Investigation Of Coating Materials On Recycled Polypropilene and Rubber Composite Under Weather Exposure

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Abstract **--- The recycled polypropylene (rPP) –rubber composite tends to depict the mechanical strength decreasing and physically degradation as well when installed as an outdoor application. The research investigated several materials which they can be applied as a protective coating materialsfor the composite. Oil based paint, waterproof paint, unsaturated polyester, and repoxy resins were selected materials to be examined.The raw materials of the composite were recycled rPP and tire after used in the powder state with mesh of 20 both. The composite consisted of rPP and rubber mixing with volume ratio of 7:3. Pressured sintering process was adopted for producing the composite with main parameters setting of temperature, pressure and holding time were 120^{o}C, 1 MPa and 5 minutes respectively. The coating materials were sprayed on the composite surface with the thickness could be neglected. The speciments were just layed on the special table during weather exposuring for three months continuously. The investigation included macro and SEM immages and bending test.The result reveals that the color degradation occured on the composite surface without coating after one month exposuring while cracks appear after exposuring takes time of two months and they tend to become propagated until the end of the third month. The SEM immages observation on fracture bending test showsthat the bonding between the plastic and the rubber began to be separated due to the influence of photo-degradation. The fracture are begun after the first month of weather exposuring. The waterproof coating provides the most stable of composite under bending test whereas unsaturated polyester coating has the highest bending strength overall exposuring periodes**

Keywords: polypropylene, coating, exposure to weather, bending test.

I.INTRODUCTION

Polypropylene (PP) and high-density polyethylene (HDPE) are the thermoplastic commodity of which are used in industrial and household applications. After used or waste from PP plastic has contributed 2.64% while the HDPE has contributed 3.97% in urban waste. PP plastic is commonly served for plastic products which have high tensile strength such as blister (snack pack) and a plastic bag [1].

The plastic has often been used both indoor and outdoor that it is possible to exposure to direct contact with sunlight in the long term. The outdoor applicationis able to create an adverse effect for the plastic products. UV radiation which is a part of sunligth can break chemical bonds in the polymer. This process is called photo-degradation and ultimately causes cracking, calcification, changes color, and the decline of certain physical properties [2].

The other waste which often cause problems in addition to plastic is after-used tires. The volume of waste vehicle tires in Indonesia from day to day has increased by an increasing number of motor vehicles. Disposal of waste tires into the environment can cause environmental pollution because the tires are not biodegradable in soil and can cause disease as well [3].

Based on the above description can be concluded that it is important for utilizingthe wastes of waste plastic and rubber which is expected to have a higher economic value.

II. METHODOLOGY

A. Materials

Materials used in the investigation consist of PP plastic powder (mass type: 0.91 g cm-3, melting point: 1750C) obtained through a process of oil bottles crushing, rubber powder (mass type: 1.1 g cm-3 and the protective coating material with white pigment. Protective materialsused were oil paint (polyurethane base material), waterproof paint (polyurethane basic material), unsaturated polyester resin (BQTN-157 type) and resin repoxy (R-802 type).

B. Composite Creation

PP plastic powder and rubber powder werescreened with mesh size of 20 and then mixed in the ratio of 70:30 using the diffusion method in a steel cylindrical container. In

the mixing process it was added the 5% by volume of steel balls of 1/8 inches diameter to antisipate the rubber powder agglomeration.

The composite production process took place at temperature of 135^{o}C and pressure of1 MPafor 10 minutes. The protective materials then were coated on the surface of the composite with the air spray gun.

C. *Weather Exposure*

Exposuring to the natural weather test of the composit took place for 3 months. It refered to ASTM standard of D1435. [4].

D. *Bending Test*

Bending test refered to the ASTM D790 standard [5].

III. RESULT AND ANALYSIS

A. *Climate Recording*

The composites with the variation of protective coating were exposured for three months from December until January. Table 1 depicts the average of temperature, humidity and radiation of sunlight during exposuring.

TABLE I
AVARAGE CLIMATE RECORDING DURING 3 MONTHS

Month	Temperature (^{0}C)	Humidity (%)	Sunlight Radiation (%)
December	26,8	82,9	76,2
January	26,6	83,1	66,7
February	27,5	80,4	85,4

B. *The Composite Surface Characteristics*

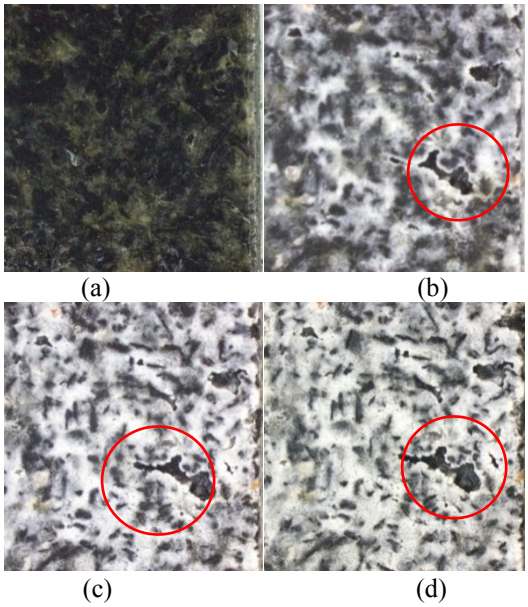


Figure 1.The composite ofrPP-rubber without coating under weather exposure for (a) 0 month (b) 1 month, (c) 2 months, (d) 3 months.

The observation of the macro image of Figure 1 shows that the condition of rPP-rubber composite without coating before weather exposure (month 0) is dark grey with a flat and smooth surface. Color degradation began to occur at the first month and the cracks start to appear as well. The cracks tended to grow up to 3 months and the composite color on the surface which was directly exposed will become to fade. The ultra violet radiation attack is able to break the polimeritation bonding of PP plastic causing the composite surface to become rough and brittle [6].

C. *Bending Testing*

The bending test result of Figure 2 shows that the weather exposure provide to decrease the bending strength of thecomposites with all of protective materials.

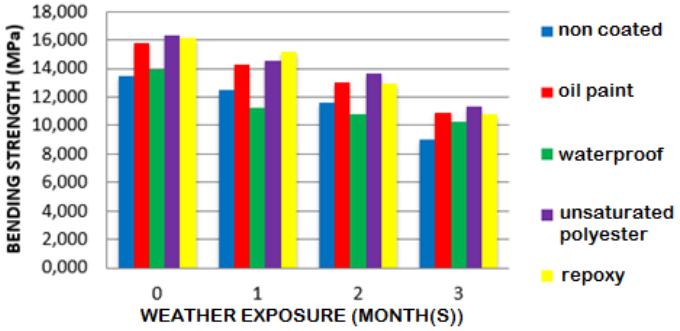


Figure 2. The bending strength comparison of variation coating materials of the composite under weather exposure

The waterproof coating shows as the most stable material after one month exposuring until the last time based on bending strength property. Waterproof based on polyurethane material has a resistantproperties to ultra violet radiation [7]. Waterproof mixed by elastomeric materialsuch as ruber will provide a high elastic, resistant to UV and weak for preventing the water flowcontinuously. Figure 3 shows that the rPP-rubber composite with waterproof layer has a bending strength of 13,873 MPa and after three months exposuring the strength decrease tobecome 10,254 MPa. The 1st month of exposure, the waterproof coated composite has the highest gradient of strength decreasing. There is an evident from the results of SEM observation at month 1. The immage illustrates that the bond between the composite and the layer begins to be apart because of the low resistance of waterproof with high rainfall (December rainfall indicated 9.5 mm). The existence of a little bit of voids int the coating contribute to decrease the strength too. The rainfall of 7.3 mm and 6.9 mm in January and February respectively make the condition of waterproof coating become stable and it will give the significant effect on the strength of composite overall.

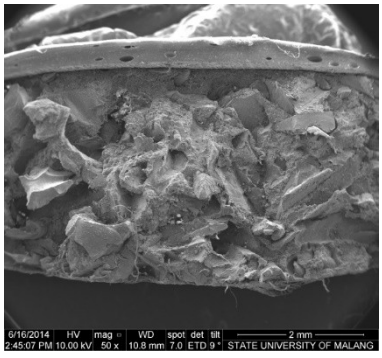
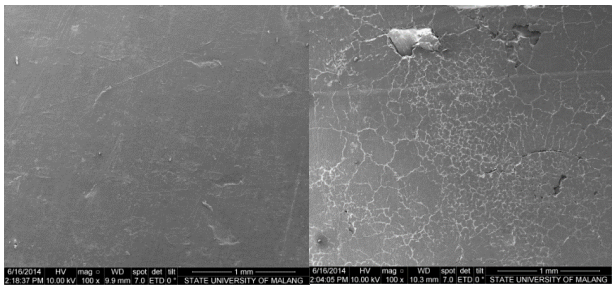


Figure 3. SEM image of bending fracture of rPP-rubber composite waterproof coating after 1 month exposure.

The ultra violet radiation destruction causes morphological changes in the structure of plastic and thus affect to the mechanical strength. The strength of the composite will decrease proportionally to the exposure time[6]. Polypropilene is a plastic type wich is strongly influenced by ultraviolet radiation. Exposuring directly tosunlight of PP would make reducing the strength. Consequentially, after exposuring of rPP-rubber composite without coating it would undergo to loose of the bending strength due to disconnection of chemical bonds in the polymer PP plastic. This is called as a photo-degradation of PP plastic. Photo-degradation effect can be seen from the SEM immages resulton Figure 4. The effect appear on the crack size of the composite surface. The longer of exposure time result the wider crack causing bending strength decrease drastically.

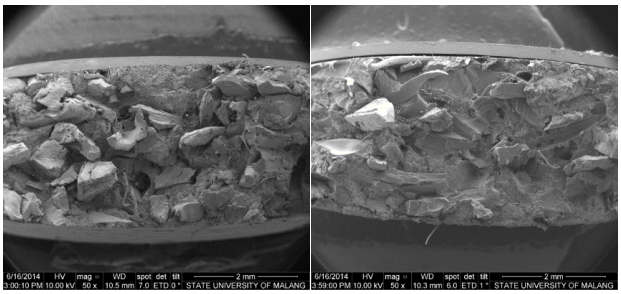


(a) (b)

Figure 4. SEM immages of rPP-rubber composite surface (a) without (b) after 1 month exposures.

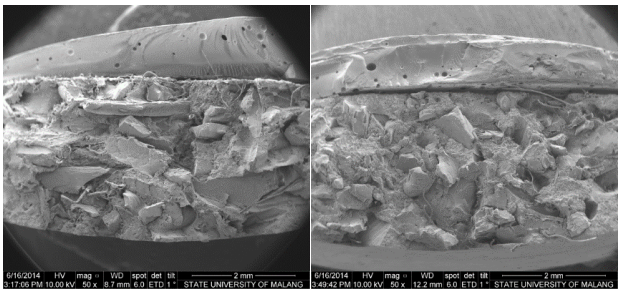
The other coating material namely the paint is made from the basic ingridient ofacrylicpolyurethane. Acrylic addition to the matric of polyurethane provide the corrosion-resistant polymer increasing but doesn't in the adhesive properties [7]. The rPP-rubber composite coated paint undergoes to decrease in the bending strength about 9% each month and the 3rd month strength decrease up to 16%. The phenomenon occurred due to the polyurethane based paint has lost in the adhesive bond after exposure at the elevated temperature for long period. There is a different of expansion coeffisient between composite and paint. When they are exposured in the increasing temperature the dimension adding of them are diferent. After temperature decrease to the normal, the contraction of composite and paint occured int the different rate as well. The continuous expantion and contraction contribute to destroy the bonding between composite and paint. Figure 5(a) illustrates that the bonding between rPP and rubber is still strong and the paint layer is attached perfectly. At month 3 of exposure as shown in the Figure 5(b) the attachment between the coating material and the composite is broken because ofsunlight radiation at the 3rd month is so high. As a result, the bond between the composite and the coating material is getting weaker at the highest rate.

Unsaturated polyester is the thermoset polymer which is widely used because it has a balance properties on mechanical, electrical, chemical and dimensional stability as well. The disadvantages of the resin are tobecome brittle atan elevated temperature and low stregth under impact and torsional loads. The rPP-rubber composite coated unsaturated polyester resin has the highest bending strength before and after exposuring. However, Figure 2 gives an evident that the slope of decreasing strength tends to be faster reach the loose strength than waterproof coating. Figure 6 illustrates the comparison of flexural surface of composite between 1 month and 3 monts exposure. The bending strength of composite coated unsaturated polyester decreases 6-10% each month except in the month of 3rd reduces up to 17%. The reason is that the exposure at the 3rd month attacts the highest irradiation and as a consequency of the condition is thatthe surface temperature is going to hoter than the other months. The SEM immages observation at month 3 as shown in Figure 6(b), shows clearly that inside of unsaturated polyester coating there are a lot of voids and cracks also appear between the coating and the composite causing strength reducing.



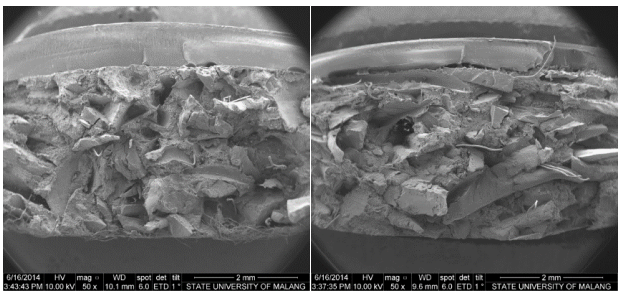
(a) (b)

Figure 5. SEM immages of rPP-rubber composite coated paint under weather exposure for (a) 1 month, (b) 3 months.



(a) (b)

Figure 6. SEM immages of rPP-rubber composite coated unsaturated polyester under weather exposure for (a) 1 month, (b) 3 months.



(a) (b)

Figure 7. SEM immages of rPP-rubber composite coated repoxy under weather exposure for (a) 1 month, (b) 3 months

Repoxy is a resin produced by modification of bis-phenol epoxy. The resin has a good properties in adhesion, chemical and corrosion resistances [7], but has not in color stability under ultraviolet exposure which the originally

white will going to yellow [8]. Figure 2 shows that the composite coated repoxy tends to reduce in bending strength approximately 7-10% per month except at the 3rd month that reveals 20% reduction. The condition occurs because of at the 3rd month is the highest radiation of sunlight. The SEM immages shown at Figure 7(b) is an evident thatrepoxycoatingbegin to break or crack after 3 months of exposure whereas the bond between the coating and the composite is detached causing strength reduction.

IV. CONCLUSION

The bending strength of rPP-rubber composite material will decrease under weather exposure even with protective materials coating. The reducing of strength is proportionally with time of exposure. Waterproof coating shows as a stable protective material for long time application under weather exposure.

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