Impact strength on fiber-reinforced hybrid composite

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Abstract. Acrylonitrile-Butadiene-Styrene (ABS) has been well known composite in automotive players to have light weight with high impact strength material compared to sheet metal material which has high impact strength but heavy in weight. In this project, the impact strength properties of fabricated pure ABS were compared to the eight samples of hybrid ABS composite with different weight percentages of short fibers and particle sizes of ground rubber. The objective was to improve the impact strength in addition of short fibers and ground rubber particles. These samples were then characterized using an un-notched Izod impact test. Results show that the increasing of filler percentage yielded an adverse effect on the impact strength of the hybrid composite. The effect of the ground rubber particle sizes however are deemed to be marginal than the effect of varying filler percentage based on the collected impact strength data from all physically tested hybrid composites.

1. Introduction
Acrylonitrile-butadiene-styrene (ABS) has been a popular material in major automotive players and other sectors [1-6]. The plastic’s composition flexibility makes it a suitable candidate for fabrication of composites where demands of engineering materials are steadily increasing over the past years [7-10]. Another aspect that drives the selection of ABS is its relative low cost to flexibility and overall durability compared to others engineering plastics or sheet metal [11]. The materials popularity has also disadvantage which they were non-environmentally-friendly wastage or disposal [7]. Various researchers have investigating the alternative to recycle the plastic or combine it with waste materials such as recycled PVC or ground rubber [1] to mitigate the problem. Ground rubber (GR) as ABS composite filler had garnered considerable interest, as it can potentially solve the problem of waste tire disposal and in the same time create a low-cost composite.

Another take to mitigate the impact of post-ABS usage is utilization of natural fibers to create fiber composites that uses renewable and environmentally-friendly sources. Natural fibers such as cotton, hemp and sisal had been investigated by other researchers as a potential replacement for synthetic fibers in composites and, they were found to be equivalent to synthetic fibers in certain aspects while being cheaper and renewable [12-13].

Addition of GR to ABS was touted to increase the plastic’s dampening properties and they were manufactured to produce pipes but some studies had pointed it is more trouble than it is worth as addition of GR was found to significantly weaken the ABS. Several studies were done by other researchers to combat this problem via GR surface modification by pretreatment or vulcanization or addition of compatibiliser chemical [1]. Interesting prospects exist on adding fibers to particle-reinforced composites whereby it can potentially improve the composite to perform better in variety of areas to be used in various applications. Thus it is relevant to add fibers to ABS/GR composites to
assess whether any improvement can be achieved, as numerous other researchers in other fields had found additions of fibers on their researched particle-reinforced composite are favorable [14-18]. Current literature on ABS/GR composites involves usage of novelty processes or complicated procedures and dangerous reagents while inclusion of natural fibers into such composites had not been investigated

Thus, a customized method had been investigated to create a similarly performing composite at vastly reduced costs and production complexity. It is also lucrative to incorporate short fibers into the composite to provide additional reinforcement as a mere ABS/GR composite is predicted to be significantly weaker than pure ABS [1] and the effects of the addition can be evaluated by conducting a simple impact strength test.

2. Experimental

2.1. Materials

Pure ABS pellets were used and mixed with ground rubber having sizes of 125, 250 and 500 microns. Short cotton fibers having an average fiber length of 5 mm to 8 mm were prepared and used as hybrid composite filler.

2.2. ABS Ratio Optimization

Approximately 100g of pure ABS pellets was liquefied in using ABS:Acetone ratios of 1:2, 1:4, 1:6 and 1:8 where each ratio sample is labeled as A, B, C and D and the liquefaction process was aided using an overhead mechanical stirrer. The process was conducted in a fume hood and left running for approximately 24 hours before retrieved for observation, preceding the sun drying process that utilizes halves of the samples respectively. The halves were subjected to five hour drying phase to direct sun with an observation for every one hour respectively. Based on the collected data, the optimum ratio was then determined for the preparation of hybrid ABS composites.

2.3. Hybrid ABS Composite Preparation

The weight of the thermoplastic was scaled down to 80g as the liquefied plastic was expected to overflow the carbon steel mould. The ground rubber particulates were prepared in sizes of 125, 250 and 500 microns. Short cotton fibers from bulk spinned yarn was then prepared into lengths of 5 mm to 8 mm. Three samples having filler percentage weight of 5%, 10% and 15% were prepared for each ground rubber particle size by initially liquefying the ABS for one hour, followed by addition of the filler materials and additional stirring time of fifteen minutes. Afterwards, the liquid mixtures were transferred to carbon steel moulds to be oven dried.

2.4. Unnotched Izod Impact Test

Three test samples were cut from each hybrid composite plate, bearing dimensions of 3.2 mm thickness, 12.7 mm width and 64 mm length. The Zwick swing arm impact test machine was then set up by attaching the Izod impact test arm and calibrated to deliver 7.5 joules of impact energy for each impact test conducted on all test samples respectively.

3. Results And Discussions

4. Analysis of ABS Ratio Optimization

Figure 1 show the undried sample C indicates intermediate elasticity between sample A and B while having uniform colour when compared to other samples. The undried sample D was ruled out due to presence of liquid mixture and this can be seen as potentially as a wasteful ratio. The sun-dried samples suggest the C sample is a best compromise in texture and colour. A uniform colour and median texture characteristics are approximated to indicate a good and complete liquefaction process thus the C sample ratio is deemed sufficient for ABS liquefaction.
5. Unnotched Izod Impact Test Analysis
Results from the impact test analysis conducted on the generated hybrid ABS composites suggest that sudden addition of the filler materials caused a drop on impact resistivity and there is a general decreasing trend of impact strength as the filler weight percentages were increased, as shown in figure 2, contrary to certain studies that indicated otherwise which may be explained due to lack of compatibiliser chemical and/or incompatible intermolecular interaction between the matrix and the fiber used in this research [19-22].

The increasing of GR particle sizes has smaller effect on impact strength in relative to filler weight percentages. The initial impact strength drop explained by the amount of additional GR to the ABS can significantly weaken the thermoplastic’s physical properties [1].

Figure 1. Sample ratio of ABS:Acetone (a) 1:2; (b) 1:4; (c) 1:6 and (d) 1:8.

Figure 2. Impact strength versus weight percent, ABS denote reference point.
The decreasing of impact strength due to random orientation of the fibres figure 3(a), uneven distribution of the filler materials at figure 3(b) and presence of air bubbles at figure 3(c) shown.

![Figure 3](image)

**Figure 3.** Defect occurred on the hybrid composite: (a) random orientation of fibers; (b) uneven distribution of filler material and (c) air bubble.

6. Conclusions
An optimum ratio for ABS liquefaction was found to be 1:6, for a customized fabrication method. As the filler increased, the impact strength shows a decreasing trend, it is due to the presence of air bubble and the non-uniformed filler distribution. The effect of the filler weight percentages is more profound than the effect of varying the GR particle sizes.

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