Preliminary studies on mechanical and physical properties for corn starch blended with glycerol

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Keywords: corn starch; glycerol; tensile strength

ABSTRACT – This study aims to investigate the mechanical and physical behavior of biodegradable corn starch blended with three different weightage of glycerol for 30, 35 and 40 (wt%). The blend of corn starch and glycerol were prepared by using hot press mold at 165ºC at 15 min duration. The related tests such as tensile, density and microstructure analysis used Scanning Electron Microscope (SEM) have been performed to characterize their mechanical and physical properties. It is observed that an existence of glycerol in the blend has increased the corn starch tensile properties (tensile strength). The result shown that corn starch with 30 (wt%) glycerol loading recorded the highest tensile strength. Higher loading of glycerol 40 (wt%) has resulted in slight decrease in tensile strength value. The physical test also shown a positive finding with 30 (wt%) of glycerol loading. As observed from experiment, the addition of glycerol (up to 30%) in corn starch has significantly enhanced mechanical and physical properties of corn starch. This finding shows the potential application of this biodegradable material to array of consumer applications such as container, tray, packaging and etc.

1. INTRODUCTION

Plastic or chemical material that made from petroleum based material polymer has brought to negative environmental impact which causes accumulation of non-biodegradable waste. They have been used in mass scaling basis, low cost, light weight, and possess fine mechanical properties [1]. However, these materials have some disadvantages due to the fact that they were processed from a non-renewable supply and not suitable for biodegradable [2-3].

In recent years, research across globe are discussing on environmental awareness with the recent environmental regulations and unsustainable consumption of chemical such as petroleum, has induced to the option of using environmentally eco-green materials [4]. Biopolymer composites are considered one of environmentally eco green materials that has practical properties as compared to synthetic fiber. Among these biopolymer materials, starch is one of the best substitute materials due to the availability, economic, non-toxic, biodegradable and renewable [5]. Zou et al. [6] reported that starch, which is a heterogeneous material, contains two microstructures namely are amylose and amylopectin. Amylose has a long linear chain structure of α-1,4 linked glucose units, whereas amylopectin has a large molecular weight and highly branched structures consists of much shorter chains of α-1,4 chains linked by α-1,6 bonds. In most cases of starch, it contains 20-30 % of amylose and 70-80 % of amylopectin. The ratio of the amylopectin to amylose in starch significantly enhanced the functional properties of the starch [7]. The most familiar type of starch used to produce biopolymer includes cassava, corn, potato, sago, and rice [8].

Corn also known as Maize is a large grain plant. Some of the corn production is used for corn starch (CS), corn syrup and other corn products such as animal feed and corn ethanol [9]. Corn starch has (72%) amylopectin and (28%) amylose content. Corn starch has comparable properties in terms of the amylose content which is higher than cassava (17%) and potato (25%) [10]. Based on literature [11], it is understood that the degree of polymerization efficiency depends on the content of amylose in the starch. Since it is simple, fast and cost effective, blending with other material is an alternative method to improve the properties of starch. An existence of plasticizer such as glycerol, water or sorbitol, starch undergoes spontaneous blend and will form of homogeneous melt [12].

The objective of this study is to investigate the effect of glycerol blended with corn starch on tensile strength, physical properties and morphological analysis. Three different ratios of weight percentage (wt%) of glycerol will be used to explore the influence on properties of corn starch blended with glycerol. Various experimental approaches will be used to characterize the properties of the blend including tensile testing, density and SEM analysis.

2. RESEARCH METHODOLOGY

Corn starch in powder form was used in this study. Corn starch powder and glycerol was procured from Polyscientific Enterprise Sdn. Bhd. The type of glycerol was Qrec G4018-1-2500.

2.1 Samples preparation

In this study, 5 samples are prepared for each

wt% loading of glycerol. All samples were prepared by using lab mixer to blend corn starch with glycerol. In order to change the property of the corn starch, different wt% loading of glycerol is added into the blend. As tabulated in Table 1 30, 35 and 40 and wt% loading of glycerol is added into the corn starch. To produce laminated plate with the thickness of 3 mm, the blend of corn starch and glycerol need to undergo a thermo-pressed. For this purpose, the blend was preheated process for 15 min and pressed for 15 min at the temperature of 165°C under the load of 20 kg/cm^2 by using Gotech (GT-7014-A30) hydraulic thermo-press machine.

Table 2.1 Composition corn starch and glycerol based on the weight percentage (wt%) loading

Blend	Glycerol (wt%)	Corn Starch (wt%)
1	30	70
2	35	65
3	40	60

2.2 Tensile Testing

Tensile tests were conducted according to ASTM D 3039: Standard Test Method for Tensile Properties of Polymer Matrix Composite Materials. The tests were repeated five times where the dimensions of the specimen were 140 mm x 13 mm x 3 mm. The testing was conducted using Universal Testing Machine (Model HZ-1003) controlled with 1 kN load and operated at constant head-speed tests of 1 min/mm.

2.3 Density

Digital electronic densimeter (MD-300S) was used to measure the density of the sample. Five samples for each mixture were used and the average value was calculated.

2.4 Scanning Electron Microscope (SEM)

The scanning electron microscope (SEM) model JEOL, JSM 6010 PLUS/LV with an acceleration voltage of 8 kV has been utilized to observe the morphological of tensile fractured surfaces. The specimen was coated out with platinum before observed under SEM because the specimen was nonconductive material.

3. RESULTS AND DISCUSSION

3.1 Mechanical Properties

The effect of glycerol addition on the tensile strength was illustrated in Figure 3.1. The result of tensile strength showed significant improvement with decreasing glycerol loading (wt%) into the blend. It was noticed that the decreasing loading of glycerol tended to cause a higher tensile strength of corn starch. Highest tensile strength was obtained from the corn starch with added by 30 (wt%) glycerol. On the other hand, at higher loading of glycerol 40 (wt%), the tensile strength was slightly decreased.

Furthermore, higher value of tensile strength of this blend might due to two reasons. Firstly, the amylose content exists in the corn starch itself and secondly is the quantity of plasticizer added to the blended with the corn starch. Based on the [13], the amylose content in corn starch (28%) is higher than cassava (17%), potato (20–25%), rice (20%), and waxy rice (5%). Prachayawarakorn et al notice that with higher amylose content exists in the blend, it will cause a higher degree of polymerization [13]. Therefore, Prachayawarakorn et.al also revealed that the quantity of plasticizer has an influence to the value of tensile strength. Finally, the different processing technique and parameters that are used to fabricate the sample is another factor that affects the dissimilarity of mechanical properties results obtained in this study.

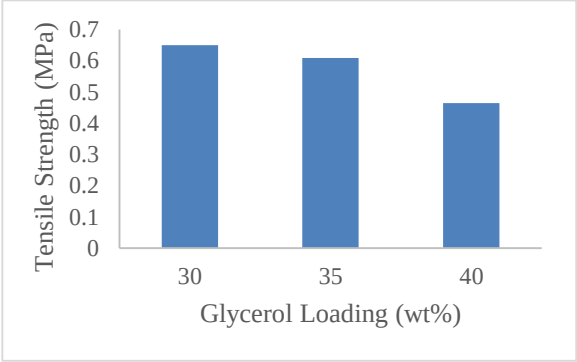


Figure 3.1 Tensile strength of corn starch blended with glycerol

3.2 Density

The density result of corn starch blended with glycerol is shown in Table 3.2. Overall, by decreasing of glycerol loading (wt%) slightly will increase the value of density. The blend for 40 loading (wt%) of glycerol show the lowest density result between others blend which is 1.3634g/cm3.

Table 3.2 Density result for different blend

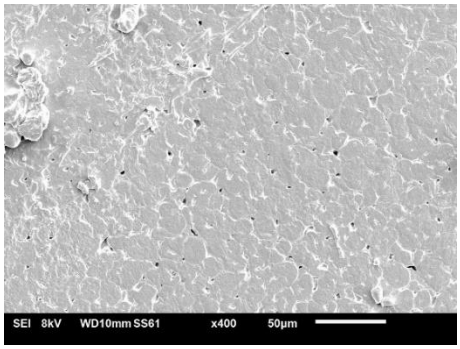
Sample	(wt%) loading		
	30	35	40
1	1.395	1.379	1.368
2	1.395	1.368	1.361
3	1.389	1.365	1.362
4	1.391	1.385	1.367
5	1.374	1.379	1.359
Average	1.3888	1.752	1.3634

Moreover, the blend which has the lowest glycerol loading (wt%) show the highest density. Based on this outcome, it can be related with the properties and structure of the corn starch itself, which has affected the increasing of the density value. The corn starch content in the blend is directly proportionate to the density value. From this finding, it can be concluded that, the existing of glycerol in the blend will affect the value of density.

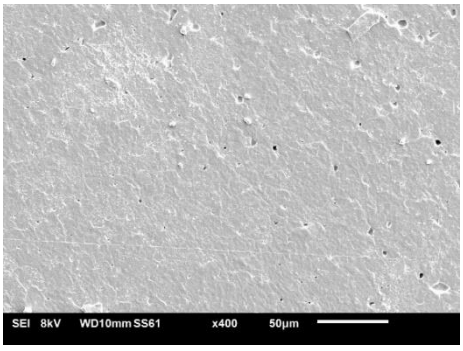
3.3 Morphological analysis

Scanning electron microscopy (SEM) was utilized to investigate the surface morphology. The scanning electron microscopy allowed an overview of the structure behavior of the corn starch blended with different ratio of

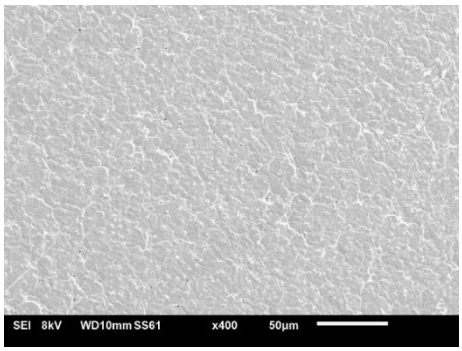
glycerol (wt%) loading. R. Jumaidin et. al. states that in the blend, the starch granules should break down and formed a continuous phase with glycerol [1]. Figure 3.3 shows that the corn starch and glycerol form a homogeneous surface between each other with minimum of clusters exists. The combination of glycerol into corn starch, has resulted in the blends having a smooth surface which shows good interaction between corn starch and glycerol with minimum existence of cluster for loading 40 (wt%). However, for loading 35 (wt%) clearly show little bit of clusters that occurs in the blend. The numbers of clusters increased for the blend is 30 (wt%). This outcome indicates that the blended has higher loading (wt%) of glycerol show a minimum of clusters rather than the lowest loading (wt%) of glycerol. This is due to the glycerol used in this research is in liquid form, so when the higher loading (wt%) of glycerol, the homogeneous composition is easy to formed.



(a)



(b)



(c)

Figure 3.3 Morphological image of (a) 30 wt%, (b) 35 wt% and (c) 40 wt% for corn starch blended with glycerol

4. SUMMARY

In this study, biopolymer matrix from blended corn starch and glycerol were successfully prepared via lab mixer and hot pressing machine. The results demonstrated that corn starch and glycerol were compatible when blend together. The addition of glycerol (up to 30wt%) in the blend has increased the tensile strength and density value of corn starch. Corn starch blended with 30 wt% glycerol shows the highest value of tensile strength which lies between others blend. Meanwhile, corn starch blended with 40 wt% glycerol constantly depicted lowest result on tensile strength and density. From this finding, it is concluded that corn starch blended with 30 wt% glycerol has huge potential to be a good biopolymer matrix. Besides that, it can also be used to reinforce with natural fiber from various sources such as pineapple leaf fiber, kenaf, banana leaf, bamboo, coconut and etc to form a fully biodegradable composite.

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