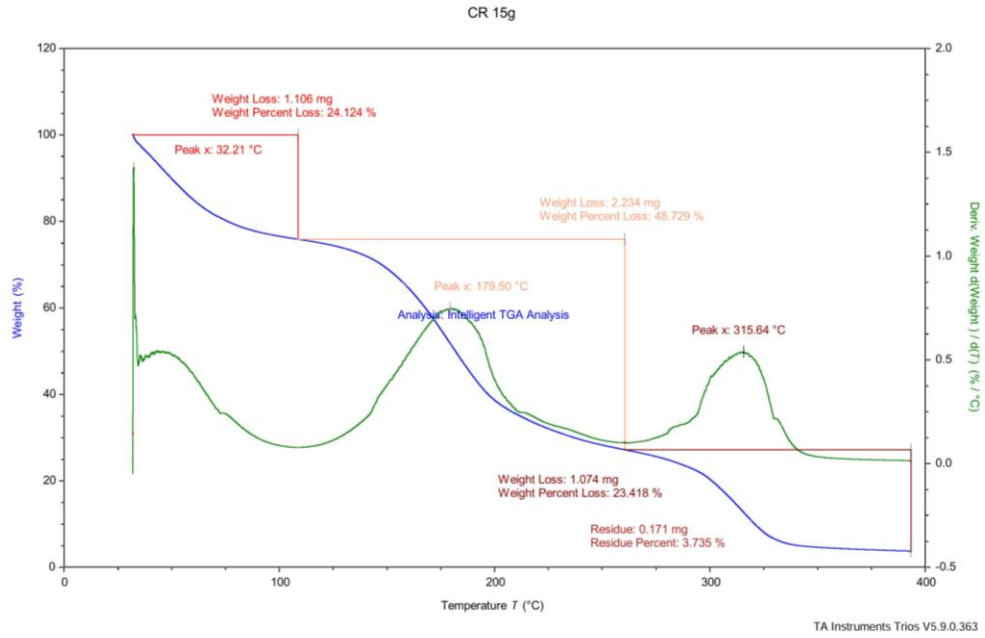


**Fig. 6** TGA result for corn starch 1.5 g

**Table 2** TGA result

| Type of biopolymer | Weight percent loss % (First degradation) | Weight percent loss % (second degradation) | Weight percent loss % (third degradation) |
|---|---|---|---|
| Potato starch biopolymer 2g | 20.890% | 49.183% | 25.442% |
| Potato starch biopolymer 1.5g | 23.146% | 44.737% | 27.315% |
| Corn starch biopolymer 2g | 21.060% | 38.163% | 25.442% |
| Corn starch biopolymer 1.5g | 24.124% | 48.729% | 23.418% |

## 3.3 Fourier Transform Infrared Spectroscopy

Fig. 4 presents the comparison of Fourier transform infrared spectroscopy (FTIR) spectra and the functional groups present in both the raw starch and the corresponding biopolymers. The analysis compares the biopolymer samples with their respective raw corn starch and corn starch. The FTIR spectra show that all four samples exhibit similar functional groups. A medium sharp peak observed at 1000–1300 $cm^{-1}$ corresponds to C–O stretching. A small sharp peak at 700–900 $cm^{-1}$, a very weak peak at 1500–1800 $cm^{-1}$, a small broad peak at 2800–3000 $cm^{-1}$, and a broad peak at 3300–3500 $cm^{-1}$ were also detected. The broad peak at 3300–3500 $cm^{-1}$ represents the O–H (hydroxyl) group, which is associated with amylose and amylopectin in both starches. The addition of glycerol as a plasticizer introduced C=O groups related to ester formation and increased the intensity of C–O–C and O–H bands. Acetic acid also contributed to the increased intensity of the C=O peak. Furthermore, changes in C–H and C–O intensities were influenced by the presence of water and the heating and drying processes, which reduced the moisture content of the biopolymer. Slight differences in peak broadness between potato starch and corn starch biopolymers indicate variations in amylose and amylopectin composition. The presence of C–O–C, C–H, and C–O groups confirm the glycosidic linkages in all samples [5] [8] [11].

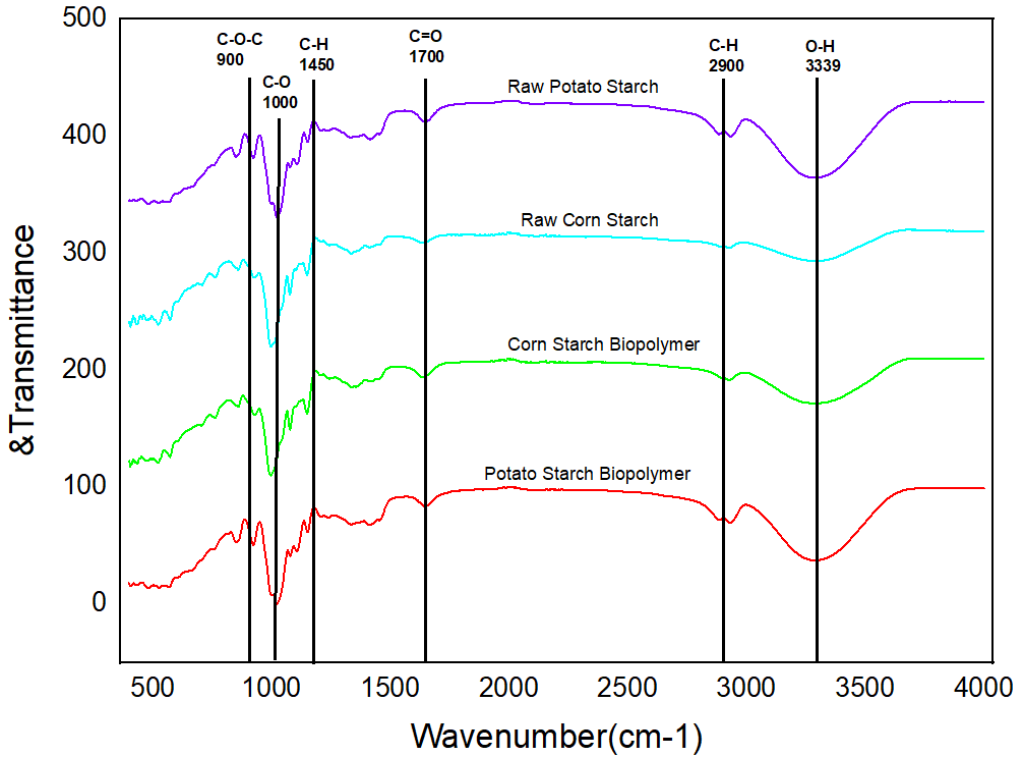


**Fig. 7** FTIR analysis

## 4. Conclusion

In conclusion, biopolymers based on potato starch and corn starch were successfully prepared and characterized. Among all samples, the biopolymer containing 2.0 g of potato starch exhibited the highest elasticity and transparency, which can be attributed to differences in amylose and amylopectin composition. TGA analysis confirmed distinct degradation behaviours for each sample. Biopolymers with higher starch content (2.0 g) required slightly higher temperatures to initiate degradation and generally exhibited higher weight loss percentages compared to the 1.5 g samples. This indicates that starch content influences crystallinity and mechanical strength of the biopolymer. FTIR analysis further revealed that biopolymers showed higher intensity peaks compared to raw starch. This increase in peak intensity is attributed to the addition of glycerol, acetic acid, and water, as well as the heating and drying processes, which altered the moisture content and enhanced functional group interactions. Overall, the study confirms that starch type and concentration significantly affect the structural and thermal properties of the resulting biopolymers.

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## Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of the paper.

## Author Contribution

*The authors confirm contribution to the paper as follows:* ***study conception and design:*** *Mohamad Syahrul Kabir;* ***data collection:*** *Mohamad Syahrul Kabir;* ***analysis and interpretation of results:*** *Mohamad Syahrul Kabir;* ***manuscript preparation:*** *Mohamad Syahrul Kabir, Saliza Asman. All authors reviewed the results and approved the final version of the manuscript.*

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