Development of A New Kenaf Bast Fiber-reinforced Thermoplastic Polyurethane Composite

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Natural fiber-reinforced polymers are attracting more notice due to benefits such as less abrasiveness to equipment, renewability, biodegradability, and reduction in weight and cost. Polyolefins have been widely used in natural fiber composites. Polyolefins have lack of compatibility with natural fibers. The reason behind the incompatibility is the hydrophobic nature of polyolefins and the hydrophilicity of natural fibers. This article will highlight new kenaf bast fiber-reinforced Thermoplastic Polyurethane (TPU) composite. In case of TPU this incompatibility barrier will not take place because of its hydrophilic nature.

No previous research has been done on natural fiber reinforced with TPU; however TPU has been compounded with synthetic fibers such as glass, aramid, and carbon fibers. TPU is more expensive than most polyolefins used in the field of natural fiber composites. Meanwhile, it has unique properties when compound with natural fibers. One of the most important properties that can be found in the TPU when compound to natural fibers - that is not found in polyolefins natural fiber composites - is the high strain. TPU-natural fiber composite can reach 35% strain without any treatment, while most polyolefins natural fiber composites cannot reach 10% strain. With some treatment TPU/KF reached 70% strain.

Kenaf (*Hibiscus cannabinus* L.), a fiber very similar to jute, is produced in small quantities of around 500,000 tons annually. In 1960, The United States, Department of Agriculture selected Kenaf as the top candidate for intensive utilization research after screening more than 500 plant species for their potential in pulp and paper making. Kenaf has a short growing period, high biomass output and good mechanical properties. It reaches 3-4 meters in 4-5 months. It can yield two or three harvests a year in tropical climates. It can produce 5-10 tons of dry fiber per acre. Two types of fibers can be extracted from this plant; bast fiber which is the outer layer, and core fiber which is the inner layer. Bast and core fibers are significantly different. Bast fiber represents nearly 1/3 of the plant and core represents the rest. These two parts have different applications. The bast fibers have been used traditionally in the manufacture and trade of cordage products such as burlap cloth, twine, and ropes.

Kenaf is planted commercially in China, Myanmar, India, Bangladesh and Thailand. Malaysian government has paid more attention towards planting Kenaf. It is a candidate to replace tobacco. Malaysia Tobacco Board (MTB) will be renamed to become Malaysia Kenaf and Tobacco Board, to facilitate the way for farmers to plant Kenaf instead of tobacco. Since 2000, more than RM 48 million have been spent by Malaysian government on research of Kenaf plantation and utilization.

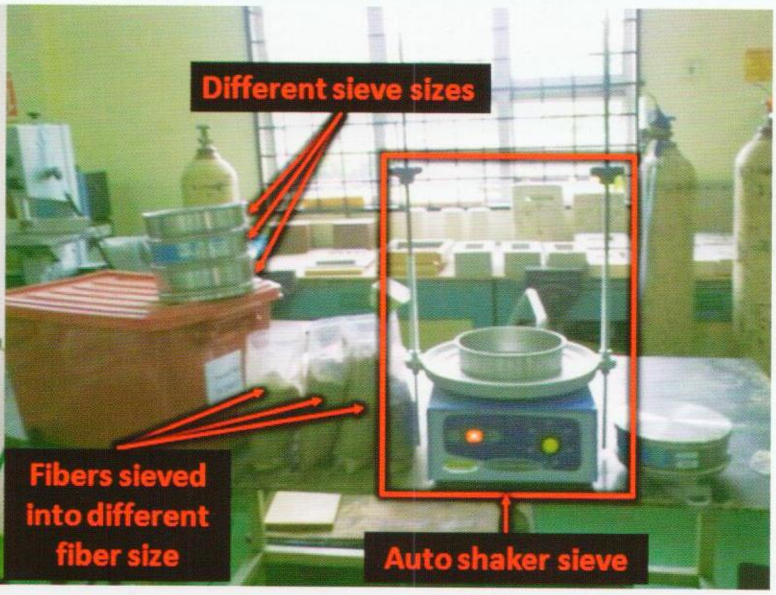
In general, polyurethane is a combination of polyols and isocyanates. Polyols represent the soft segments, and isocyanates represent the hard segments that impart rigidity to the polymer. Isocyanates are petroleum driven and the most used isocyanates are toluene diisocyanates TDI and diphenylmethylene diisocyanate MDI. Polyols are divided into two groups: petroleum and bio-based. Petroleum polyols can be classified into three groups: polyether, polyester and polycarbonate polyols. Polyether polyols represent 90% of the commercially available polyols. Bio-based polyols are derived from renewable resources such as plant oils, wood, carbohydrates, lignin, cashew shell, and cork. Polyurethanes can be both a thermoplastic (TPU) and a thermoset (PU). The most important difference between both is that thermoplastics are linear polymers, which normally need no cure during consolidation into a composite. TPUs are reformable, therefore recyclable. PUs are crosslinkable polymers, and not reformable.

TPU is available, as most thermoplastics, in pellet form. Both non-reinforced and reinforced pellets can be purchased commercially. The reinforced pellets contain very short fibers up to about 35% loading. Polyurethane has got a vast range of applications. Automotive, construction, furniture and mattress, and technical insulation industries are the major consumers of polyurethane. Polyurethane has also been used in biomedical, coatings, adhesives and composites. TPU is a material that is categorized under the thermoplastic elastomers. It can be recycled due its ability to reform if reheated.

In order to develop TPU/Kenaf new composite two main steps has been done. First, optimizing processing parameters, such as, temperature, speed and time were optimized. Second step was optimizing the fiber size. Bast fiber was extracted by mechanical decortication. Fiber was pulverized using a Fritsch Pulverisette mill. Pulverized fiber was sieved using an auto shaker sieve into three different sizes. TPU/Kenaf composite was compounded using a Haake Polydrive R600 internal mixer. Matrix was charged into the mixer until torque was stabilized, and then fiber was added into the mixer. A 30% fiber loading was fixed throughout the study. The sample was hot pressed using Vechno Vation 40 ton compression molding.

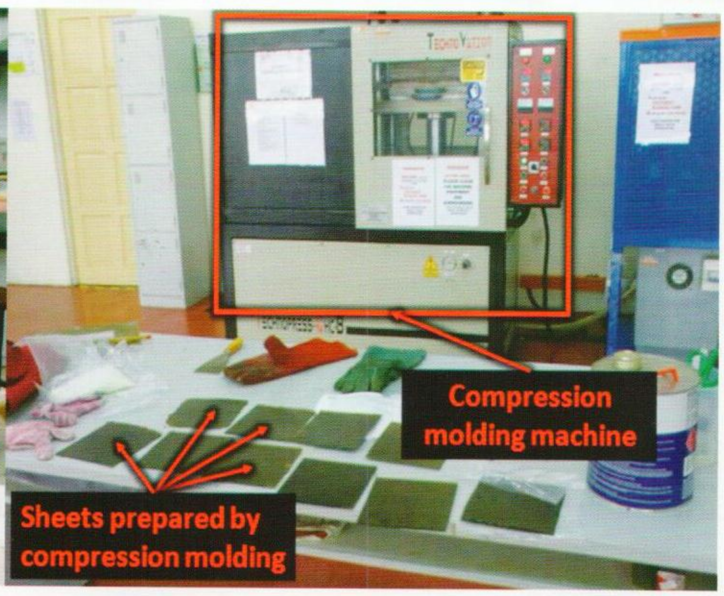
The development of a new TPU/KF composite was successful. Changing various processing parameters (i.e. temperature, time, and speed) showed significant changes in the tensile properties. Optimum values 190 °C, 11 min, and 40 rpm, of temperature, time and speed, respectively, were chosen based on the best tensile strength of 33.5 MPa. Different fiber size showed significant changes in the tensile and flexural properties and impact strength. Fiber sizes in the range between 125 and 300 μm exhibited the best tensile and flexural strength and modulus. A larger fiber size showed only a slight increment of impact strength of about 7%. Therefore, a fiber size between 125 and 300 μm was considered to be the optimum size amongst the three size ranges examined.

Mill Used To Pulverize The Fibers



Auto Shaker Sieve

Internal Mixer



Compression Molding Machine

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