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Preparation of Magnesium Hydroxide and Nanofiber Polymer Composites to Reduce the Flammability and Melt Dripping Behaviour of Polymers

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ABSTRACT

Nanoscale alumina fibers reduce the flammability and melt dripping behaviour of polymers. Magnesium hydroxide breaks the agglomerates by generating shear and iterative forces. Mixing was done with Brabender Plasticoder. The temperature and time of mixing greatly affects the mixing behaviour. At higher temperatures blow holes were observed. By increasing the mixing time agglomerates were broken to a greater extent. Different concentrations of nanofibers, Magnesium hydroxide and surface treatments are used to investigate the properties of polymer. Thermogravimetric analysis (TGA), optical microscopy and flame test was done to see the effect of different parameters on mixing and flame retardancy behaviour.

Keywords: Polystyrene, Flammability, Melt dripping, TGA

1. INTRODUCTION

The prime aim of this research work is to use nanoscale fibrous filler reducing the flammability and melt dripping of polymeric materials. It was studied whether a combination of the nanofibers with conventional flame retardants, Magnesium hydroxide, gives improved results or not. Melt blending under different conditions was used to disperse nanofiller with a conventional flame retardant in a polymer matrix. A surface treatment was used to facilitate the mixing of the particles with the polymer. The fire behavior of the composites was evaluated in a simple flame test. The base material used is polystyrene (P.S). Material which is melting strongly in any combustion often use as a model polymer. The chemical formula is as under:

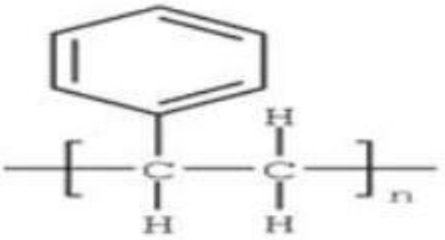

Fig-1: Chemical Formula of Polystyrene

Alumina nano particles are used. They are used to prevent melt dripping, if it burns; low viscous material is going to melt easily. At elevated temperatures Polystyrene becomes liquid, nanofibers attached to the structure and resist the flow[1]. Quantity used is 2 wt % of the original polymer. The diameter of the fibers is 0.02 micron. The calculated surface area is 500-600 m2/g. Surface treatment (S.T) has been added to have better linkage between polymer and the nanofibers. The amount used is 6 wt % of filler. The chemical formula of the surface treatment is as under:

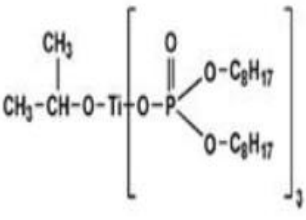

Fig-2: Isopropyl, tri (dicotyl) phonphate titanate (Titanium 4, 2-propanolato, tris phonphate-O)

Magnesium hydroxide decomposes giving the following reaction:

$$\mathbf{Mg\,(OH)2 \rightarrow MgO{+}H2O}$$

It is an endothermic reaction with a release of water and act as a fuel depletion providing a blanket effect which limits the oxygen available for combustion [1].

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2. MIXING TECHNIQUE AND EVALUATION EQUIPMENTS

Melt blending has been carried out with a Brabender Plasticorder. Speeds used are 50,120 rpm. Temperatures were 160 °C, 180 °C and 200 °C. Mixing times are 12 min and 16 min.

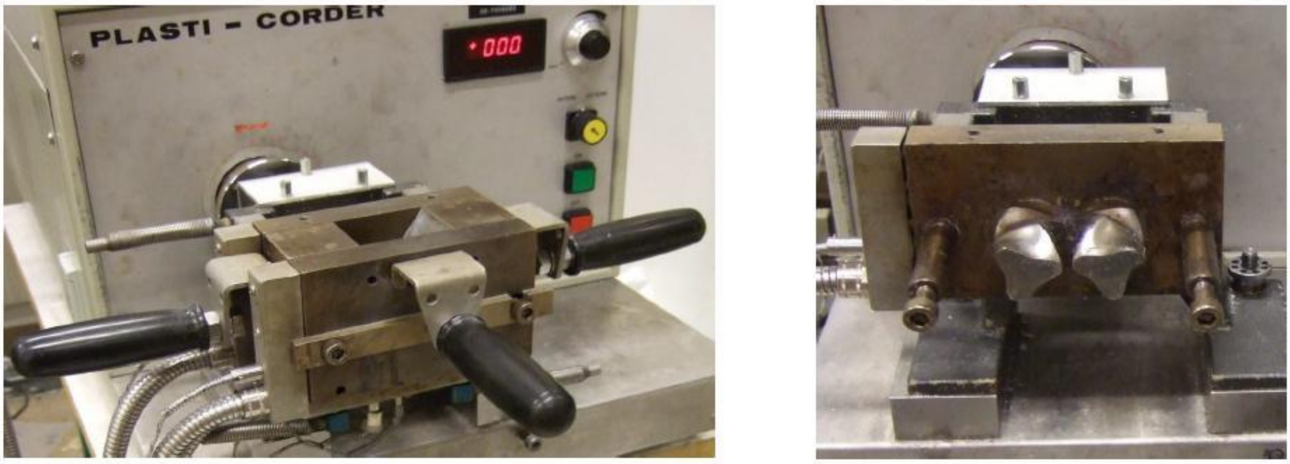

Fig-3: Brabender Plasticorder; (a) Mixer with control panel (b) Mixing screws

Optical microscopy has been done to observe the efficiency of mixing technique by seeing the agglomerates and blow holes at different temperatures and time of mixing. A controlled temperature and controlled atmosphere (nitrogen) was used. Measurement of mass loss as a function of temperature with microgram sensitivity was done with TGA analysis. A UL 94 burner was used with a 20 mm blue flame according to the NIST standards[3].

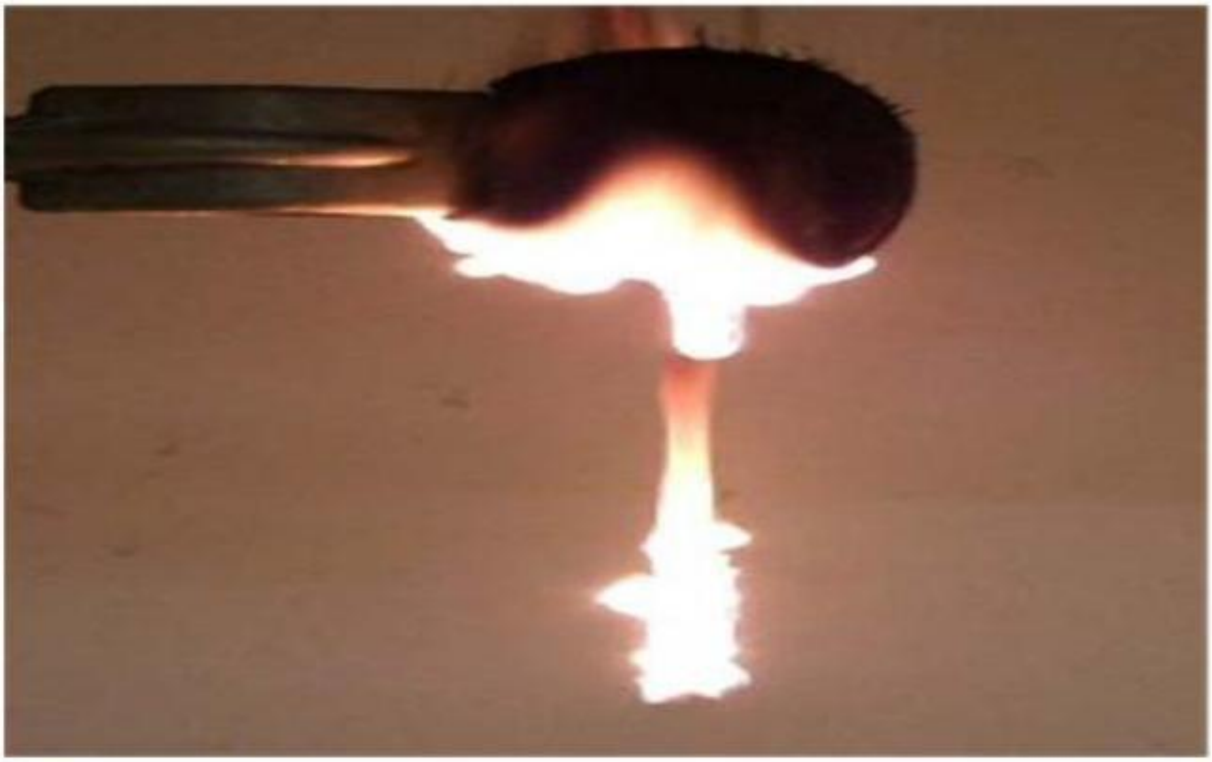

Fig-4: Flame test showing the melt dripping of Polystyrene

3. RESULTS AND DISCUSSION

3.1 *Optical microscopy*

Three samples were prepared one is of pure polystyrene, second one with surface treatment and the third one with surface treatment and Magnesium Hydroxide. All the samples were made at 180 °C at a speed of 50 rpm for 15 minutes for comparison. The samples and their microstructure are as under:

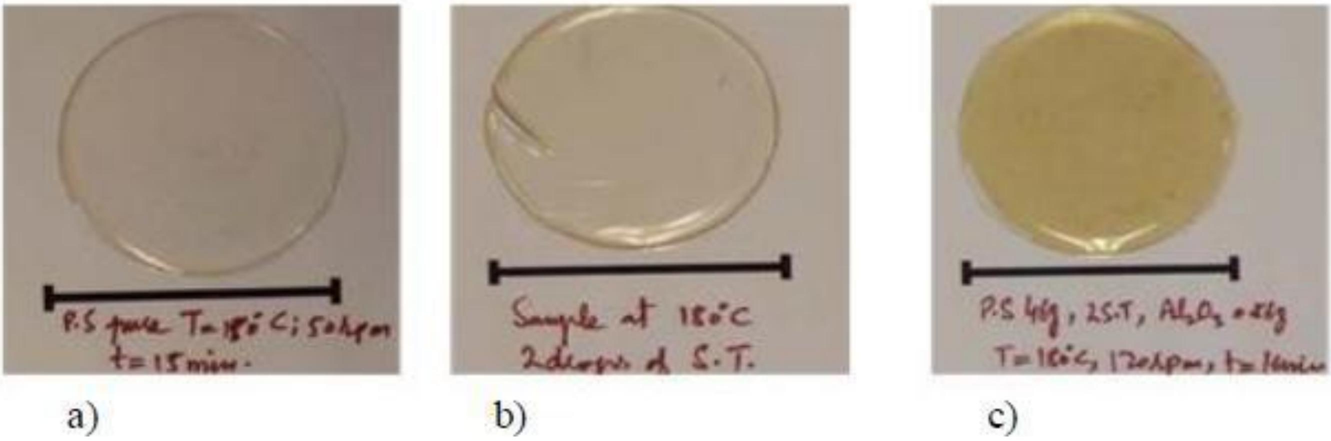

Fig-5: a) Polystyrene b) P.S with S.T c) P.S with S.T and Mg $(OH)_2$

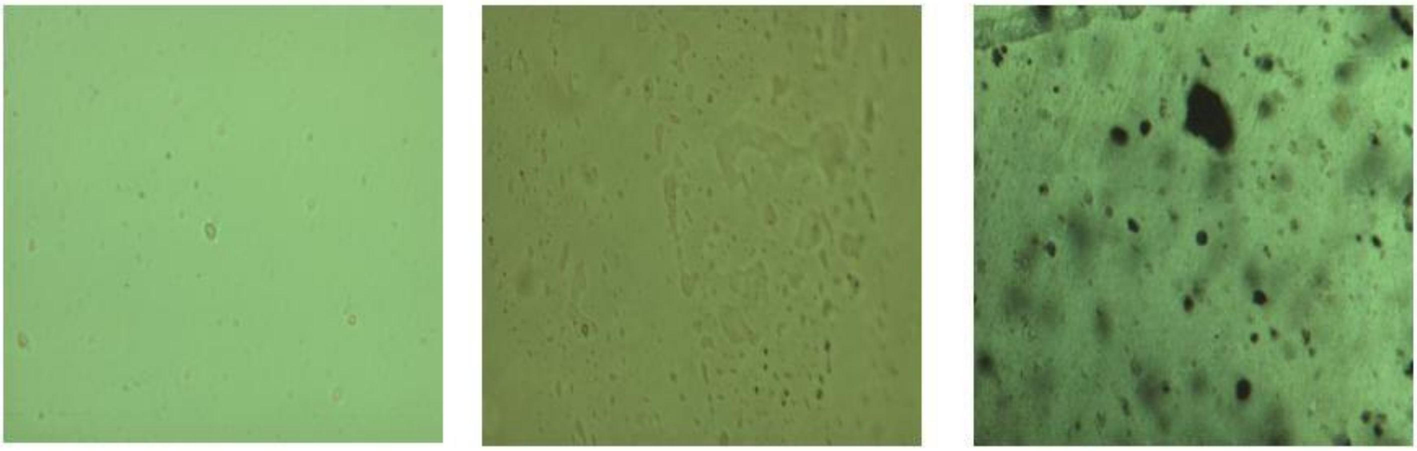

Fig-6: a) Polystyrene b) P.S with S.T c) P.S with S.T and Mg $(OH)_2$ (Magnification 630x)

Marks of surface treatment are observed with alumina nanofibers agglomerates can be seen in the microstructure. Agglomerates retard the mechanical properties by acting as stress concentration sites[2].

3.2 *Influence of temperature on mixing technique*

Microstructure of samples of Polystyrene mixed with nanofibers and flame retardant are as under. A large number of agglomerates can be seen at 160ºC then at 180ºC.The blow holes are found at 200ºC. So, 180°C is a good temperature value for mixing.

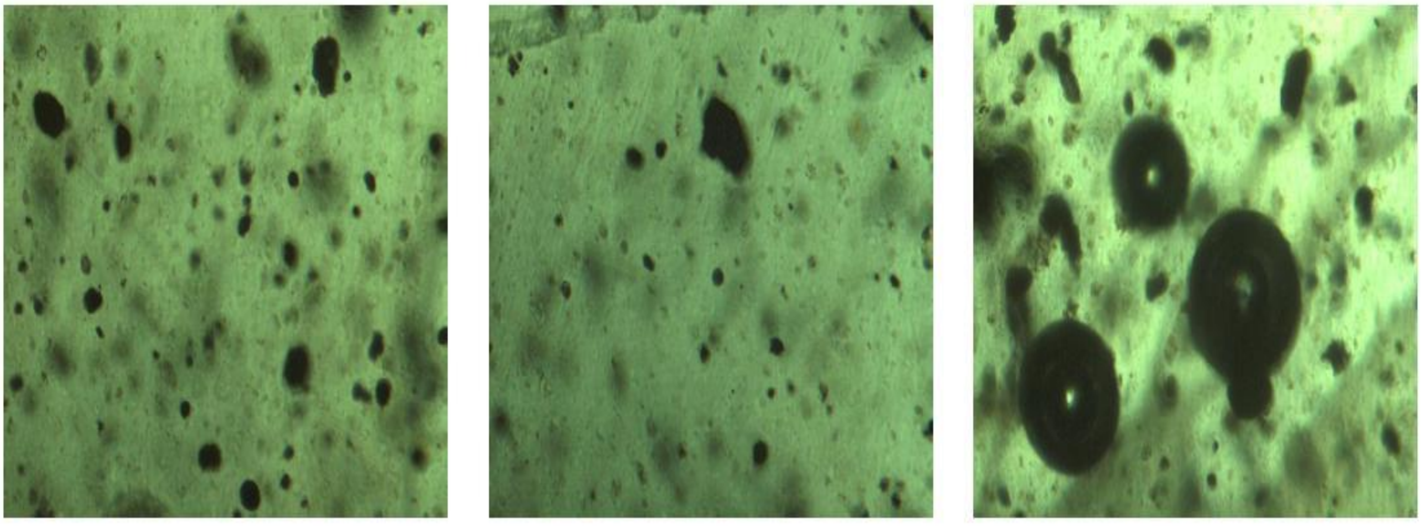

Fig-7: Microstructures a) 160ºC b) 180ºC c) 200ºC (Magnification 630x)

3.3 *Effect of dispersion with both fillers*

Large iterative and shear forces have been generated by Magnesium hydroxide which breaks the agglomerates as can be seen by the microstructure. Both the effects were seen at 180 °C.

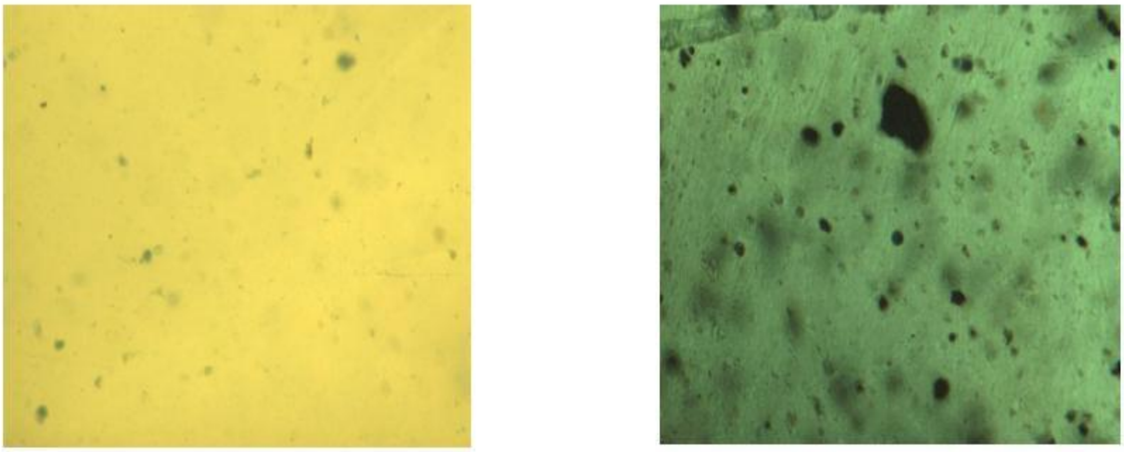

Fig-8: a) P.S, S.T, Alumina fibers, Mg (OH) 2 b) P.S, S.T and Al2O3 fibers. (Magnification 630x)

3.4 *TGA Analysis*

Pure Polystyrene decomposes completely while with alumina nanoparticles there is some residue left because of higher melting point of alumina. The results are shown below:

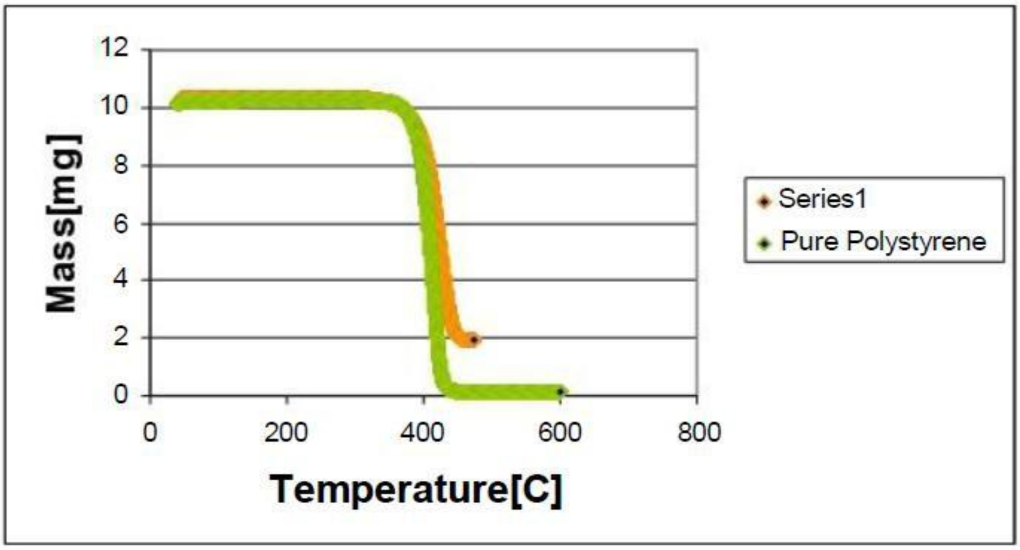

Fig-9: TGA Analysis (Polystyrene and Polystyrene Alumina Nano fiber 2%)

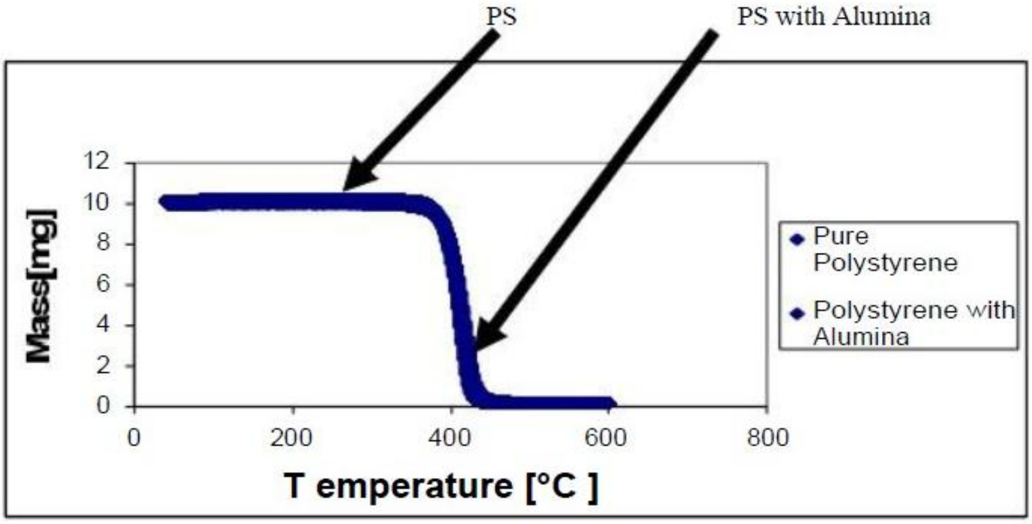

Fig-10: Polystyrene pure vs Polystyrene, Mg(OH)2 40 %

Pure polystyrene decompose leaving behind no residue while in case of Magnesium hydroxide first the decomposition occur and the residue left of Magnesium oxide.

3.5 *Simple Flame Test*

The melt dripping phenomenon can be seen by the following illustration.

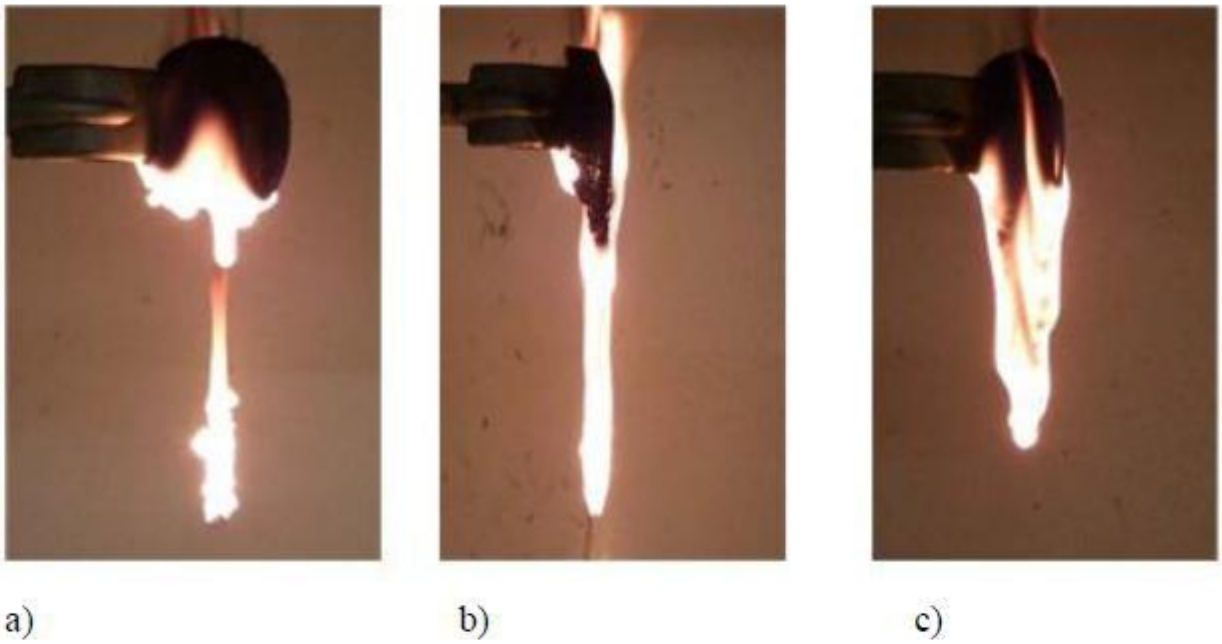

Fig.11: a) Polystyrene b) P.S with alumina c) P.S, Mg (OH) 2 with alumina

In case of pure Polystyrene after 15 sec first drips occurred. Many small drops were there after first drip. In Polystyrene with alumina nanocomposites the drip gets longer and the first drip was after 12 sec. It behaves different but was better. In case of Magnesium hydroxide, nanocomposites and polystyrene first drip was after 18 seconds. Nanofibers don’t contribute much in restricting melt dripping. Polystyrene droplets were small just a change in flow pattern was seen.

4. CONCLUSIONS

Following are some conclusions:

1. Best mixing of alumina fibers were obtained at 180°C. At this temperature blow holes were not seen. Still many agglomerates were observed.
2. Mixing Magnesium hydroxide and the alumina fibre together reduced the agglomeration.
3. Melt dripping could not be effectively reduced. A strong deformation rather than flow of small droplets was observed.

5. ACKNOWLEDGEMENTS

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3. http://standards.gov/sibr/query/index.cfm?fuseaction=Home.regulatory_sibr_all & start Row=300,13, 15-02-2008.