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# Influence of Epoxidized Palm Oil on Polyhydroxyalkanoates Tensile Properties

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**ABSTRACT.** These papers focus on the influence of epoxidized palm oil (EPO) on polyhydroxyalkanoates (PHA) tensile properties. Previous researchers has found a thermoplastic polymer polyhydroxyalkanoates (PHA) that exhibit biodegradable properties and produced from renewable materials such as sugar and molasses. However, pure PHA are brittle materials. A modification on the mechanical properties of PHA can be done by introducing plasticizer to the materials. In this study, (EPO) was used as plasticizer to PHA with varied composition of EPO content range 1wt.% to 5 wt.%. The blend was prepared by mixing the two components using internal mixer at 175 °C. The mechanical property of each sample was determined by tensile test. Result shows that the Young's modulus of PHA was improved with 3 wt.% optimum plasticizer loading while lowest tensile strength which indicates the rigidity of PHA/EPO at this composition is optimized.

***Keywords:*** *Plasticizer, EPO, Mechanical properties, PHA;*

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## 1. INTRODUCTIONS

Plastics waste is a part of main problem in environmental issues. Developments of biodegradable plastics become a concern in solving this issue. Researchers has discovered a polymer known as polyhydroxyalkanoates (PHAs) that can be produced from renewable and bio-waste resource by bacteria fermentation [1,2]. Numbers of studies did focus on the PHA synthesis methods [3-5]. The biodegradability of PHA was good in solving the plastics packaging waste issues. However, pure PHA is a brittle material due to re-crystallization with ageing at room temperature. Thus, the mechanical properties of PHA change with time. It is reported that the mechanical properties of PHA can be modified by adding plasticizer [6]. Addition of plasticizer enhances the molecular motion and reduces the glass transition temperature of the materials hence change the thermal properties of biopolymer [7-9]. Numbers of research done including modified the mechanical properties of PHA by adding various plasticizer such as soybean oil, epoxidized soybean oil, dibutyl phthalate and triethyl citrate [10-16]. However, few number of research if any done on EPO as the plasticizer for PHA. Development of PHA blend with natural plasticizer like EPO is very interesting as the blend will be completely biodegradable in environment and epoxidized palm oil (EPO) source is available in this country hence will increase the utilization of EPO. The objective of this paper is to investigate the effect of local produced EPO to the mechanical properties of PHA.

## 2. MATERIALS AND METHODS

Polyhydroxyalkanoates (PHAs) used was in pellets form supplied by Shenzen Bright China Industrial Co. Ltd., China with density of 1.23 g/cm$^3$. The yellowish PHA palette was dried for 5 hours at 50 °C to remove any moisture before blended with EPO. The EPO used supplied by Budi Oil Holding Sdn Bhd was in semi-solid

state at room temperature.The PHA and EPO was blend using the internal mixer Hakee Internal Mixer Rheomix 600 p at 175 °C with speed 50 rpm for 15 min. The blend composition was varied as summarized in Table 1. After been cold, the blend was crushed into size from 1 mm to 10 mm. The blend then molded into dumbbell shape tensile sample by hot pressing at 165 °C for 5 min.

**Table 1** Composition of PHA/EPO blend

| Blend | Polyhydroxyalkanoates (wt.%) | Epoxidized Palm Oil (wt.%) |
|---|---|---|
| B0 | 100 | 0 |
| B1 | 99 | 1 |
| B2 | 98 | 2 |
| B3 | 97 | 3 |
| B4 | 96 | 4 |
| B5 | 95 | 5 |

The tensile properties were determined by testing 4 samples for each composition using Universal Testing Machine based on ASTM D638. The tensile test was run at constant speed 5 mm/min with similar storage time. The break surface of the sample then was observed by The Field Emission Scanning Electron Microscope (FESEM) (JSM 6700F, JEOL) at the break surface.

## 3. RESULTS AND DISCUSSION

The tensile properties of plasticized PHA were compared to pure PHA. Fig. 1 shows the effect of EPO content to the Young's modulus of PHA. The Young's modulus of PHA increase from 420 MPa to 890 MPa with 3 wt.% of EPO introduced to the composition. At this point, the EPO composition was optimum followed by 5 wt.% EPO (515 MPa), 2 wt.% EPO (467 MPa), 1 wt.% EPO (428MPa) and 4 wt.% EPO (344 MPa). High Young's modulus exhibited by rigid materials which more stress required for deformation to occur.

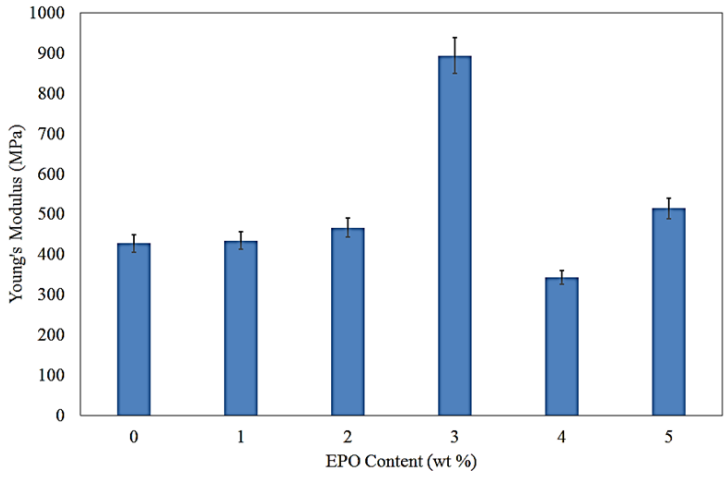


**Fig. 1** Effect of EPO loading on Young's modulus of PHA

For tensile strength shows in Fig. 2, the trend was decrecreased as the EPO loading increase. The trends of increasing of Young's modulus while decreasing in tensile strength as EPO loadingincreased indicate that the strain range was wider. The interaction between PHA and EPO makes the blend more rigid. However at 4 wt.% of EPO the tensile sterength drop to the lowest. This may results by non homogenous

blend due to excessive content of EPO. FESEM analysis was done to study the homogenity and breaking behaviour of the samples.

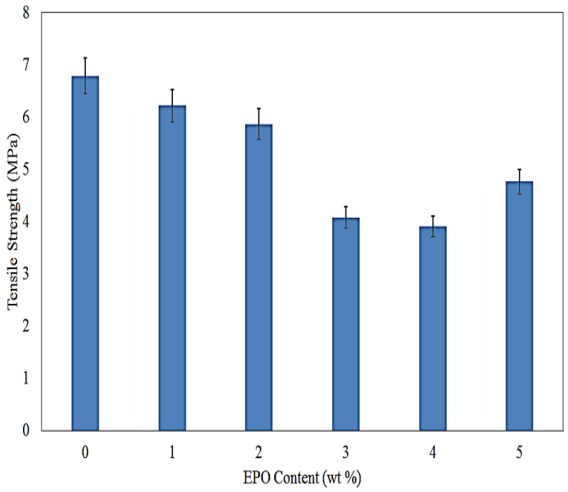


**Fig. 2** Effect of EPO on tensile strength of PHA

Fig. 3 ilustrate the FESEM image of the tensile sample fracture surface of the optimum blend with 500x magnification. In this figure, it shows good compatible morphologies and smooth fracture surface indicate that the miscible of EPO in the blend. It is also show good adhesion between the PHA matrix and plasticizer as there are only one phase produce. Fig. 4 shows the morphology of fracture surface for 4 wt.% EPO with similar magnification. The presence of voids can be observed clearly indicating region of accumulate EPO in PHA matrix. The voids formed due to inhomogeneous dispersion between PHA and EPO which contribute to low Young's modulus. Therefore better dispersion of EPO in PHA at lower EPO loading compare to high EPO.

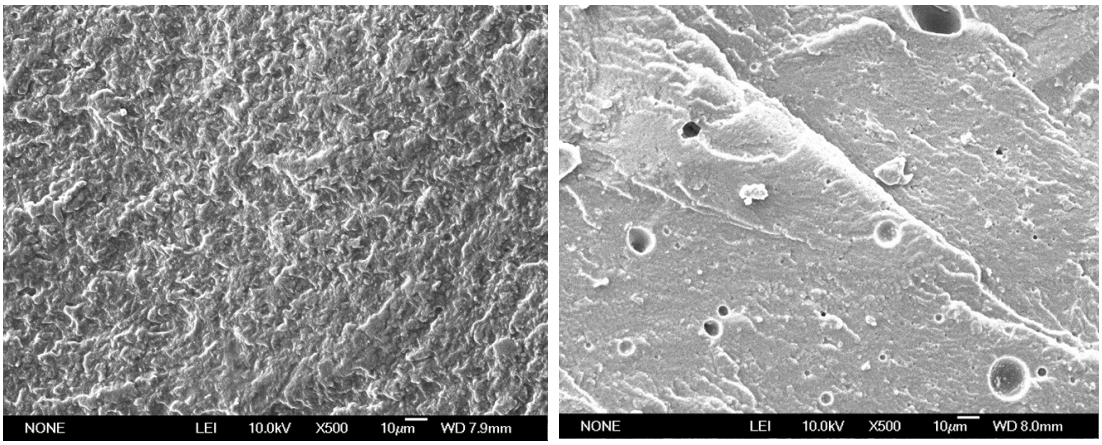


***Fig. 3*** *FESEM image for 3wt% EPO in PHA blend*

**Fig. 4** FESEM image on fracture part of sample with 4 wt.%

## 4. SUMMARY

The optimum composition for EPO is 3% with Young's modulus of 890 MPa and low value of tensile strength. The efficiency of EPO loading as plasticizer was higher in order 3 wt.% > 5 wt.% > 2 wt.% > 1 wt.% > 4 wt.%. The tensile strength of PHA decrease as the composition EPO increase and at 3 wt.% EPO content, the tensile strength lower compared to neat PHA. The relation of Young's modulus to tensile strength indicate wide range of elastic region for PHA at this composition. This indicates high rigidity of PHA with 3 wt.% EPO.

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