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Effect of Strain Rates on Tensile Properties of Kenaf Fiber and Rice Husk Silica Reinforced Polypropylene Composites

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Abstract: The expanding interest for eco-accommodating materials, expanding exhaustion rate, and squeezing ecological controls have all set off a developing enthusiasm toward the field of composites. There is a demand for composites that have excellent mechanical characteristics, but also low cost, environmentally friendly and lightweight. The aim of this research is to investigate the behaviour tensile under elevated strain rates of kenaf fiber and rice husk silica reinforced polypropylene composites at different grades of rice husk silica (89.09% and 94.05%) content. The samples of composite materials were prepared by using injection molding at different composite percentage of kenaf fiber, rice husk silica and polypropylene composites. The composite materials at the best composition ratio of kenaf fiber and rice husk silica were tested for tensile stresses. Overall 20 wt.% kenaf fiber and 20 wt.% rice husk silica with high silica content show the best result of yield stress, ultimate tensile strength and elongation with 20.31MPa, 20.86MPa and 13.05% compared to others composites percentage. The result shows that 2nd grade with high silica content of rice husk silica has better behaviour with increases the yield and ultimate tensile strength compared to results of 1st grade of rice husk silica.

Keywords: Kenaf fiber, rice husk silica, polypropylene, strain rates

1. Introduction

The expanding interest for eco-accommodating materials, expanding exhaustion rate, and squeezing ecological controls have all set off a developing enthusiasm toward the field of composites. Many researcher and industrial nowadays research on machining to improve the performance of production, space utilization, and reduced production cost [1-4]. Materials made of two or more components are called composites to enhance the effectiveness of the existing components. Polymer composites usually consist of a polymer resin when the matrix and one or more fillers are added to fulfil certain objectives or demands [5].

In the previous decades, manufactured filaments, for example, glass or carbon strands have been utilized to strengthen composites of polymer. Be that as it may, with the developing worldwide ecological concerns, moderate biodegradability is their drawback [6]. In this way, researchers are finding other conceivable ways to deal with enhance polymeric composites biodegradability. Natural fiber bio-composites have many advantages, including low costs, sustainability, renewability, good formability, good thermal insulation, eco-friendly, lightweight, processability,

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and safety for health. However, it has some disadvantages, such as hydrophilicity, poor thermal stability, and poor fiber/matrix interfacial adhesion, which can be solved by using compatibilizers or chemical treatment [5,7].

Polypropylene has applications in many areas such as automobiles, aerospace, packaging, and household goods. Polypropylene is a material that lightweight, low cost and linear-olefin commodity thermoplastic with good process ability. Polypropylene is also heat and chemical resistance, making it appropriate for many applications. Rice husk and kenaf materials strengthened in polypropylene will enhance several properties resulting in composites reported by many researchers. For example, in a study by Yang et al., it showed that the polypropylene matrix and rice husk bio-composite became more ductile and loosened as the test temperature risen [8]. They proposed that this issue could be decreased by using a compatible or bonding agent. Next, Akil et al. have reported that the corresponding tensile strengths of the 30-40 weight percentage kenaf polypropylene bio-composites are greater than sisal and coir, similar to hemp and flax reinforced PP bio-composites [9]. PP/KF bio-composites with 30 weight percentage kenaf gave greater modulus relative to other natural fibers such as hemp, flax, sisal, hemp, and coir.

Kenaf is one of the lignocellulose plants that can be produced in incredible weather conditions [10]. Kenaf which is one of business plants in Malaysia was picked as natural fiber for plastic reinforced because of its capacity to build the stiffness of the composites altogether [11]. A study by Rowell et al. and K. Siti Nor Azila et al., revealed that the 50 weight percentage tensile and flexural matrix of polypropylene composites mixed with kenaf fibers is roughly equivalent or higher than 40 weight percentage of glass fibers mixed with polypropylene composites [12, 13]. Rice husk is one of the rice milling agro-wastes [14]. Rice husk is an incredible thermal insulation due to the critical amount of silica content [15, 16]. Like kenaf, rice husk containing cellulose, hemicelluloses and lignin also improved the composite modulus. The quantity of hemicelluloses in rice husk can assist in the process of biodegradation. Bledzki et al., made a comparison between common different types of natural fibres such as wood, kenaf, abaca, microfibers, and jute fibres, as reinforcement in polypropylene bio-composites [17]. The results revealed that the kenaf fiber offered great strengths to their bio-composites. Based on previous studies, the properties of natural fiber enhanced polypropylene bio-composites were primarily affected by their mechanical properties [17, 22-23]. Many studies into the mechanical, physical, and thermal properties of rice husk and kenaf fiber reinforced polypropylene bio-composites and how this strengthening affects bio-composites have been undertaken as discussed in the accompanying sections. The polypropylene bio-composite properties are to a great extent rely upon the sorts and properties of the natural fibers used. The aim of the study is obtained the tensile properties of kenaf fiber with different grades of rice husk silica reinforced with polypropylene composites.

In this study, the application is focused on developing eco-friendly furniture by producing wood-free mainstream indoor furniture by using kenaf fiber and rice husk silica as reinforcement of polypropylene.

2. Experimental Material and Procedure

2.1 Materials

Kenaf fiber and rice husk ash were used as the composite materials that reinforced with polypropylene materials. Two grades of rice husk ash that have been used in this study have different chemical content as shown in Table 1 and Table 2. An X-ray Fluorescence analysis was used to characterize the chemical composition of rice husk ash.

Table 1 – Chemical composition of rice husk ash 1 (wt %).

SiO_2	K_2O	P_2O_5	CaO	MgO	SO_3	Cl	others
89.09	4.53	3.31	1.12	1.12	0.55	0.16	0.12

Table 2 – Chemical composition of rice husk ash 2 (wt %).

SiO_2	K_2O	P_2O_5	CaO	MgO	SO3	Cl	others
94.05	2.24	0.98	0.49	0.55	0.48	0.14	1.07

2.2 Preparation Composite Materials Sample

The composites volume percent between kenaf fiber, rice husk ash, and polypropylene were prepared, Table 3. All materials were melted and mixed by using brabender machine. Polypropylene, kenaf fiber and rice husk ash were weighed according to the required weight composite material composition using a high precision weighing machine.

Table 3 – Sample preparing for mixing process.

Material	Composition percentage (%)				
Kenaf Fiber	20	30	10	40	0
Rice Husk Silica	20	10	30	0	40
Polypropylene			60		

By referring to its standard melting point, the polypropylene melting temperature 173°C and melt flow index was at 10.5g/10 min at 230°C. The temperature setup for the composites was 190°C, allowing it to equalize for 30 minutes. The drum velocity was kept at 12 rpm. After that, polypropylene was then gently poured, allowing 5 minutes to thaw. After polypropylene was fully placed according to its weight composition, kenaf was randomly mixed by milligram, which completion of duration is 20 minutes. Rice husk silica was then added to the mixer. Finally, the composite mixture is removed quickly to prevent overheating. After the mixing process, crusher machine was used to crush the material into mild pieces.

2.3 Injection Molding

The composite mixture of the material has been injected with a temperature of 190°C by injection molding machine. The pelletizing raw material and colorant were decreased to a hot liquid by the molding machine. This melting was forced under high pressure into a cooled mold. The mold was unclamped after the specimen was fabricated and a sample was automatically ejected.

2.4 Tensile Test

Tensile test specimen was prepared follows to the standard of ISO 527. The universal testing machine (UTM) with 10N capacity of load cell was used to conduct the tensile test under strain rates of 5 mm/min, 25mm/min and 50mm/min to obtain the tensile properties of composites. Fig. 1 shows tensile test specimen geometry which follows with ISO 527 standards.

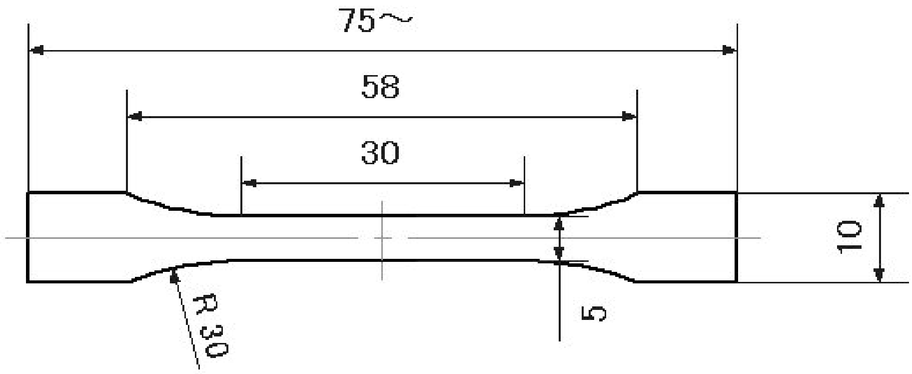


Fig. 1 – Geometry of tensile test specimen

3. Results and Discussion

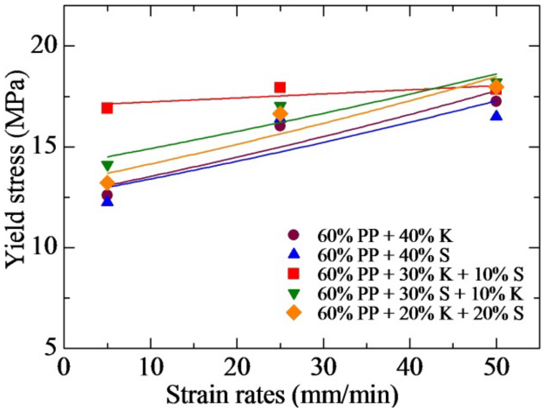
Fig 2 shows the effect of strain rates on tensile properties of composite materials between kenaf fiber, rice husk silica (89.09% and 94.05%), and polypropylene composites. The yield stress (MPa), ultimate tensile strength (MPa) and elongation (%) of composites sample were determined.

Refer to the results of 1st grade from Fig 2 – (a), its shows that the yield stress increase and increasing strength rate of composites materials. It's also shown similar results to the ultimate tensile strength, Fig 2 – (c), except ultimate tensile strength at 60% polypropylene+ 30% kenaf fiber+10% rice husk silica composite material. The higher percentage of kenaf fiber is sufficient to provide the composite with good mechanical properties [9,18].

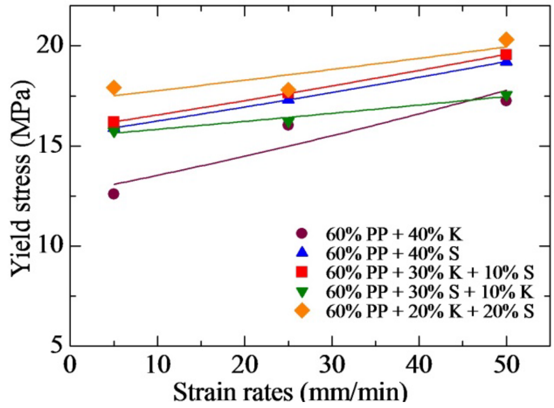
2nd grade of rice husk silica uses as composite material with kenaf fiber reinforced polypropylene shows that 60% polypropylene+20% kenaf fiber+20% rice husk silica, has good behavior at yield stress and ultimate tensile strength, Fig 2 – (b) and (d). The yield stress increase and increasing strength rate. The tensile strength and its Young's modulus exhibited an increasing trend for 20 wt% of kenaf fiber and rice husk content [19-21]. This proves that the addition of kenaf fiber and rice husk silica as reinforcement increase the tensile strength of composites. The elongation decreases as its ductile material. The range of its elongation is between 7.5 to 14.5%.

Overall, the results shows that 2nd grade of rice husk ash has better behavior material compared to 1st grade of rice husk silica. The higher silica content, the good the composite materials obtained.

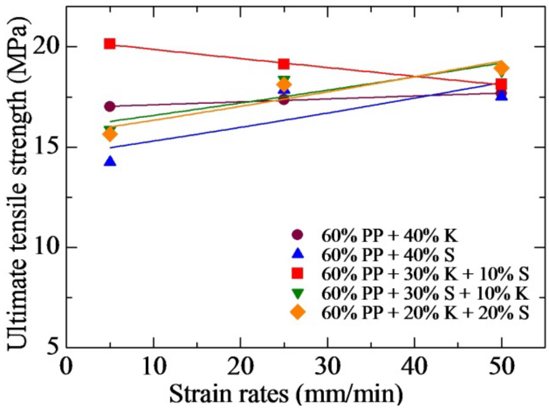
Rice husk silica 1st grade (89.09%)	**Rice husk silica 2nd grade (94.05%)**



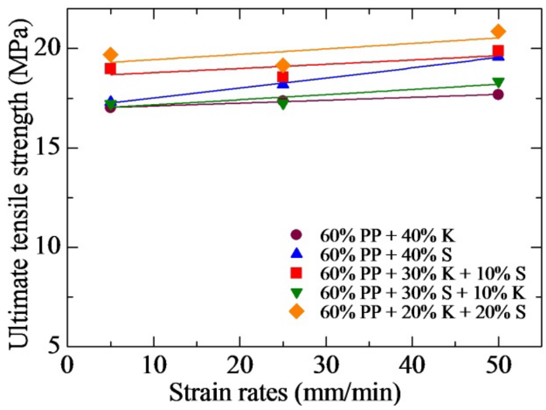
(a) Yield stress



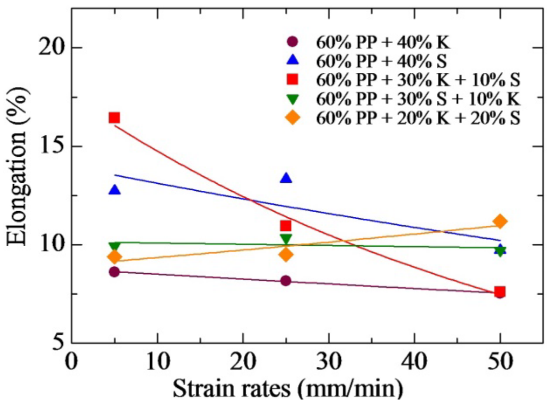
(b) Yield stress



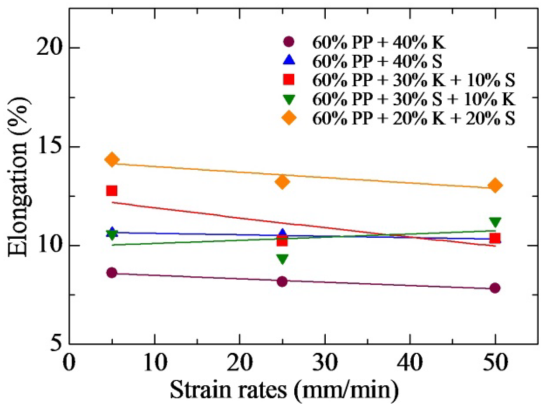
(c) Ultimate tensile strength



(d) Ultimate tensile strength



(e) Elongation



(f) Elongation

Fig. 2 –Tensile properties for composite kenaf fiber and rice husk silica reinforced polypropylene of (a) Yield stress at 1st grade; (b) Yield stress at 2nd grade; (c) Ultimate tensile strength at 1st grade; (d) Ultimate tensile strength at 2nd grade; (e) Elongation at 1st grade; (f) Elongation at 2nd grade.

4. Summary

The behaviour tensile under elevated strain rates of kenaf fiber and rice husk silica reinforced polypropylene composites at different grades of rice husk silica (89.09% and 94.05%) content were investigated. The tensile tests that carried out found that the best result of yield stress, ultimate tensile strength and elongation is in composition of 20 wt.% kenaf fiber and 20 wt.% rice husk silica with 20.31MPa, 20.86MPa and 13.05% compared to others composites percentage. High silica content which is 2nd grade shows the best result compared to 1st grade rice husk ash. This also proves that silica content of rice husk ash improves behaviour with increases the yield and ultimate tensile strength of composites.

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