

Synthesis and characterization of Sugarcane Bagasse (SCB) - Polystyrene (PS) Composites by In-situ Polymerization and its Mechanical behaviour

Md. Aiyaz Ali Khan¹, Mohd. Farhan Zafar^{2*}, M. Arif Siddiqui³

¹PG Student, Department of Mechanical Engg., Aligarh Muslim University, Aligarh, India

²Research Scholar, Department of Mechanical Engg., Aligarh Muslim University, Aligarh, India

³Associate Professor, Department of Mechanical Engg., Aligarh Muslim University, Aligarh, India

Abstract This paper presents the study on the synthesis of PS-SCB composites using in-situ polymerization technique. The SCB was used after drying in sunlight. The SCB was taken 10% by weight in all the synthesized SCB-PS composites. Four different sizes namely 75 μm to 105 μm , 105 μm to 150 μm , 150 μm to 255 μm and 255 μm to 350 μm of SCB particles were used to synthesize the composites. Hand operated injection moulding machine was used to make the test specimens. The effect of SCB particle size on the morphology and hardness of the PS-SCB composites were studied. It is observed that as the size of the filler decreases hardness increases. This is due the fact that the dispersion of the SCB particles in the PS matrix is better than the other particle sizes used. The SEM shows the morphology of the synthesized composites and it is evident from the SEM.

Keywords: Polypropylene, Sugarcane Bagasse, Insitu Polymerisation, Mechanical Properties

I. INTRODUCTION

The concept of composites originated from the continuous and intense desire to tailor the structure and properties of materials. In a composite, substantial volume fraction of high strength, high stiffness reinforcing elements are embedded in a matrix phase. The final properties of composites are function of the properties of the constituent phases, their relative amounts, as well as the geometry of the dispersed phase [1]. Several procedures are known so far to synthesize polymer composites like melt intercalation method, solution method and in-situ polymerization [2].

In situ polymerization is done by first dispersing filler powder in monomer followed by homogeneous polymerization within the dispersion through addition of catalyst. Polymerization start either by using heat, radiation, initiator diffusor or by organic initiator or catalyst fixed through cationic exchange [3]. Several advantages are attributed to in situ polymerization. First of all, thermoplastic and thermoset based composites can be synthesized via this route. In addition, it permits grafting of polymers on filler surface which can generally improve properties of the final composite [4].

II. MATERIAL AND METHODS

1. Sugarcane bagasse (SCB): The sugarcane bagasse which is used as a filler was procured from a juice factory and is sun-dried thoroughly for used as a filler.



Figure 1 Formation of Bagasse composite

2. Matrix (styrene monomer): Styrene, the monomer, used in polymerization to synthesize virgin as well as PS-SCB composites.
3. NaOH of N/10: For washing the monomer before polymerization
4. Acetone: For washing the glassware to remove the synthesized polymer after the utilization.
5. Benzoyl peroxide (BPO): Initiator
6. Glassware and equipment

III. EXPERIMENTAL PROCEDURES

Sugarcane bagasse (SCB) particle was used as filler material. The SCB was first cleaned to remove contaminant and then dried for 5 days in sunlight. After drying, the SCB was ground in a food processor to obtain filler powder/particle. The fillers then passed through sieves of different sizes to get the required filler sizes. In the present study four different sizes of the filler powder i.e. $75\mu\text{m}$ to $105\mu\text{m}$, $105\mu\text{m}$ to $150\mu\text{m}$, $150\mu\text{m}$ to $225\mu\text{m}$ and $225\mu\text{m}$ to $350\mu\text{m}$ were used. The weight% of sugarcane bagasse filler of each type was kept constant which was equal to 10% of weight of styrene.

A. Washing of styrene

Styrene monomer is taken into separating funnel and shaken with N/10 solution of NaOH in water. This method is suitable for water insoluble monomer. The inhibitor reacts with alkali and the reaction product, being water soluble, comes out of the monomer phases and can be removed along with the aqueous phase. After thorough shaking, the NaOH/styrene solution is made still for about 2 minutes to separate out the monomer and alkali from the solution. The alkali solution is removed from the separating funnel. Washing with alkali is repeated twice to obtain pure styrene in this work.

B. Synthesis of polystyrene composites by in-situ polymerization

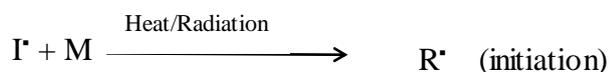
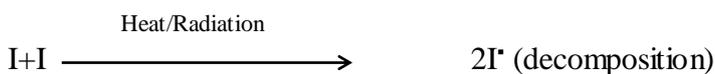
Through literature it has found that 0.011 g BPO is required for 5.5 ml of monomer. Hence in this case 1.0g of BPO is required for 500ml of monomer.



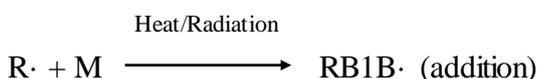
Figure 2 Washing of styrene by NaOH

Synthesis of polymer composites by in-situ polymerization basically involved the dispersion of filler in styrene followed by free-radical polymerization initiated by the addition of benzoyl peroxide. Styrene monomer containing the desired amount of filler was mechanically mixed by stirrer for 30 minutes at room temperature in order to obtain better dispersion. The required quantity of benzoyl peroxide was then added to the mixture to initiate the polymerization which took place at 95°C at a constant speed (650 rpm) of stirrer in each case for approximately one and a half hour till the monomer solution becomes viscous i.e. completion of the reaction.

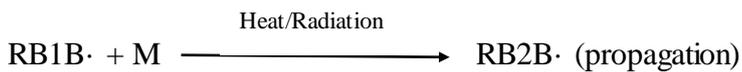
The decomposition process is as follows:



In the schematic reaction steps, (I) denotes initiator, (R) the radicals and (M) the monomers. The formed radical attacks styrene to initiate chain growth.



The formed product is still a free radical; it proceeds to propagate the chain by adding another monomer unit.



Growing chains can be terminated in one of two ways. Two radicals may go mutual termination by either a combination or a disproportionation reaction. Termination by combination results in higher molecular weight polystyrene than any of the other termination modes.

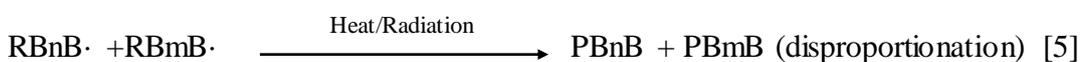
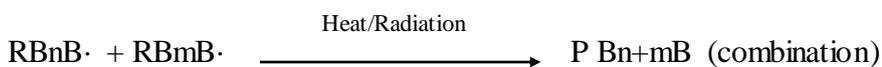


Figure 3 SCB-PS synthesized composite

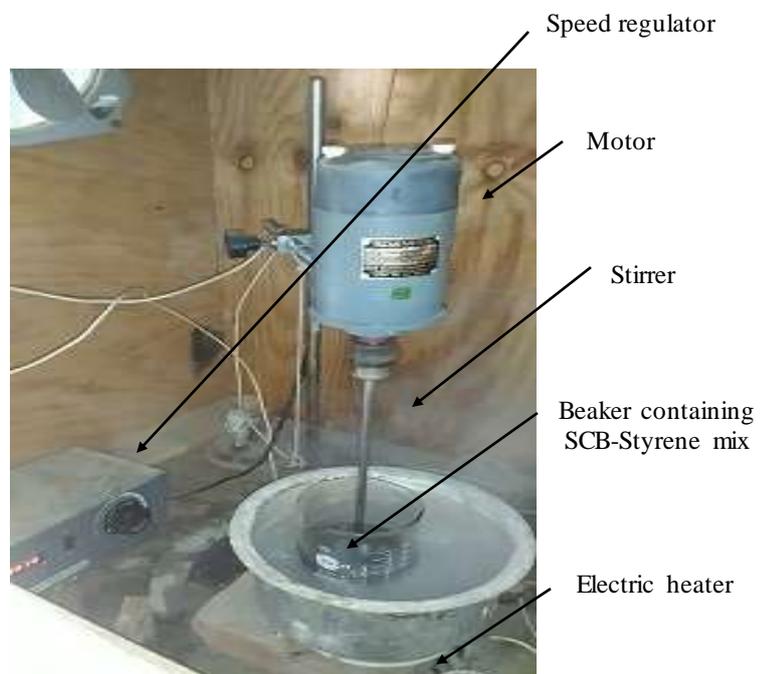


Figure 4 Working on experimental setup

IV. RESULTS AND DISCUSSION

A. *Hardness Test*

Hardness is one of the most basic mechanical properties of engineering materials. Hardness test is practical and provide a quick assessment and the result can be used as a good indicator for material selections. Hardness test is also employed for quality assurance in parts which require high wear resistance such as gears.

Digital Rockwell hardness tester was used for analysis of hardness. M- Scale was used in Rockwell hardness testing having ¼ inch ball indenter. The load of 100 kg was used. The test was carried out in powder metallurgy lab. Z. H. C.E. T, AMU, Aligarh. Mean of three readings for each sample were taken.

Table1 shows the Rockwell hardness of polystyrene composites containing natural filler.

Table I. Rockwell hardness of polystyrene composites

Filler content (wt. %)	Filler size(μm)	Rockwell Hardness
Virgin	-	53.8
10	255 to 350	85
10	150 to 255	88.5
10	105 to 150	91.3
10	75 to 105	96.4

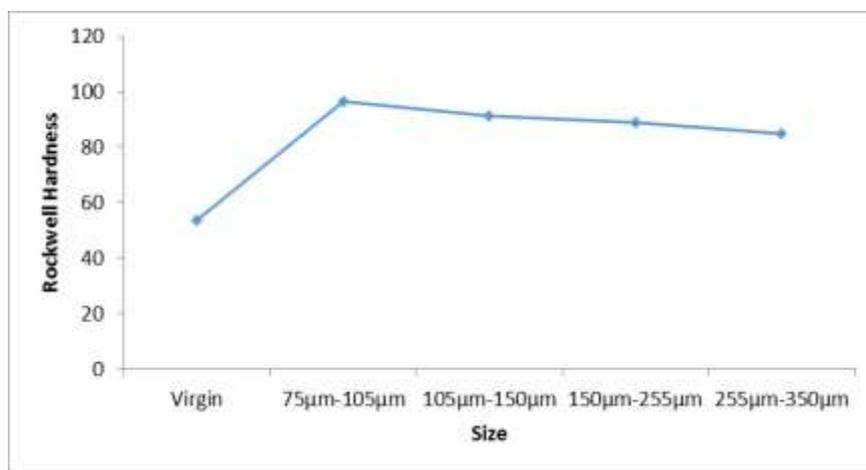


Figure 5 Effect of fillers size on hardness of polystyrene composites

From the result we observed that as we are increasing the filler size of composite hardness is decreasing uniformly. Adding the filler result in increased hardness as compared to that of the virgin polystyrene. Composite of having minimum size of filler i.e. 75 μm to 105 μm is showing maximum hardness which is equal to 96.4. This is due to better dispersion of lower size of filler in the matrix.

V. MORPHOLOGY

Figures showing the morphology of polystyrene composites of different sizes of fillers.

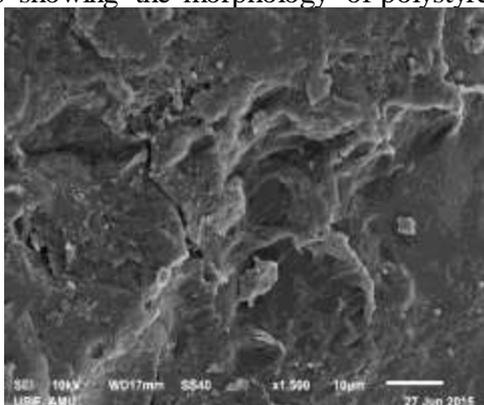


Figure 6(a) SEM of size 255 μm to 350 μm filler composite

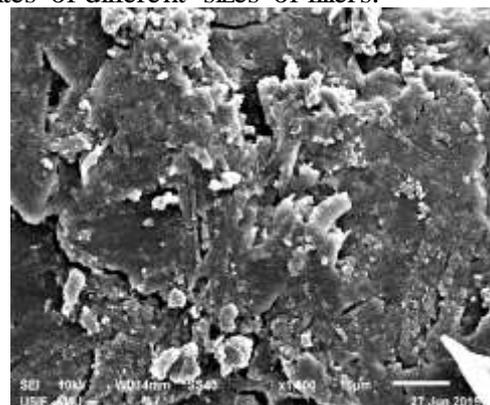


Figure 6(b) SEM of size 150 μm to 255 μm filler composite

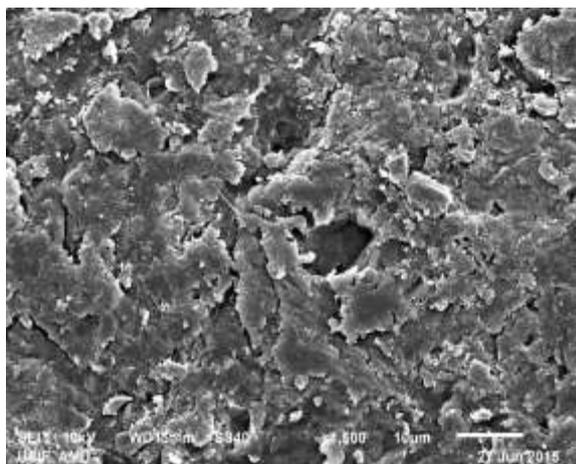


Figure 6(c) SEM of size 105µm to 150µm filler composite

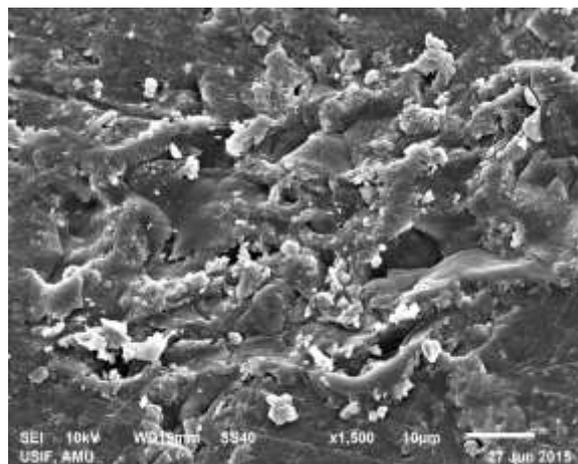


Figure 6(d) SEM of size 75µm to 105µm filler composite

As we can see in the above micrographs that as the size of filler decreases, the filler composition appears to be more homogenous. Lower size of the filler is dispersed uniformly in the composite. This may be one of the reason of increased hardness of composite with decrease in filler size.

VI. CONCLUSIONS

It may very well concluded from this article that we can very well synthesize the polymer matrix composite using natural fillers and the hardness properties of this composite is better than those of the virgin polymer. Also better dispersion of filler particles is attributed to the better hardness of the composite. SEM analysis shows that as size decreases, dispersion of filler improves in polymer matrix. This leads to better mechanical properties of composites having smaller size of SCB filler particles.

REFERENCES

- [1] S. Ahmad, T. Alam, A. Siddique, and A. H. Ansari, "Tensile Strength of Synthesized Polystyrene Composites", IJSRET, vol. 4, no. 10, pp. 1038–1044, 2015
- [2] Progelhof R.C. and Throne J.L., "Polymer Engineering Principles-Properties, Processes and Tests for Design", Hanser/Gardner Publications, Inc., Cincinatti, 1993
- [3] Brian M. Cromer, Sakaia Scheel and Gerrit A. Luinstra, "In-situ polymerization of isotactic polypropylene-nanographite nanocomposites" Elsevier ltd. 2015
- [4] Joel Fawaz and Vikas Mittal, "Synthesis of polymer nanocomposites: review of various techniques" wiley-VCH verlag GmbH & co. 2015
- [5] P. Buback and T. Haramina, "Report on Project Week Free Radical Polymerisation," Group, pp. 1–3, 2004.