Studies on the Solubility of Polymers Carrying Plastic Bags and Preparation of Wheat Starch PVA Blend Film

Pa Pa San
Department of Chemistry
Yadanabon University
papasan1771@gmail.com

Thandar Win
Department of Chemistry
Kyaukse University

Abstract

Plastic can cause damage to the environment. Plastics are not easily broken down by micro-organisms and therefore most are not biodegradable. This leads to waste disposal problems. When plastics burn, they can produce toxic gases such as carbon monoxide, hydrogen cyanide and hydrogen chloride. In this research work, "Top Choice" carrying plastic bag sample (S_1) and "D" carrying plastic bag sample (S_2) were collected from Mingalar market, Chan Aye Thar Zan Township, Mandalay. The solubility of plastic samples was investigated. For the solubility tests, the organic solvent such as n-hexane, toluene, benzene, ethyl acetate, dichloromethane, ethanol and methanol were chosen. Starch was extracted from wheat flours. The blend films with starch and polyvinyl alcohol were prepared by casting method. Glycerol was used as plasticizer. The different amount of solvent (water), starch and glycerol were investigated to get the optimum condition. Biodegradability of the prepared film was tested by water absorption test, moisture absorption test and soil burial test.

Keywords: Wheat Flour Starch, Plasticizers, Biodegradable Polymer, Polyvinyl alcohol

1. Introduction

All living things contain polymers just like proteins. Most of the things, people daily uses are polymers such as clothes, household items, home supply and polymer are included all kinds of matter in our surrounding. Polymers are large organic macromolecules made by linking together repeating units of small molecules called monomers. Nowadays, people are using synthetic polymers instead of using natural polymers. They are the members of organic polymers, while others are inorganic. Both of these groups of polymers play a very important role in our lives. Using polymers are cheap and easy to make. Polymers are very durable and flexible. [1]

Plastics, mostly used in today, are included in organic polymers. But they often contain other substance. They are usually synthetic, most commonly derived from petrochemicals, but many are partially natural. Plastics could be made by chemical changing natural polymers. All plastics were soft and moldable during their production. [3]

Plastic rubbish is a common but unwelcome sight around the world. Over the past 30 years, plastics have taken over as replacement materials in many applications. This is not surprising because they are light, cheap and corrosion-resistant, and they can be easily molded and dyed bright colors. [4]

Therefore, research should carry out to produce plastics that are biodegradable or photodegradable. But, it is very difficult to recycle plastics because each type of plastic has different properties and so different recycling methods may be needed for each plastic.The aim of the present work is to investigate the solubility of plastic sample and prepare the biodegradable polymer film. [3]

2. Materials and Methods

2.1. Sample Collection

"Top Choice" carrying plastic bag sample (S_1) and "D" carrying plastic bag sample (S_2)were collected from Mingalar market, Chan Aye Thar Zan Township, Mandalay, and they were cut into pieces (2" × 2").

Figure 1."Top Choice" carrying plastic bag sample (S_1)

Figure 2."D" carrying plastic bag sample (S_2)

2.2. Examination of Solubility of Samples in Various Solvents by Stirring Method

Procedure

The plastic sample (S_1) was weighed and put into the beaker. 20 mL of n-hexane was added into the beaker. The mixture was stirred by the magnetic stirrer for 30 min at room temperature and then taken out from the beaker. The sample was dried by a dryer and weighed. The procedure was repeated four times to get total time taken five hours.

Similarly, the same procedure was performed for other selected solvents such as toluene, benzene, ethyl acetate, dichloromethane, ethanol and methanol. For

other sample S_2, the similar procedure was done as mentioned for S_1.

2.3. Examination of the Solubility of samples in Various Solvents by Standing Method

Procedure

The plastic sample was weighed and put into the beaker. 20 mL of n-hexane was added into the beaker and allowed for 5 hours. After five hours, the sample was taken out from the beaker and dried by a dryer and weighed. Similarly, the same procedure was performed for other selected solvents such as toluene, benzene, ethyl acetate, dichloromethane, ethanol and methanol. For other sample S_2, the similar procedure was done as mentioned for S_1.

2.4. Extraction of Wheat Flour Starch

Starch

Starch is a white, granular, organic chemical that is produced by all green plants. Starch is manufacture in the green leaves of plants from excess glucose produced during photosynthesis and serves the plant as a reserve food supply. In humans and other animals, starch is broken down into its constituent's sugar molecules, which then supply energy to the tissues. Most commercial starch is made from corn, although wheat and potato starch are also used. [5]

Wheat Starch

Wheat starch is a product from wheat flour produced by removing the proteins including gluten. Wheat starch is used as thickening agent and stabilizer in gravies and processed foods. It is also used as an ingredient in food sweeteners such as glucose syrup. [5]

Procedure

Wheat flour (10 g) and 100 mL of water were put into the beaker and the mixture was heated for 15 minutes. If it was pasty, it was squeezed in a two-layered cotton cloth and the filtrate was centrifuged. The residues were put into a petridish and dried.

2.5. Preparation of Wheat Starch Film without Plasticizer

Plasticizers

A plasticizer is an organic compound that dissolves in the polymer, lowering the attractions between the polymer chains. They are any of a number of substances added to materials in order to modify their physical properties. Their uses include softening and improving the flexibility of plastics and preventing dried paint coatings from becoming too brittle. Plasticizers help to reduce a coating's surface tension. Water is the main plasticizer. Other less volatile plasticizers are glycerol, sugar, alcohols, non-ionic and anionic surfactants. [1]

Procedure

Polyvinyl alcohol (1 g) and 0.1 g of wheat flour starch were put into the beaker. Then, 20 mL of water was added into the beaker and stirred with magnetic stirrer for 45 minutes at 50°C with 500 rpm. And then, the solution was poured into the glass plate (4" × 4") and dried in air for two days.

2.6. Preparation of Wheat Starch Blend Film

Polyvinyl alcohol

Polyvinyl alcohol is a water-soluble synthetic polymer. It is used in papermaking, textiles, and a variety of coatings. Polyvinyl alcohol has excellent film forming, emulsifying and adhesive properties. It is also resistant to oil, grease and solvents. It has high tensile strength and flexibility. [1]

Polyvinyl alcohol (1 g) and 20 mL of water were put into a beaker. 0.1 g of flour starch was added into the mixture. The solution was stirred at 50°C and 1.5 g of glycerol was added after 15 minutes. The solution was stirred again for half an hour. Therefore, total time taken was 45 minutes. Then, the solution was poured into the glass plate to prepare biodegradable film. To determine the optimum condition, 20 mL, 25 mL and 30 mL of water were used as the solvent. The different amount of plasticizer, glycerol, were used to select the optimum condition.

2.7. Biodegradability of Wheat Starch Blend Films

Biodegradable Polymers

Biodegradable materials are used in packaging, agriculture, medicine and other areas. In recent years there has been an increase in interest in biodegradable polymer. Two classes of biodegradable polymers can be distinguished: synthetic or natural polymers. [1]

Procedure

The biodegradability of the wheat starch blend films were investigated by soil-burial test. The wheat starch blend films were introduced into the soil (one feet depth). Total time of biodegradation was two weeks. The influence of microbial action on the biodegradability were studied daily.

2.8. Soaking in Water (Wheat Starch Blend Film)

The weight of each wheat starch blend film was measured and dried in a desiccator until the weight become constant. Then the sample was soaked in water for one weeks at room temperature and the biodegradation level was shown in figure 3.

Figure 3.Biodegradation of wheat starch blend **film by Soaking in water**

2.9. Water Absorption Test

The weight of each wheat starch blend film was measured and soaked in water at room temperature. After 60 minutes, the sample was taken out, dried and weighed. The water absorption capacity was calculated from the final weight of the film relative to that of the original film sample. The results are shown in Table 9.

2.10. Moisture Absorption Test

The wheat starch blend film samples were dried in a desiccator unit their weights become constant, W1. These samples were then placed in normal atmosphere for 24 hours. After that, the samples were weighed, W2 and the percentage of moisture absorption (% M) can be calculated from the following equation.
The results are shown in Table 9.

$$\% M = \frac{W_2 - W_1}{W_1} \times 100$$

3. Results and Discussion

The solubility of plastic samples (S_1, S_2)were analyzed by using different solvents such as n-hexane, toluene, benzene, ethyl acetate, dichloromethane, ethanol and methanol. Stirring method and standing method were used. The results were described in Table(1-6).

Table 1. Solubility of plastic sample S_1 for n-hexane

Sam-ple	Time (minute)	Stirring		Standing	
		Weight of plastic sample (g)	Solubility (%)	Weight of plastic sample (g)	Solubility (%)
S1	0	0.0402	-	0.0426	-
	30	0.0401	0.2488		
	60	0.0401	0.2488		
	90	0.0401	0.2488		
	120	0.0400	0.4975		
	150	0.0400	0.4975		
	180	0.0400	0.4975		
	210	0.0400	0.4975		
	240	0.0400	0.4975		
	270	0.0400	0.4975		
	300	0.0400	0.4975	0.0425	0.2347

Table 2. Solubility of plastic sample S_1 for toluene

Sample	Time (minute)	Stirring		Standing	
		Weight of plastic sample (g)	Solubility (%)	Weight of plastic sample (g)	Solubility (%)
S1	0	0.0402	-	0.0402	-
	30	0.0400	0.4972		
	60	0.0400	0.4972		
	90	0.0400	0.4972		
	120	0.0400	0.4972		
	150	0.0400	0.4972		
	180	0.0400	0.4972		
	210	0.0400	0.4972		
	240	0.0400	0.4972		
	270	0.0400	0.4972		
	300	0.0400	0.4972	0.0400	0.4975

Table 3.Solubility of plastic sample S_1 for methanol

Sample	Time (minute)	Stirring		Standing	
		Weight of plastic sample (g)	Solubility (%)	Weight of plastic sample (g)	Solu-bility (%)
S1	0	0.0397	-	0.0400	-
	30	0.0397	0		
	60	0.0397	0		
	90	0.0397	0		
	120	0.0397	0		
	150	0.0397	0		
	180	0.0397	0		
	210	0.0397	0		
	240	0.0397	0		
	270	0.0397	0		
	300	0.0397	0	0.0400	0

Table 4. Solubility of plastic sample S_2 for n-hexane

Sample	Time (minute)	Stirring		Standing	
		Weight of plastic sample (g)	Solubility (%)	Weight of plastic sample (g)	Solu-bility (%)
S_2	0	0.0483	-	0.0490	-
	30	0.0483	0		
	60	0.0483	0		
	90	0.0482	0.2070		
	120	0.0482	0.2070		
	150	0.0482	0.2070		
	180	0.0482	0.2070		
	210	0.0482	0.2070		
	240	0.0482	0.2070		
	270	0.0482	0.2070		
	300	0.0482	0.2070	0.0489	0.2041

Table 5. Solubility of plastic sample S_2 for toluene

Sam-ple	Time (minute)	Stirring		Standing	
		Weight of plastic sample (g)	Solu-bility (%)	Weight of plastic sample (g)	Solu-bility (%)
S_2	0	0.0465	-	0.0485	-
	30	0.0464	0.2151		
	60	0.0464	0.2151		
	90	0.0464	0.2151		
	120	0.0463	0.4301		
	150	0.0463	0.4301		
	180	0.0463	0.4301		
	210	0.0463	0.4301		
	240	0.0463	0.4301		
	270	0.0463	0.4301		
	300	0.0463	0.4301	0.0483	0.4124

Table 6.Solubility of plastic sample S_2 for methanol

Sample	Time (minute)	Stirring		Standing	
		Weight of plastic sample (g)	Solubility (%)	Weight of plastic sample (g)	Solubility (%)
S_2	0	0.0488	-	0.0488	-
	30	0.0488	0		
	60	0.0488	0		
	90	0.0488	0		
	120	0.0488	0		
	150	0.0488	0		
	180	0.0488	0		
	210	0.0488	0		
	240	0.0488	0		
	270	0.0488	0		
	300	0.0488	0	0.0488	0

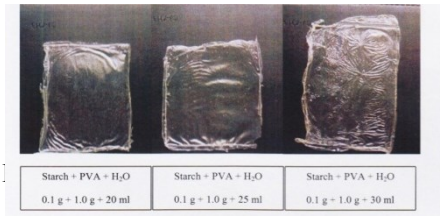
Table 7. Result of solubility of plastic bag sample (S_1 and S_2) with various solvents for standing and stirring method

Solvent	S_1		S_2	
	Stirring	Standing	Stirring	Standing
n-hexane	0.2488% – 0.4975%	0.2347%	0.2070%	0.2041%
toluene	0.4975%	0.4975%	0.2151% – 0.4301%	0.4124%
benzene	0.4902%	0.4963%	0.4566%	0.4228%
ethylacetate	0.2410%	0.2347%	0.2410%	0.2381%
dichloro-methane	0.4938%	0.5063%	0.4739%	0.4796%
ethanol	0.2381%	0.2404%	0.4902%	0.4494%
methanol	insoluble	-	insoluble	-

According to Table 7, for sample S_1 and S_2, the plastic polymer samples were found to be very slightly soluble in selected organic solvents. Therefore, for preparing biodegradable polymer, water soluble polyvinyl alcohol chosen for the study.

Table 8. Determination of optimum value of water

No	Wheat Starch (g)	Polyvinyl alcohol (g)	Water (ml)
1.	0.1	1.0	20
2.	0.1	1.0	25
3.	0.1	1.0	30



It was seen that the optimum value of water for the preparation of biodegradable polymer was found to be 30 mL .

starch: polyvinyl alcohol: glycerol for different amount of water
0.1g: 1g: 1.5g (0.1: 1: 1.5 wt. ratio)

Figure5. Wheat starch blend film

starch: polyvinyl alcohol: glycerol for different amount of water
0.1g: 1g:3g (0.1: 1: 3 wt. ratio)

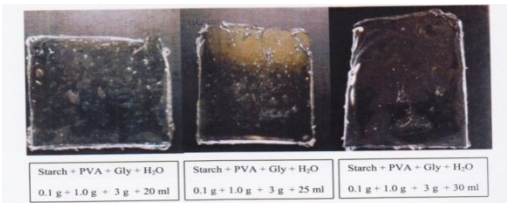


Figure 6. Wheat starch blend film

starch: polyvinyl alcohol: glycerol for different amount of water
0.1g: 1g :4.5g (0.1: 1: 4.5 wt. ratio)

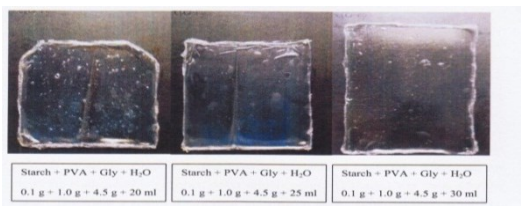


Figure 7. Wheat starch blend film

Table 9. Characteristics of Biodegradable wheat starch blend film

Sr. No.	Test	Biodegradable wheat starch blend film					
		A_1	A_2	A_3	B_1	B_2	B_3
1	Water Absorbance g (water uptake) g/ (film)	3.10	3.08	3.53	3.21	3.73	3.84
2	Moisture Absorptic(%)	2.23	1.88	2.90	2.37	3.28	3.42

A1 = starch 0.1 g + PVA 1.0 g + Gly 1.5 g + H_2O 25 mL
A2 = starch 0.1 g + PVA 1.0 g + Gly 3 g + H_2O 25 mL
A3 = starch 0.1 g + PVA 1.0 g + Gly 4.5 g + H_2O 25 mL
B1 = starch 0.1 g + PVA 1.0 g + Gly 1.5 g + H_2O 30 mL
B2 = starch 0.1 g + PVA 1.0 g + Gly 3 g + H_2O 30 mL
B3 = starch 0.1 g + PVA 1.0 g + Gly 4.5 g + H_2O 30 mL

3.1. Soil Burial Test of wheat starch blend film

Biodegradability of the prepared blend film was tested by soil burial method. From Figure 8, it can be seen that the biodegradability of the prepare blend film increased with time.

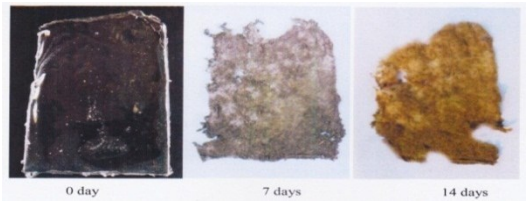


Figure 8. Wheat starch blend film

4. Conclusion

The plastic carrying bag samples, S_1 and S_2were collected from Mingalar market, Chan Aye Thar Zan Township, Mandalay. The solubility of plastic samples was investigated by using some organic solvents such as n-hexane, toluene, benzene, ethyl acetate, dichloromethane, ethanol and methanol. The selected polymer samples were found to be very slightly soluble in nonpolar organic solvents such as n-hexane, as ethyl acetate, dichloromethane and ethanol. However, samples S_1 and S_2 were insoluble in methanol. Therefore, for preparing biodegradable polymer, water soluble polyvinyl alcohol was chosen for the study. The wheat starch was extracted from wheat flour. Biodegradable blend film was prepared from polyvinyl alcohol and wheat starch. Glycerol was used as plasticizer. Biodegradable blend films were prepared by using different amount of starch and various amount of glycerol. Biodegradability of the prepared blend films were tested by water absorption test and moisture absorption test indicated the increasing the amount of glycerol and water content with increase water absorption and moisture absorption. Soil burial test of wheat starch blend films was also found that the biodegradability increased with time.

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