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EFFECT OF COUPLING AGENT ON MECHANICAL PROPERTIES OF COMPOSITE FROM KENAF AND RECYCLED POLYPROPYLENE

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ABSTRACT

This study shows the effect of using Maleated polypropylene (MAPP) as coupling agent on composites of RPP/kenaf fibre. Grinded fibre was compounded into recycled polypropylene with and without MAPP using a twin-screw compounder. The incorporated fibres in the composites were up to 50 wt%. The compounded samples were prepared into test specimens by injection moulder. The composites were characterized by tensile strength (TS), tensile modulus (TM), melt flow index (MFI). Incorporation of coupling agent had shown better result than that of without coupling agent to a certain level of fibre loading.

Key Words: composite, Recycled Poly Propylene (RPP), kenaf, coupling agent.

INTRODUCTION

Kenaf (*Hibiscus cannabinus* L.) is one of the world's leading sources of bast fibre in the cottage industry. However, the demand for kenaf as a substitute to jute in the fibre industry has encouraged its production to a commercial level in this area. The use of natural plant fibers as a reinforcement in fiber-reinforced plastics (FRP) to replace synthetic fibers such as glass is receiving attention, because of advantages such as renewability, low density, and high specific strength. In addition to that, such fibres have high specific properties such as stiffness, impact resistance, flexibility, and modulus. The first growing interest nowadays has focused on thermoplastic composites reinforced with lignocellulosic and cellulosic based materials [1-3]. Lignocellulosic materials are considered as new generation of reinforcing materials with thermoplastics since they are renewable natural resources. Furthermore, lignocellulosic materials, due to the strong cellulose backbone structure, possess good strength properties and the favourable strength/weight-ratio of the fibre is an advantage compared to other conventional reinforcing materials. The natural fibre reinforcing thermoplastic composites provide attractive new value-added markets for agricultural products; on the other hand reduce the consumption of petrochemical-based plastic resins and also increase the biodegradable nature of the thermoplastic materials.

The utilization of lignocellulosic materials in production of polymeric composites is attractive particularly because of low cost and high volume applications. Biodegradable lignocellulosic filler posses several advantages compared to inorganic fillers, such as lower density, greater deformability, smaller abrasiveness, high stiffness, reduce dermal and respiratory irritations, good thermal properties, enhance energy recovery and relatively lower cost [2-9]. The uses range from automotive interior components [3] to geotextile [4]. Short fibre reinforced polymeric composite have gained importance due to considerable processing advantages and improvement in certain mechanical properties [5]. At present there are different types of plant based natural fibres are being used as reinforcing agent with thermoplastic resins. Among the plant based fibres flax, hemp, jute, straw, wood, bamboo, baggase, kenaf, sisal, coir, banana are most common [6-8]. It is shown that incorporation of fillers as reinforcing materials significantly changes various properties of thermoplastics [7,8]. Numerous studies carried on other wood-based filler also have been reported by a number of researchers [9,10]. This study investigates the effect of fibre loading and coupling agent on the properties of RPP/kenaf composites.

The main disadvantage of natural fibre is its hydrophilic nature that lowers the compatibility with hydrophobic polymeric matrices. It also presents poor environmental and dimensional stability that prevents a wider use of natural fibre composites [11]. Cellulose fibres contain many hydroxyl groups (-OH) and readily interact with water molecules by hydrogen bonding. Swelling of water lead to micro-cracking of composites and degradation of mechanical properties [5]. It is difficult to entirely eliminate the absorption of moisture in composites without using expensive surface barriers [12]. Good wetting of the fibre by the matrix and adequate fibre–matrix bonding can decrease the rate and amount of water absorption in the interface region of the composite [13]. Optimization of interfacial adhesion between cellulose-based fibres and thermoplastics has been the focus of a large amount of research conducted during the last two decades [14]. Coupling agents in wood fibre reinforced plastic composites play an important role in improving compatibility and adhesion between polar wood fibre and non-polar polymer matrices by forming bridges of chemical bonds between the fibre and the matrix. So far, more than forty coupling agents have been used in production and research. Among them, maleated polypropylene (MAPP) is the most popular one [15]. Beg et.al and John et.al studied coupling agent performance in wood-fibre reinforced high-density-polyethylene composites [16], and found that the improvement on the interfacial bonding strength, flexural modulus, and other mechanical properties was mainly related to the coupling agent type, functional groups, molecular weight, concentration, and chain structure. The maximum value of interfacial adhesion was achieved with 3 wt % concentration level for most maleated composites. Sonia et. al. reported that silane-modified polymer increased the interfacial adhesion between the fibre and the matrix and this effect was better than that obtained for the maleated-polypropylene-coupled composites [17].

Although a great deal of research over the past decade has demonstrated the efficiency of the use of coupling agents in wood plastic composites [18,19,20,21]. Figure 1 and 2 showing the very raw kenaf fibre. Recycled poly propylene we may can use to upgrade the utilization of recycled polymer to an useful composite, which is another concentration of this study. The specific objectives of the work were to:

- Study the effects of different types fibre loading obtained from kenaf.
- Study the effects of coupling agents on the mechanical properties of composites

Figure 1: The very raw kenaf fibre exposed to open yard for drying.

Figure 2: The greenish look kenaf fibre just from the Kenaf Decorticator Machine.

EXPERIMENTAL

Materials

The recycled polyprolylene called commercially PP Black copo - mainly from car bumper and vehicle battery case and of MFI : 5 to 10. The coupling agent used was maleated polypropylene Epolene E43 produced by Eastman Chemical Company. Molecular weight and acid number of E43 was 9100 and 45 respectively. Kenaf was used as natural fibre collected from Pahang-one state of Malaysia.

Methods

Preparation of Composites

The kenaf fibre was dried at 80^{o}C until reached the moisture content of below 5%. The fibre were compounded into recycled polypropylene by means of a Brabender DSK 42/7 twin-screw compounder having barrel temperatures from 170^{o}C to 190^{o}C from the feeding zone to the die zone, respectively. The fibre was oven dried at 105^{o}C for 24 hours prior to compounding in order to achieve a moisture content of less than 5%. Five levels of loadings were prepared for all composites. The incorporated fibre contents for kenaf fibre composites were 10, 20, 30, 40 and 50%% (by weight). The mixture was then extruded and pelletized. The compounded samples were prepared into test specimens by injection moulder using a 20-ton Battenfeld BA 200CD Plus machine, with a UNILOG 4000 control system (closed-loop control). A mould from Master mold Inc., having cavities for tensile specimens according to ASTM D638 Type 1 and rectangular bar, 125mm x 12.5mm x 3.13mm, was used for production of test specimens.

Tensile Tests

Tensile tests were carried out using an Instron machine with a load cell of 5 kN. Tests were performed as specified in ASTM D 638 - Type I: Test method for tensile properties of plastic. The gauge length was 50 mm and the crosshead speed of testing was 50 mm/min. Five specimens were tested for each batch. Tensile modulus (TM) and tensile strength (TS) were taken for analysis.

RESULTS AND DISCUSSION

Figure 1 showed the tensile strength of RPP is 23 MPa where as that of RPP/kenaf is increased with loading of fibre and also with the coupling agent. The maximum tensile strength found at 40% fibre loading (figure 1) but the maximum tensile modulus was at 30% fibre loading (Figure 2).

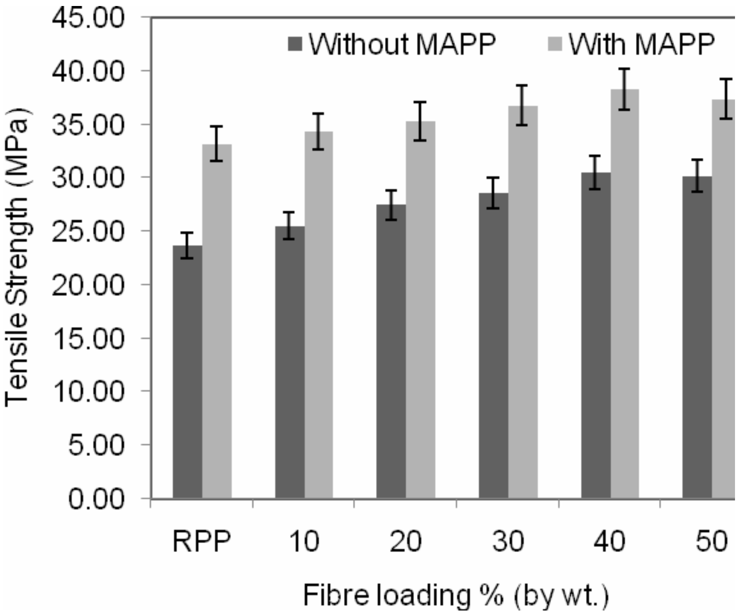

Figure 3. Tensile Strength of RPP and RPP/Kenaf composite with and without coupling agent at different fibre loading.

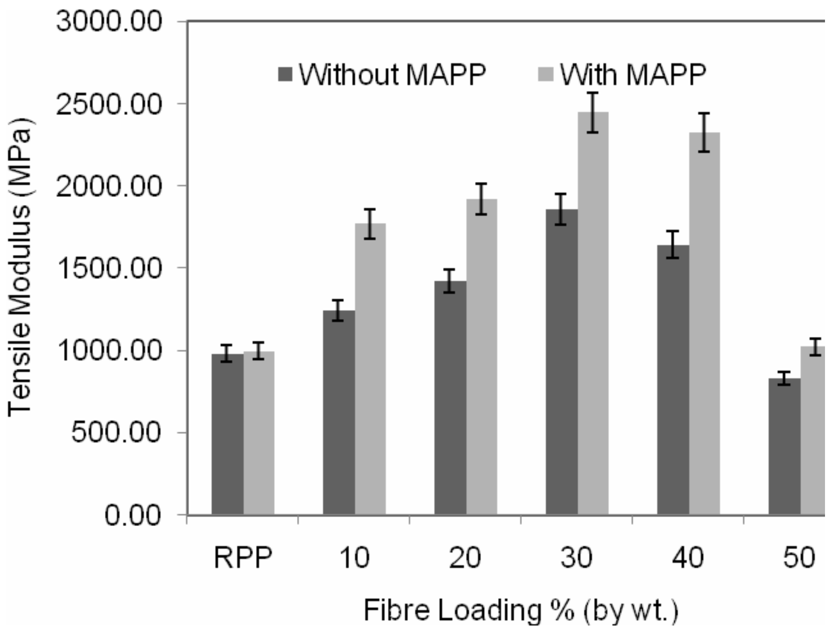

Figure 4. Tensile Modulus of RPP and RPP/Kenaf composite with and without coupling agent at different fibre loading.

CONCLUSIONS

It was found that using MAPP has a significant effect on composite properties. Fibre loading at both 30 and 40% also showed very good result regarding tensile strength and tensile modulus. Using MAPP it showed the tensile strength for each category increased by nearly 10MPa which is more interesting and the same proportion for the tensile modulus.

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