The Effect of *Cyperus Odoratus* Size and Loading on the Properties of Polypropylene/*Cyperus Odoratus* (PP/CY) Composites

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Abstract. In this research, a new bio-plastic composite was developed using *Cyperus Odoratus* (CY) as natural filler along with Polypropylene (PP) matrix. PP/CY composites were prepared using different CY size, fine size at (0-63) and coarse size at (150-250) and using different PP/CY ratio at (100/0, 95/5, 90/10 and 85/15). The extrusion process followed by injection molding process was conducted for PP/CY composites fabrication. The tensile and morphological characteristics of PP/CY samples were evaluated. The results suggest that the addition of CY content (fine size) up to 95/5 PP/CY ratio gave highest tensile strength (TS) value. The increasing of CY content, particularly CY coarse size into PP/CY composites has decreased the TS. By contrast, the high CY content, particularly CY coarse size shows highest Modulus indicating that the sample became stiffer and more rigid. The increasing of stiffness and rigidity of PP/CY composites as CY content increased has reduced the flexibility. Therefore, the elongation at break of the composites decreased. The tensile fractured surface of composites was evaluated using SEM analysis. SEM micrographs show that the low CY content, particularly CY fine size was well bonded in PP matrix in contrast to high CY content, particularly CY coarse size.
1. Introduction
The composite materials are usually used to improve the properties of products. Generally, the composite materials comprise two or more physically distinct phases and this combination produce aggregate properties, which can be different from its constituents [1,2]. Currently, the polymer composite (PC) products are extensively used in several applications due to the advantages of these products such as lightweight, high stiffness and high strength compared with the original constituent [3-5]. Moreover, PC can also enhance the chemical, thermal and physical properties along with the mechanical properties [6]. The utilization of natural fiber as reinforcement materials has attracted much attention in both industrial and academic field due to the significant advantages over synthetics fiber such as low cost, low density, non-abrasive to the equipment, non-irritation to the skin, reduced energy consumption, less health risk, recyclability, sustainability and biodegradability [7-9]. There are numerous kinds of natural fibers spread widely in the nature, particularly in tropical area such as kenaf, flax, jute, hemp, sisal, banana, kapok, henequen, coir, grass, wheat and many others. Furthermore, the waste of natural materials can also be use as natural filler to improve some properties of polymer composites [6,10]. *Cyperus Odoratus* (CY) or fragrant flats edge is a plant that can be found in most tropical and warm temperate areas such as the South America, southeastern Asia, Australia and parts of Africa. In Malaysia, this plant can be easily found in big amounts in wet areas such as lakes and abandoned paddy fields. The height of CY can extend up to 1.0 - 1.5 meters short time, which make CY a sustainable plant. Based on recent researches, natural fibers are valuable materials that are use as reinforcing agent in polymer-based materials [11,12]. It is also become a valuable alternative to synthetic fibers for various industrial applications [8]. Therefore, the aim of the current research is to evaluate the different amount and size of *Cyperus Odoratus* as natural fiber on the tensile properties of Polypropylene / *Cyperus Odoratus* Composites.

2. Experimental

2.1. Materials
*Cyperus Odoratus* (CY) was collected from Hutan Kampung, Jitra, Kedah, Malaysia. Polypropylene was purchased from Titan Polymer Sdn. Bhd., Malaysia.

2.2. *Cyperus Odoratus* preparing
First, CY leaves were dried under sunlight for 2 days. The dried CY were cut, ground and sieved into two different size, 0 - 63μm, and 150 - 250μm respectively. After sieving, ground CY were dried using vacuum oven at 60 oC for 8 hours.

2.3. Composites fabrication
The PP matrix and ground CY were mixed together in 100/0, 95/5, 90/10, 85/15 and 80/20 ration of PP/CY composites using Twin Screw Extruder according to ASTM D4101-14e. The screw speed of the Extruder was 120 rpm while the temperature-feeding zone, mixing zone, reacting zone and die zone were 175, 190, 190, and 180°C, respectively [13]. After cut it into pallets shape, the pallets were introduced through 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
The tensile test was conducted according to ASTM D638 using universal tensile testing machine (Instron 5569). The dumbbell shaped specimens 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 specimens were analyzed using scanning electron microscope (SEM), model JSM-6460LA. The specimens were platinum coated to increase the resolution of the micrograph and to avoid the electrical charging.

3. Experimental Results and Discussion

3.1. Tensile properties

The tensile strength value of PP control and PP/CY composite at different CY loading and size are shown in Figure 1,a. From the graph below, it shows decrease in tensile strength in the overall trends of PP/CY composites for both CY fine and coarse size as the CY content increased. This was probably due to the amount of the plastic as adhesive decrease when the filler content in the composite increase. The high CY content, particularly 15wt% of CY coarse size shows the lowest reading of tensile strength at 23.94 MPa. This is attributed to the CY aggregation inside PP matrix, which in turn effected negatively on the stress transition from PP matrix to CY filler during tensile strength test. However, the low CY content, particularly 5wt% of the CY fine size shows the optimum tensile strength reading at 31.28 MPa. The relatively small particle size and high distribution of 5wt% of the CY fine size contributed to a strong interfacial adhesion between PP matrix and CY fiber, which in turn increased the strength of the composite [14,15].

Figure 1,c illustrates the tensile modulus of PP control and PP/CY composites. The tensile modulus of the composite increased slightly with the increasing of CY content. CY filler have higher stiffness than PP matrix, which in turn contributed to the increases in the tensile modulus of the composites as shown before in Figure 1,c. The increasing of modulus led to decreasing in flexibility. Our previous researches reported that the increasing in the tensile modulus was due to the increase in the rigidity as well as the intermolecular interaction between polymer matrix and the natural filler, which in turn led to decrease in flexibility [16,17].
3.2. Morphology

Figure 2 (a) and (b) shows the morphological comparison of the tensile fractured surface of PP/CY composites at 5wt% CY content in both CY fine and coarse size respectively. In figure 4 (a), the SEM micrograph shows better dispersion of CY, which in turn resulted a good stress concentration. Therefore, the ductility phenomenon has occurred causing increases in the tensile strength of the composite. The SEM micrograph of Figure 4 (b) shows the relatively big particle size of CY that was detached from PP matrix. The gap between CY filler and PP matrix are big compared to CY fine size. However, it still can be seen that CY was bonded on to the matrix [17,18].

Figure 4 (c) and (d) illustrate SEM micrograph of PP/CY composite at 15wt% CY content at fine and coarse sizes respectively. In both figures, it can be observed clearly the CY filler detachment from PP...
matrix. The poor adhesion between PP matrix and CY filler created weak interfacial regions, which can result in debonding and frictional pullout [19,20].

![Figure 2. The SEM micrographs of tensile fractured surface of PP/CY composite at (a) 5wt% CY fine size, (b) 5wt% CY coarse size, (c) 15wt% CY fine size and (d) 15wt% CY coarse size](image)

4. Conclusion
From this research, it could be concluded that the *Cyperus Odoratus* (CY) was successfully used as natural fiber to improve polypropylene tensile properties. However, the high CY content and/or coarse CY size is not recommended due to the deterioration of tensile properties of PP/CY composite caused by CY high content and coarse size.

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