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Impact and Thermal Properties of Unsaturated Polyester (UPR) Composites Filled With Empty Fruit Bunch Palm Oil (EFBPO) and Cellulose

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Abstract. In this research, the impact properties of unsaturated polyester (UPR) composites filled with empty fruit bunch palm oil (EFBPO) and cellulose are investigated. The composites were made by hand-lay up method by mixing UPR with the content of each fillers (EFBPO and cellulose) of 5,10,15,20 wt.%. The parameter which was carried out on the prepared samples was impact test. It was found that the addition of fillers to the matrix caused the impact strength of composites increased at 10% addition of EFBPO and 5% addition of cellulose. The results are confirmed by fourier transform infra-red (FTIR) and supported by thermogravimetric analysis (TGA) and scanning electron microscopy (SEM).

Introduction

The study of polymer composites filled with natural fibers has increased rapidly. Natural fibers provide a better property than synthetic fillers such as lower cost, high modulus and strength, lower density, ease of fiber treatment and a wide range of application [1]. Also environmental problem caused by and higher cost from synthetic fillers has led researchers to prefer natural fiber over synthetic filler. The main component giving rise to these improve properties is cellulose. Several natural fibers such as hemp, kenaf, kraft and jute has been investigated [1-4]. One commercial type of matrix commonly used is unsaturated polyester (UPR). UPR is one of thermostets which possess better properties than other types of thermoset such as low shrinkage, ability to mold at room temperature, low viscosity, thermal and weather resistance, and low cost [5-8]. Other fillers potentially of use are empty fruit bunch palm oil (EFBPO). As one of the largest country produced of palm oil, Indonesia has plenty of EFBPO waste. If EFBPO could be treated further such as by bleaching and pulping, then cellulose inside EFBPO could be extracted. The objective of this study is to investigate the effect of filler contents on different types of fillers such as EFBPO and cellulose to impact produced in the properties of composites.

Experimental Procedure

Materials Unsaturated Polyester Yukalac 157® BTQN-EX was supplied by PT. Justus Kimia Raya Indonesia and empty fruit bunch palm oil (EFBPO) and cellulose was obtained from Indonesian Oil Palm Research Institute. The matrix, unsaturated polyester (UPR) was mixed with the fillers with content 5,10,15,20 wt% of each fillers (EFBPO and cellulose) by using hand lay-up method. The catalyst used was methyl ethyl ketone peroxide (MEKP) acted as hardener for the matrix for 1,5 wt% of the matrix. The curing period took 24 hours. The composites then were tested in accordance to ASTM D4812-11 and carried out by GOTECH Impact Tester. The fracture of composite from impact test then was analyzed by Scanning Electron Microscope (SEM) JEOL JSM-6360 LA. The data then was supported by Fourier Transform Infra-Red (FTIR) using Shimadzu IR-Prestige 21 and Thermogravimetric Analysis (TGA) using Shimadzu Simultaneous TGA/DTA Analyzer DTG-60.
Results and Discussion

The impact properties of UPR-EFBPO and UPR-Cellulose composites is shown in Fig.1. Fig.1 shows that impact strength of UPR-EFBPO composites increase as the fillers content increase while the impact strength of UPR-cellulose composites decreases. This is happening due to absorption of UPR matrix by cellulose during the mixing between both of them to produce UPR-cellulose composites while it was not found in mixing between UPR and EFBPO. The cellulose fillers which extracted from EFBPO have high pores compared before EFBPO treatment of pulping and bleaching hence its tendency to absorb UPR would be higher than EFBPO. As the cellulose content is increased to 20 wt%, the matrix cannot provide a sufficient area to hold up the fillers, hence the interfacial adhesion between matrix and fillers decreases which results in the decreasing impact strength of UPR-cellulose composites as the fillers content increase. The maximum impact strength is found at 5 % filler content. On the other hand, the impact strength of UPR-EFBPO composites is found to increase as the fillers content increases where the maximum value at 20% filler content. This shows that a good interfacial adhesion between matrix and fillers occurs. The increased fillers make the composites more elastic and enhance the flexibility of network in composites so it absorbs more energy to failure [9-10]. The composites then were characterized by Fourier Transform Infra-Red (FTIR) as is shown by Fig.2. Fig.2 shows the FTIR characterization of the compounds analyzed. It can be observed that the IR spectrum of both composites formed has a similar spectrum with UPR matrix. Hence it shows that mixing of matrix with the fillers does not give any new peaks in the composites. The interaction occurs in the composites had been stated previously by Ray and Rout [8] such as mechanical anchoring, interaction between natural fillers and resin where –OH group in matrix (UPR) backbone provide an area to hold hydrogen bonding with natural fillers which contain many hydroxyl groups inside and attractive molecular forces (Van der Waals force and hydrogen bonding). The possibility interaction between matrix and fillers is shown in Fig. 3. Since each of EFBPO and cellulose contains hydroxyl groups, both of them would have similar interaction with the matrix. Fig.4 shows the scanning electron microscope (SEM) analysis of impact fracture of composites. It shows that the addition of fillers reduce the amount of void in the matrix. From both composites’ fracture, it shows the fiber pull out from the matrix. Fig.4 (b) and (c) shows the fiber pull out of UPR-EFBPO composites and UPR-cellulose composites. In UPR-EFBPO composite, it can be seen that the EFBPO fiber has more size diameter compared to cellulose in UPR-cellulose composite which its fiber pull out consists of several fibrils. This form difference between EFBPO and cellulose.
could lead in difference of energy absorbed in each of composites which EFBPO would absorb more energy to break it down compare to cellulose. Therefore UPR-EFBPO composite must have higher impact value than UPR-cellulose composites. The SEM analysis is shown in Fig.4.

**Figure 3.** Possibility Interaction Between Matrix and Natural Fillers [8]

As addition data of this study, the thermo gravimetric analysis (TGA) of EFBPO, cellulose, UPR-EFBPO 80/20 and UPR-cellulose 95/5 is done and shown in Fig.5. Fig.5 shows that TGA curves of the materials exhibit three mass loss steps. The initial mass loss of EFBPO and cellulose is below 225°C while for UPR and both composites the initial mass loss is below 325°C which is due to loss of volatile material and loss of moisture [11]. In the second step, the natural fibers are decomposed due to degradation of its inside material to become a volatile material [11] between 225°C and 375°C. Meanwhile for UPR and both composites, degradation of materials is due to decomposition of matrix and fibers between 350°C-450°C. In the final step, natural fiber has transformed into ash which marked by constant mass loss while UPR and both composites still have remain mass loss. The degradation is due to decomposition of aromatic chain, methane (CH₄), CO₂, and CO release and structural rearrangements [12]. Table 1 gives the thermal data of TGA curves. From Table 1, it can be seen that UPR has more thermal stability compared to composites. This is due to cross-linking process in UPR when cured process occurs, hence the polymer network becomes denser and it needs more thermal energy to break down the network [9]. When natural fillers filled into the matrix, it causes the thermal stability of composites formed decreases because the natural fillers have low thermal stability. From both composites, it can be seen that UPR-cellulose composite has more thermal stability than UPR-EFBPO composite due to its more degree of crystalline in cellulose than EFBPO when EFBPO is having bleaching and pulping process produced cellulose.
Conclusion
(1) UPR-EFBPO composites have higher impact strength than UPR-cellulose composites.
(2) In both composites formed, interaction occurs such as mechanical anchoring, hydrogen bonding and Van der Waals forces.
(3) UPR still has the higher thermal stability than its composites due to “undisturbed” cross-linking in polymer network

References