The Influences NaOH Treatment on Polypropylene/Cyperus Odoratus (PP/CY) Composites: Tensile and Morphology

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Abstract. The bio-plastic composite has attracted the attention of people who work in academic and industrial fields due to the several advantages of this composite as compared with conventional plastic composites. However, the modification of the natural filler used in the bio-composites usually needs a modification before use. In the current work, the chemical modification on Cyperus Odoratus (CY) using different sodium hydroxide (NaOH) concentration at 1, 3, 6 and 9 wt.% were used to investigate the effect of this modification on the tensile properties of Polypropylene/Cyperus Odoratus (PP/CY) composites. The extrusion and injection molding processes were used respectively to prepare the composites. Results suggest that the presence of NaOH, particularly 3 wt.% has improved the tensile strength and the elongation at break of the composite. By contrast, the high NaOH concentration, particularly 9 wt.% has affected negatively on this properties. The tensile modulus increased linearly as NaOH concentration increased in the composites. The SEM micrograph of treated specimens at 3 wt.% NaOH shows improvement on CY surface while 9 wt.% NaOH shows deterioration on the DS surface.
1. Introduction

Nowadays, polymer Composites (PC) is used extensively in the industry to enhance the product properties. Normally, the composite materials contain two phases which are primary and secondary phase. Primary phase is the matrix while the secondary phase is reinforcement, which is the imbedded phase. The uses of natural fiber for the reinforcements have attractive the attention of both sectors in industry and academy due to the significant advantages of natural fiber as compared with synthetics fiber [1-3]. *Cyperus Odoratus* (CY) is one of the natural fibers that can be located near the paddy field. It does not give any benefits to the farmer. *Cyperus Odoratus* (CY) can be an attraction to the dangerous animal such as snake in the paddy field. Thus, it can be harmful to the farmer. This plant cans also bothering the growth of paddy plant. It will be such a waste if this plant is cut and being thrown away.

When the natural filler is use as the reinforcement of the composite, there will be some disadvantages such as lignocellulosic fiber contain high level of moisture absorption, poor surface adhesion to hydrophobic polymer, low processing temperature permissible ad many more [4-6]. The main problem is because these filler have strong hydrophilic character, which make the interfacial adhesion between this type of filler and hydrophobic polymer matrix poor.

The chemical modification is the common method used to improve the performances of natural fiber reinforced composites by linking the gap in compatibility between hydrophilic natural fibers and hydrophobic polymer matrix [4,8]. The chemical modification using alkaline is a simple and efficient treatment that can enhance the adhesion between lignocelluloses fiber and polymer matrix [8,9]. Rong et al. 2001, studied the effect of alkaline modification on the mechanical properties of sisal/epoxy composites. Results showed that the alkaline modification introduced some reactive groups and provide the fibers with higher extensibility through partial removal of lignin and hemicellulose, which in turn effected positively on the mechanical properties of the composite [10].

In our current research, we have investigated the effect of different NaOH concentration as an alkaline treatment on the tensile properties of polypropylene/Cyperus Odoratus (PP/CY) Composites.

2. Experimental

2.1. Materials

Polypropylene was used as a matrix in this study. It was obtained from Titan Polymer Sdn. Bhd., Malaysia. The *Cyperus Odoratus* (CY) was used as a natural fiber, which was obtained from Hutan Kampung, Jitra, Kedah, Malaysia.

2.2. Preparing of Cyperus Odoratus

The leaves of CY were initially dried under sunlight for 2 days. After drying, CY were cut, ground and sieved at 0 - 63μm particle size. The ground CY were then dried using vacuum oven at 60 °C for 8 hours. After drying, the ground CY were treated using different NaOH concentration at 1, 3, 6 and 9 wt.% respectively.

2.3. PP/CY composites fabrication

The polymer matrix (PP) and treated natural fiber (CY) were mixed together at fixed PP/CY ration (95/5) with different NaOH concentration at 1, 3, 6 and 9 wt.% respectively. Twin Screw Extruder was utilized for extrusion process according to ASTM D4101-14e. The Extruder screw speed was at 120 rpm and the temperature feeding zone, mixing zone, reacting zone and die zone were 175, 190, 190, and 180°C, respectively [11]. After that, the extrudate were molded using injection-molding process. Standard tensile dumbbells (ASTM D638) were used in Battenfell Injection Molding Machine with temperature profile from feed to exit die zone at 150, 165, 170 and 175°C respectively.
2.4. Tensile properties
According to ASTM D638, the tensile test was carried out using universal tensile testing machine (Instron 5569) and the dumbbell shaped samples was used for this test with a crosshead speed at 50mm/min and 25 ± 2 °C. The tensile strength, elongation at break and Young’s modulus were reported. The average value of the tensile properties was obtained from five specimens.

2.5. Scanning electron microscope
The tensile fracture surface of the samples were examined using scanning electron microscope (SEM), model JSM-6460LA. The samples were platinum coated to enhance the micrograph resolution and also to reduce the electrical charging during analysis.

3. Results and discussion
3.1. Tensile properties
The influence of different NaOH concentration on the tensile strength, elongation at break and tensile modulus of PP/CY composites are shown in Figure 1a, b and c respectively. It can be observed clearly that the addition of NaOH up to 3 wt.% has increased the values of the tensile strength and elongation at break (Figure 1a and b). This is due to the improvement on the fiber surface caused by NaOH solution. Mishra et al. reported that the addition of NaOH up to 5% into natural fiber/ polyester composite have improved the tensile strength while the high NaOH concentration such as 10% NaOH have effected negatively on the properties of the composites. The high concentration of NaOH increased the delignification of natural fiber, which in turn leads to damage of fiber structure [12]. Other researcher, such as Jacob et al. assessed the effects of different concentration of NaOH (0.5, 1, 2, 4 and 10%) on the properties of sisal fiber-reinforced composites. Their results concluded that the maximum tensile strength value was 4% of NaOH [13]. Therefore, the values of tensile strength and elongation at break of PP/CY composite decreased steadily after 3 wt.% of NaOH concentration. However, The high concentration of NaOH, particularly 9 wt.% shows higher tensile modulus than other NaOH concentration (Figure 1c). This could be attributed to the high hydrogen bonding disruption in the network structure causing increases in surface roughness of the natural fiber. The roughness of the fiber surface improves the interaction between fiber and polymer matrix, which in turn make the composite stiffer and more rigid [14]. Thus, the tensile modulus value has increased.
Figure 1. The effect of NaOH concentration on the (a) tensile strength, (b) elongation at break and (c) tensile modulus of PP/CY composites

3.2. Morphology
The scanning electron micrographs (Figure 2 a and b) show the tensile fractured surfaces of treated PP/CY composites at 3 wt.% and 9 wt.% NaOH concentrations respectively. The SEM micrograph of treated LLDPE/DS composite with low NaOH concentration (3 wt.%) shows relatively smoother CY surface and stronger interfacial bonding between CY fiber and PP matrix. Nevertheless, the high NaOH concentration, particularly (9 wt.%) shows rough surface (Figure 1 b) indicating that the high NaOH concentration increased the delignification of natural fiber (CY), which in turn lead to damage of fiber structure [15-17].
4. Conclusion
The fabrication of bio-plastic composites such as Polypropylene/Cyperus Odoratus (PP/CY) composites can give a great opportunity to the manufacture of green plastic products. Nevertheless, the mechanical properties of this composite were relatively poor. Consequently, the chemical modification using NaOH was necessary to improve the properties. The using of low concentration (3 wt.% of NaOH gave better tensile properties compared with control and other NaOH concentration. The SEM micrograph of treated composite with 3 wt.% NaOH shows strong interfacial bonding between CY fiber and PP matrix, which reflected positively on the tensile properties of the composite.
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