Degradable Plastic Characterization as an Interface Layer on Multilayer Plastics to make the Recycling Process Easier

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種類の異なるプラスチックを貼り合わせた製品のリサイクルでは、再利用に先立ってプラスチックの種類ごとに分別する必要がある。その際のインターフェイスに生分解性プラスチックを用いる方法を検証した。

Abstract

Plastic waste is one of the waste which can harm the environment. Using plastic drastically increased 20 times in the last 50 years. Because it has very long hydrocarbon circle which makes it hard to digest. The Recycling process has an important role in reducing plastic waste pollution. Before recycling process, plastic waste must be sorted first, according to its kind and then ground into plastic seeds. Plastic seeds will be melted and formed into new products. However, this process is hard to apply for a multilayer plastic that has several layers of different types of plastic. This structure makes this kind of plastic hard to melt because the melting points of those layers are different. If layers could easily be separated, the recycle process of this kind of plastic will be easy. This research utilizes biodegradable and oxo-degradable plastic that has been produced by the factory to apply to one of the layers of multilayer plastic because of the degradable characteristic they owned. So, it can be obtained multilayer plastic that can be separated between each layer and to simplify the multilayer plastic recycling process

Keywords multilayer plastic, biodegradable, oxo-degradable, plastic, recycle

Introduction

The waste produced is equal to population growth, waste that can endanger the environment is plastic waste more population means more waste produced.

One of the Plastic waste can damage the environment because it can reduce soil fertility and damage the aquatic environment.

The solution to solve the plastic waste problem is recycling. The recycling process is commonly done by industry. Generally, there are four requirements waste can be processed by the industry. The requirements are waste must be in certain form as needed (seed, pellets, powder, or fraction), waste must be homogenous, not contaminated and oxidized. Therefore, before plastic waste melt, plastic must through a process of separation, cutting, washing, and removal of substances such as iron. (Macklin, 2009). Then, melted plastic formed into a new product. Using recycled plastic in the rebuilding of plastic goods has grown rapidly. Almost all the kind of plastic waste (80%) can be reprocessed into original goods even though it must be mixed with new raw materials and additives to improve quality (Syafitrie, 2001).

However, there are kinds of plastic that hard to be recycling. One of them is multilayer plastic. India environment ministry announces to change rules of plastic waste management and suggest removal of multilayer plastic. Multilayer plastic hard to be recycling. So, it is an important threat of ecosystem. (The Hindu, 2018).

Multilayer plastic has some plastic layers with different kinds. The different types of plastic layers can combine the characteristic of each layer. So, multifunctional plastic is obtained. Through multilayer system can produce thin package but has the strength and function as a good packaging.

Besides that, technology allows the industry to modify the strength of packaging. But, because it is durability multilayer packaging have weaknesses. When it becomes waste the packaging very difficult to recycle and accumulate in a landfill. Even, scavengers do not want to take this type of waste because they can't be sold. Observation study done by Mr.Wahyudi et.al. (2018), on two landfills in Bandung city found that multilayer plastic waste reached 17% of total plastic waste in these landfills.So far, multilayer plastic waste in Indonesia used as a handicraft material such as a plastic bag etc.

The durability of multilayer plastic makes handicraft products strong and durable. The recycling process of multilayer plastic packaging is challenging.

The biggest challenge is the separation process because various types of plastic mixed and bonded very strongly. If plastic melted before sorted, this multilayer structure will affect the quality of mono-material such as PET. As an example, Plastic A has melting point 90° C and Plastic B has melting point 200° C, if these plastics heated in temperature 150° C, plastic A will damage meanwhile Plastic B hasn't melted and the result there is a significant degradation in quality. When it's melted, the plastic will not be mixed spontaneously. Therefore, multilayer plastic waste becomes an inseparable complex mixture. If the layers can be separated the recycling process will be easier.

This research is to find an alternative solution to separate layers on multilayer plastic by applying degradable plastic as an inter-layer bulkhead. Hopefully in the presence of degradable plastic as an inter-layer partition, multilayer plastic will be more easily separated so that it is easily recyclable too. Currently, Indonesian scientists are developing degradable plastic that is environmentally friendly. Based on the causes of degradation, the degradation process caused by biodegradable, compostable, hydro-biodegradable, oxo-degradable, and photo-biodegradable.

This research use two types of degradable plastics that are biodegradable and oxo-degradable. In general biodegradable plastics are composed of plastics that are mixed with biomass sources such as vegetable oils, corn amyum, cassava starch, ercis and others that allow the acceleration of the plastic decomposition process.

Polymers from promising renewable resources to plastic degradable due to abundant supply, low cost, biodegradability, and ease in chemical modifications (Liza, 2014). While Oxo-degradable is a type of plastic can be degraded with the aid of oxygen, generally composed of polyethylene (PE) plus additives in the form of minerals.

Biodegradable and oxo-degradable plastics are often found in the plastic bags of bookstores and minimarket in Indonesia. This type of plastic is already a commercial product and PT. Harapan Interaksi Swadaya is one of the producer. In this study we use the existing degradable layers, so that it can obtain shorter test results.

Method

This research was conducted in two stages. The first stage, to obtain the right formulation for the first prototype making of multilayer plastic. Prototype making is done by moulding compression method between Polypropylene plastic (PP) and biodegradable or oxo-degradable plastic using hot press machine Collin P 300 P with certain setting and composition and then continue with final prototype making of multilayer plastic. In this stage, the chosen formula will be printed more according to research need.

The second stage, both prototypes are characterized: Accelerated weathering with Q-UV Method, mechanical properties testing (tensile and elongation), and morphology through a scanning electron microscope (SEM). It is to determine whether there is any degradation in the degradable bulkhead layer. After the first stage finished, all prototypes will be collected and printed into several specimens and undergone UV resistance test with certain time setting. Irradiated specimens collected and undergone a strong pull test (elongation). It is to find out whether the quality of the prototype meets the standard although given bulkhead between the layers.

Table 1. Formula and Optimum Condition

Nomenklaktur	Formula	Temperature (C)	pressure (bar)	Time (minute)
Multilayer X	PP//*Biodegradable*//PP	160	40	35
Multilayer Y	PP//*Oxodegradable*//PP	160	40	35

Formulation and optimum condition of multilayer plastic

Expected optimum condition from multilayer plastic is not broken or burned and having a thickness of 0.1 mm. PP is optimum material as a cover layer of prototype making in multilayer plastic insulated degradable, with the same optimum condition between multilayer X and multilayer Y as follow: temperature 160 Celsius, pressure 40 bar, and time 35 minutes. Look at table 1.

Multilayer Plastic

Multilayer plastic used to provide protective, functional and decorative properties. They consist of at least two layers, aiming to meet the required performance for a particular application. Multilayer structures may lower the total cost of production by incorporating inexpensive materials such as recycled material in addition to the expensive polymers or by film thickness reduction. (Butler & Morris 2010) Flexible packaging structures for medical applications have from three up to eleven layers. Multilayer structures with barrier films such as EVOH often require a tie layer, thus producing a five or seven layer structure (Breil 2010; Butler & Morris 2013).

Individual layers contribute to specific functional properties, such as enhancing permeation resistance or tensile strength. Other common properties that need to be taken into account include optics, formability, machinability, economics, sealability and adhesion. An individual layer may contain polymer blends, neat polymer, recycled material or additives. Important key properties for multilayer structures in flexible packaging include good barrier properties, selective permeability, machinability, sealability, esthetics and damage preventing properties, such as impact strength. (Butler & Morris 2010).

Multilayer plastic degradable X and Y characterization with QUV method

Evaluation result of UV Irradiating test toward Multilayer X and Y sample could be seen at Table 2. After 120 hour UV irradiating test, all samples in every duration shows the highest greyscale number is 5. The result shows both samples meet greyscale standard and no changing color compared with sample before irradiating process.

Table 2. Result of UV Irradiation at sample *multilayer* X and *multilayer* Y

Num.	Sample's name	Kind of evaluation	Result test in every hour			
			8	16	72	120
1.	*Multilayer* X	*Grey Scale*	5	5	5	5
		Visual	No color changes in Sample			
2.	*Multilayer* Y	*Grey Scale*	5	5	5	5
		Visual	No color changes in Sample			

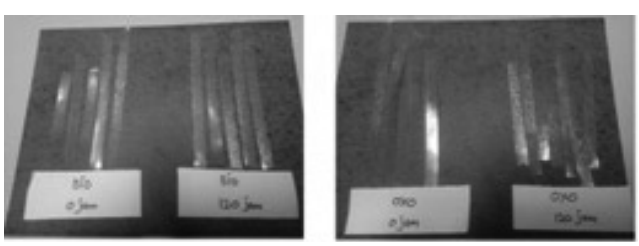
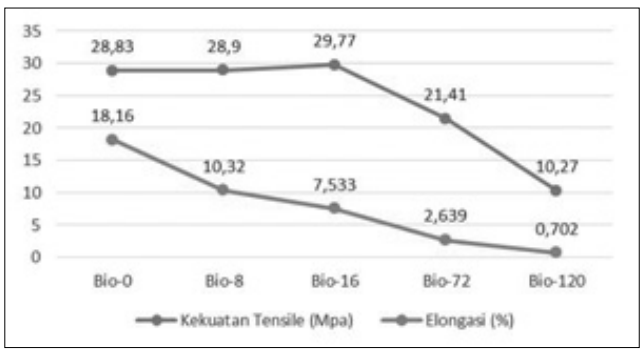


Figure 1. Sample condition before and after UV irradiating for 120 hour. (a) Sample *Multilayer* X, (b)Sample *Multilayer* Y.

Mechanical Properties Characterization

Tensile test is a test to measure the ability of material to withstand tensile strength. This is to determine how far the material experience stretching before breaking up. Testing in this test including tensile strength and elongation. The result of the test can be seen on Figure 2.



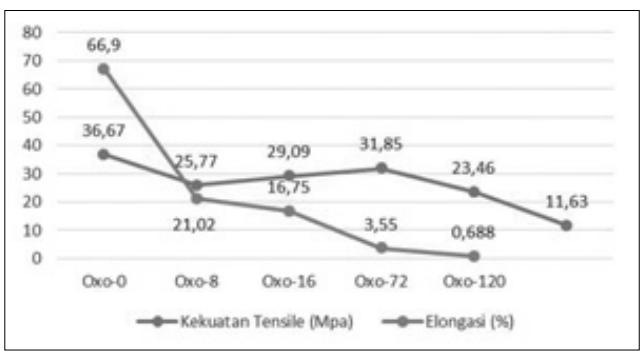
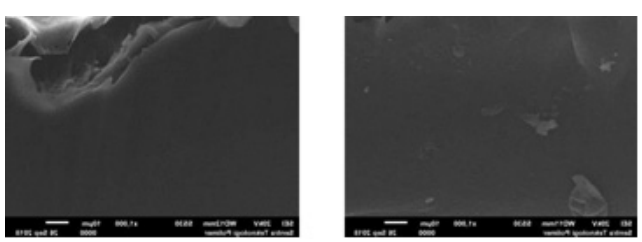


Figure 2. Graphich result tensile and elongation test *multilayer* X and Y (biodegradable bulkhead layer) sample.

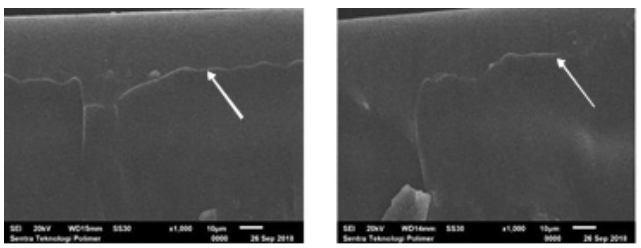
Morphology evaluation with SEM

SEM result shows there is a damage in PP surface layer at 120th hour. At 120th hour, there are cracks in PP layer.



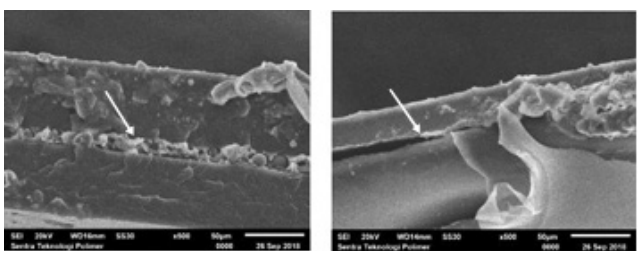
(a) (b)

Figure 3. First Sample zooming 1000 times: (a) *Multilayer* X, (b) *Multilayer* Y



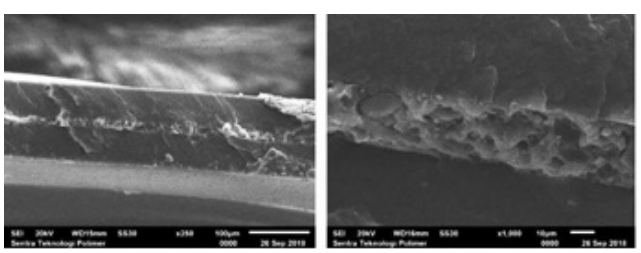
(a) (b)

Figure 4. Sample condition 8th hour zooming 1000 times: (a) *Multilayer* X, (b) *Multilayer*

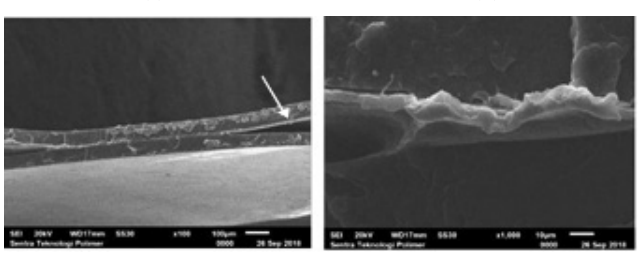


(a) (b)

Figure 5. Sample condition at 16th hour zooming 500 times: (a) *Multilayer* X, (b) *Multilayer* Y



(a) (b)



(c) (d)

Figure 6. Sample condition at 72th hour: (a) *Multilayer* X with zooming 250 times, (b) *Multilayer* X with zooming 1000 times, (c) *Multilayer* Y with zooming 100 times, (d) *Multilayer* Y with zooming 1000 times

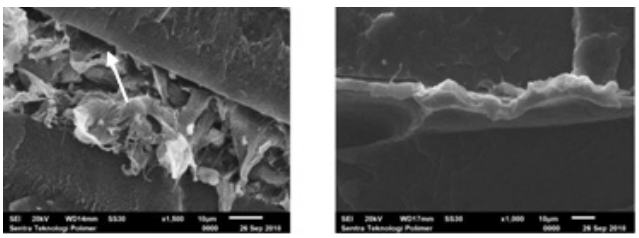


Figure 7. Sample condition at 120th hour with zooming 1000 times: (a) *Multilayer* X, (b) *Multilayer* Y

Conclusion

Multilayer plastic with formulation PP//Degradable// PP, according to ASTM D 3826-98, 2002, with multilayer X sample (biodegradable layer) and multilayer Y (oxo-degradable layer) proven as good degradable material according to elongation test and tensile. As well as SEM test result which shows there are cracks in the layer. The cracks is as parameter and evaluation that degradable happened. As a result, it means degradable layer can be used as alternative solution of multilayer plastic recycle problem

This research is a strategic first step to solve multilayer plastic waste recycle problems. .Furthermore, this research has great potential to explore foremost about degradable layer composition used in this research. This research is very feasible to continue.

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