# MESUREMENT ON THE DYNAMIC PROPERTIES OF NANOSILICA/POLYPROPYLENE COMPOSITE USING SPLIT HOPKINSON PRESSURE BAR TECHNIQUE

**Hazizan Md Akil[a], Zainal Arifin Ahmad[a], Mohd Firdaus Omar[a], Ong Hui Lin[a], David Hui[b]**
[a]School of Materials & Mineral Resources Engineering, Universiti Sains Malaysia,
14300 Nibong Tebal, Pulau Pinang, Malaysia
[b]Composite Material Research Laboratory, University of New Orleans, EN 909
New Orleans, LA 70148, USA

## Introduction

Polymeric nanocomposites are materials that are created by introducing inorganic nanoparticles (often referred to as filler) into organic polymer matrix and are finely dispersed within the matrices [1].These polymer nanocomposites have thus attracted great interest in industry and academia due to their exhibition of remarkable enhancements in material properties when compared to the virgin polymer or conventional micro and macro-composites. In service, the composite materials may behave differently under various loading conditions. Dynamic loads are characterized by high amplitude and short duration stress pulse or a high strain rate [2]. Base on this concern, to ensure the safety use of the composites at high strain rate, measurement on dynamic properties of composites is investigated. There are many available techniques in investigating the dynamic properties of materials which reviewed by Hamouda [3]. Among those techniques, Split Hopkinson Pressure Bar (SHPB) is one of the most widely used for strain rate in the range of $10^2$ $s^{-1}$ to $10^4$ $s^{-1}$. The important characterization of SHPB technique is highly depending on the compatibility of the technique to obtain stress-strain curve as output which holds useful information to characterized materials. Therefore, in this study, the effect of filler loading (from 1% to 3%) to the dynamic properties of the PP-SiO2 nanocomposite samples was investigated where 0.6 bar pressure was selected to be used as the applied pressure during the experimental.

## Experimental

*i) Materials*

Polypropylene homopolymer (TITANPRO PM-255) was supplied by Titan PP polymers (M) with a melt flow index of 1.6 g/10 min (at 2308C). The density of the polymer is 0.9 g/cm3. Quartz fumed silica with an average primary particle size of 7 nm and a specific surface area of 390 m2/g was obtained from Sigma-Aldrich. 3-Aminopropyl-triethoxysilane (APTES) and a commercial grade of titanate Lica 12 (neopentyl(diallyl)oxy,tri(dioctyl)phosphate titanate) supplied by Fluka Chemie and Kenrich. Petrochemicals, respectively, was used as coupling agents in this compounding.

*ii) Apparatus and Procedures*

High velocity impact test was performed using compression Split Hopkinson Pressure Bar technique (Model KHT-52-CT) which is illustrated in Figure 1. The samples were fabricated in rod geometry shape with dimension of 12.5mm (diameter) x 4mm (length). The PP-$SiO_2$ nanocomposites samples were exposed to one specific pressure which is 0.6 Bar with approximately 1300$ms^{-1}$ of applied strain rate. The static properties of PP-neat was taken from previous researcher for comparison purpose.

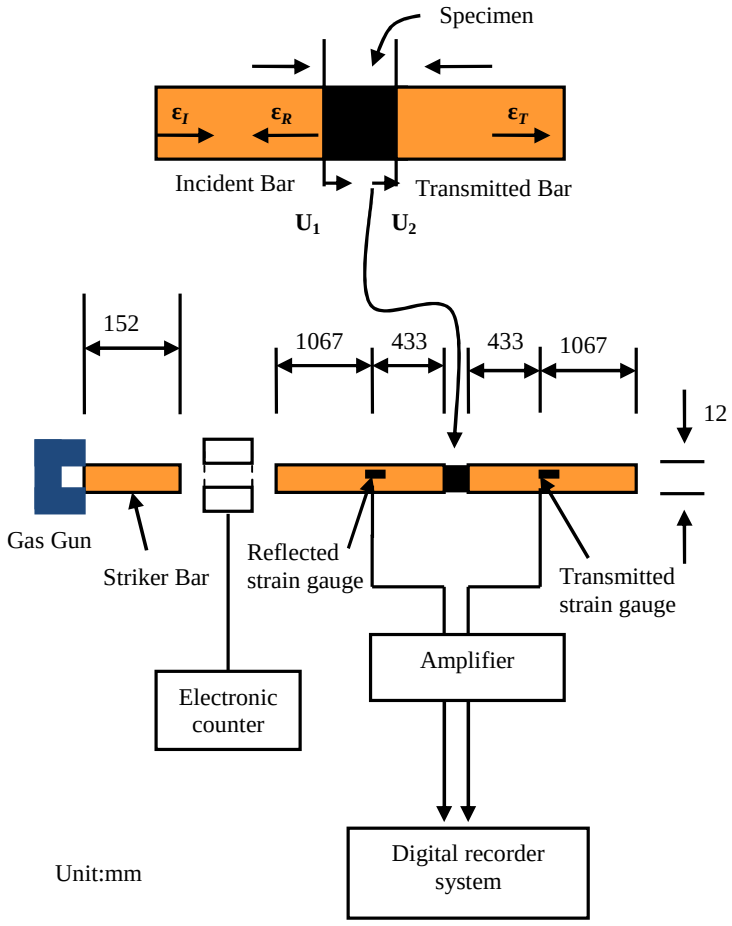


Fig 1. The schematic diagram of compression Split Hopkinson Pressure Bar apparatus

## Results and Discussions

*i. Effect of filler loading*

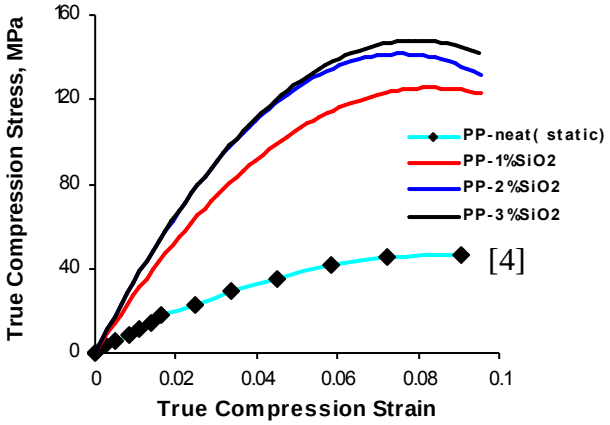


Fig.2 Stress versus strain curve of PP-$SiO_2$ nanocomposites samples at 0.6 bar pressure.

Figure 2 shows a series of stress-strain curve for PP-$SiO_2$ nanocomposites at various filler loading produced at high strain rate (approximately 1300$ms^{-1}$). From Figure 2, it is clear that, by increasing the amount of $SiO_2$ filler from 1% to 3% will result in significant improvement in term of dynamic mechanical properties. The PP-3%$SiO_2$ and PP-2%$SiO_2$ samples are much harder than PP-1%$SiO_2$ and PP-neat under compressive impact. Typically, PP-3%$SiO_2$ and PP-2%$SiO_2$ samples show higher compression modulus compare to PP-1%$SiO_2$ and also PP-neat where at 1300$ms^{-1}$ of strain rate, the compression modulus of PP-3%$SiO_2$ and PP-2%$SiO_2$ samples are highest (3.06GPa) followed by PP-2%$SiO_2$ (2.22GPa) and PP-neat (0.77GPa) as shown in Figure 3. This phenomenon cause by the amount of filler loading itself where the higher the filler loading added into nanocomposite systems results in higher strengthen mechanism and also higher in terms of work hardening rate.

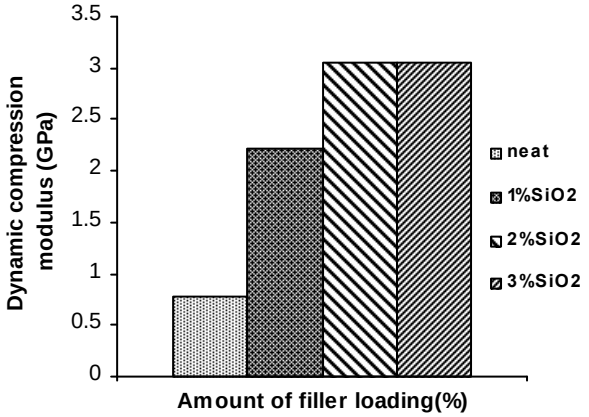


Fig.3 The dynamic compression modulus of PP-SiO2 nanocomposites with various amounts of filler loading

Figure 4 represent a variation of the compressive strength values of PP-$SiO_2$ nanocomposite at approximately 1300$ms^{-1}$ of strain rate. From the graph, it is clearly seen that the compressive strength of the samples is significantly influenced by the increase of the filler loading. The higher the filler loading results in higher compressive strength where the PP-3%SiO2 samples recorded the highest value of compressive strength (146.7MPa) followed by PP-2%SiO2 (141.3MPa), PP-1%SiO2 (125.3MPa) and lastly PP-neat (46.5MPa ).

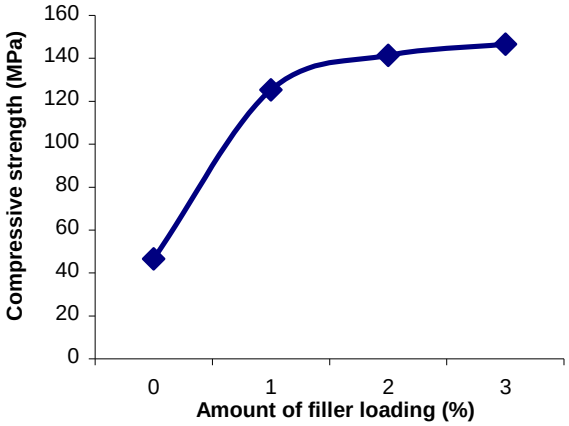


Fig. 4 Variation of the compressive strength value of PP-SiO2

## Conclusion

Effect of filler loading behaviour on the dynamic mechanical properties of the PP-SiO2 nanocomposite has been successfully evaluated. It may be concluded that, by adding optimum filler loading into these composite system gives a significant improvement on the dynamic properties of PP-$SiO_2$ nanocomposite. From this study, dynamic compression modulus and compressive strength properties are seen to increase with the increase of filler loading where PP-3%SiO2 recorded the highest value of compression properties.

## Acknowledgement

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## References

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