Physical Properties of Thermoplastic Starch Made from Tacca Leontopetaloides Extract

Muhammad Azizi bin Ab Wahab, Prof Madya Kamariah, En Mohibah

Faculty of Chemical Engineering, Universiti Teknologi Mara

Abstract – Usage of thermoplastic made from renewable sources from plants has been a focus in research in recent years due to the potential of the product being usable in variable of method and industries because it is biodegradable and is seen as one of the possible method of reducing the amount of waste in landfills. This research focuses on the physical properties of tacca leontopetaloides/ethylene thermoplastic blend properties which are the shear stress and tensile strength respectively.

Keywords- Tacca leontopetaloides, mechanical properties, Thermoplastic starch

I. INTRODUCTION

The call for renewable sources of plastic is caused by the amount of plastic waste that is non-biodegradable is being dumped into the landfills. In China, over half of the landfill is being occupied by the plastic waste (Zhou, Fang, Xu, Cao, & Wang, 2014). This coupled with the growing problem of petroleum shortage causes the need to find a renewable replacement for commodity plastic (Zhang, Wang, Zhao, & Wang, 2012)

Throughout the years, a lot of discoveries have been made that allows the production of plastics from renewable materials such as starch and cellulose, which are a product of agriculture that is easily available around the world. They are naturally carbohydrate polymers that can be easily processed from crops and has a low cost compared to the synthetic polymers. Starch are nowadays being researched as a replacement of synthetic polymers to make water soluble detergent and insecticide pouches, flushable liner bags and medical delivery system and devices. They can also be made into edible bags for soups and noodle ingredients(Fishman, Coffin, Konstance, & Onwulata, 2000). Cellulose is also has been used as reinforcement in plastic materials as it is the alternative and is made and used in automotive components, aerospace parts, sporting goods and building industry (Jumaidin, Sapuan, Jawaid, Ishak, & Sahari, 2017).

Bioplastics are plastic products that contains polymers that are made from natural resources in a certain controlled environment. By adding these materials, it also helps in addressing one of the problems of synthetic plastics which are degradability. For regular plastics, they are expected to last for a long time and this property is one of the reasons why landfills are filling up in a faster rate. They are not able to degrade naturally without any outside intervention. Bioplastic such as thermoplastic made from starch (TPS) and polylactic acid (PLA) can degrade naturally and is seen as the solution in controlling the amount of plastic waste produced by the population.

Past studies have shown that thermoplastic starch, while it is certainly renewable and do not cost a lot to reproduce, it has several major flaws that was recorded, mainly in term of mechanical strength and water resistance(Jumaidin et al., 2017). Some studies had tried to fix this problem by using different materials such as potato and seaweed as a base as it is shown that having a higher molecular number can help in increasing the strength of the produced plastic (Bergel, da Luz, & Santana, 2017; Jumaidin et al., 2017; Shogren, Lawton, Doane, & Tiefenbacher, 1998; Thunwall, Kuthanová, Boldizar, & Rigdahl, 2008; Volpe, De Feo, De Marco, & Pantani, 2018). Different types of plasticizers are also considered such as glutaraldehyde, sunflower oil and chemicals such as 1-ethyl-3-methylimidazolium chloride ([Emim] Cl) and 1-ethyl-3-methylimidazolium acetate ([Emim Ac) (Ismail, Mansor, & Man, 2017; Volpe et al., 2018; Yeh et al., 2015).

There were some studies that is conducted that used tacca leontopetaloides as a base material for the production of TPS (Makhtar et al., 2013) but the characteristic of the TPS produced is only done for the thermal properties and chemical properties and also without considering different composition blends that can be produced. Thus, this research will be focusing on synthesizing different composition of TPS blends of tacca and polyethylene and studying their properties according to the standards

II. MATERIALS AND METHODOLOGY

A. Sample preparation

The souce of starch that is being used are from the Tacca leontopetaloides or also commonly known as Polynesian arrowroot, is a wild perennial herb belonging to the species Dioscoreaceae (Ukpabi, Ukenye, & Olojede, 2009). This plant is distributed naturally from western

Africa through southern Asia to the northern Australia where it is intentionally brought to tropical Pacific Islands by early human migrations. It is a plant with a tuberous rhizome, where from a single petiole, 60 – 90 cm long arises, bearing leaf blades that has three main segments which are further segmented in a pinnate manner and is documented as a treatment ingredient for wounds to stop the bleeding and internal stomachs haemorrhages (Ubwa, Anhwange, & Chia, 2011; Ukpabi et al., 2009)

The preparation of the TPS samples are to be made by blending the tacca leontopetaloides starch flour with the polyethylene as the thermoplastic component. The composition of the mixtures is going to be in 10, 20% tacca to polyethylene. The starch flour was dissolved in distilled water and heated at 85^{o}c on a hotplate for 30 minutes until the mixture is fully gelatinized, the mixture is then cooled to the ambient temperature. The dried films are then peeled off and is ran through a two-roll mill machine to obtain the thickness of 0.25 mm. One sample that was made from a pure polyethylene that acts as the base of the results for the tests

B.Tensile Test

Samples are taken to be tested using the Tinius Olsen Universal Testing machine (H50KT). The films are cut into 5 2cm x 7 cm strips before being installed into the machine. The thickness of the strips is measured using a micrometer and is then being clamped the machine before the test is conducted. The test is being conducted at the cross-head speed of 5cm/ min at room temperature. Strips of sandpaper is attached to the films so it can be clamped and stay in place while the experiment is taking place.

III. RESULTS AND DISCUSSION

From the test, the ultimate pressure for each of the sample type shows that the maximum value decreases with the amount of tacca in the polymer matrix. Ultimate strain for the 20% is the lowest followed by the 10% and highest is the pure polyethylene. The break stress of 10 % is stronger than the 20% and the pure polyethylene has the lowest value of the sample tested. The modulus for the 20% is the highest among the samples and the break strain is also with the 20% samples that has the

Speed: 50.0 mm/min

	Width mm	Thickness mm	Area mm²	Yield Stress MPa	Yield Strain %	Ultimate MPa	Ultimate Strain %	Break Stress MPa	Break Strain %	Modulus MPa	Secant Modulus MPa	Break Energy MJ/m³
	20.0	0.250	5.00	N/F	N/F	4.93	14.6	1.13	74.0	101	21.5	2780000
	20.0	0.250	5.00	N/F	N/F	5.20	23.0	4.73	25.6	112	53.9	1030000
	20.0	0.250	5.00	N/F	N/F	4.80	11.1	4.32	451	79.7	56.7	18800000
	20.0	0.250	5.00	N/F	N/F	5.06	12.8	0.491	125	137	36.8	4480000
Average				N/A	N/A	5.00	15.4	2.67	169	108	42.2	6780000
SD				N/A	N/A	0.171	5.31	2.16	193	24.0	16.4	8160000

Table 1 80/20 Tensile test result

Speed: 50.0 mm/min

	Width mm	Thickness mm	Area mm²	Yield Stress MPa	Yield Strain %	Ultimate MPa	Ultimate Strain %	Break Stress MPa	Break Strain %	Modulus MPa	Secant Modulus MPa	Break Energy MJ/m³
	25.0	0.250	6.25	N/F	N/F	4.52	497	4.13	470	106	70.7	17000000
	25.0	0.250	6.25	N/F	N/F	4.43	9.53	4.30	493	77.3	3.05	19300000
	25.0	0.250	6.25	N/F	N/F	4.72	16.1	1.59	135	82.6	0.00	4340000
	25.0	0.250	6.25	N/F	N/F	3.68	-18.3	2.34	37.8	90.2	310	1880000
	25.0	0.250	6.25	N/F	N/F	4.19	9.64	3.87	505	86.6	69.7	18600000
Average				N/A	N/A	4.31	103	3.25	328	88.6	90.7	12200000
SD				N/A	N/A	0.399	221	1.21	224	11.0	127	8400000

Table 2 90/10 Tensile test result

Speed: 50.0 mm/min

	Width mm	Thickness mm	Area mm²	Yield Stress MPa	Yield Strain %	Ultimate MPa	Ultimate Strain %	Break Stress MPa	Break Strain %	Modulus MPa	Secant Modulus MPa	Break Energy MJ/m³
	25.0	0.250	6.25	N/F	N/F	3.44	30.6	1.66	131	69.8	291	4660000
	25.0	0.250	6.25	N/F	N/F	4.53	922	4.18	875	64.7	12.0	26800000
	25.0	0.250	6.25	N/F	N/F	2.93	16.4	1.29	223	52.8	17.6	5810000
	25.0	0.250	6.25	N/F	N/F	3.23	9.47	-0.0267	515	52.6	6.29	10100000
	25.0	0.250	6.25	N/F	N/F	4.72	517	4.70	523	63.2	15.7	20100000
Average				N/A	N/A	3.77	299	2.36	453	60.6	68.6	13500000
SD				N/A	N/A	0.805	410	2.01	293	7.62	125	9590000

Table 3 Pure PP Tensile test result

lowest value among the types that were tested. It is also noticed that it took less energy to break the starch thermoplastic materials compared to the conventional polypropylene film. The content of plasticizer influence heavily on the elongation of the sample, as stated by Mardhiah, (2017). This also might be the reason why the energy needed to break is higher in the pure polypropylene film compared to the mixture films. Some of the samples breaks in seconds and some of them breaks after stretching for a long time for the same batch of film. This is one of the reasons of why the data is not as uniformed as it could have been.

IV. CONCLUSION

Varying amount of starch in the matrix has certainly helps in modifying some of the properties of the starch/polyethylene matrix. Some of the properties are buffed with the additions of the starch compound and some of them decreases after comparison with the pure polyethylene film. Some of the testing data is inaccurate as the samples exhibits different failure characteristics and it has, in some capacity, influenced the whole data in terms of elongation and break energy. More testing is required as it is inconclusive to state that the thermoplastic made from tacca leontopetaloides starch is better than the pure polymer thermoplastics.

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