

## Synthesis of Silica Nanospheres of Differing Diameters and their Incorporation into Polypropylene Nanocomposites.

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**Abstract** – Nanocomposites consisting of silica nanospheres in a polypropylene matrix have been prepared using nanospheres of varying diameters, synthesized using a sol-gel process. Particles of 12 – 153 nm were generated and the physical and permeation properties of the resulting composites were evaluated. It was found that the diameter of the particles used had a dramatic effect on the resulting materials properties. The strain at break and permeation at break being particularly affected, with larger particles reducing the strain at break while at the same time increasing the permeability of the material.

The incorporation of inorganic fillers into polymer matrices has been of industrial, and hence academic, interest for more than 100 years[1]. The first patents covering the incorporation of clays into shoe soles to improve their durability were submitted, likely with little understanding of the trend they had begun. Even in that era it was known that size matters and treatments which produced the most homogeneously sized particles and the greatest enhancements were specified. It was found that smaller was better and that trend towards smaller and smaller particles has continued even today. During the preparation of SiO<sub>2</sub>-nanosphere/polypropylene composites we noticed that materials prepared with different sized nanoparticles possessed properties which varied greatly and began to wonder if there is a limit to this utility, and if there was a point at which smaller is not better.

Therefore we chose to explore the effect of particle size on the properties of the resulting material. Silica nanoparticles were synthesized using sol-gel chemistry in a batch method. The concentrations of the surfactant (octadecylamine), ethanol, and water were varied systematically in order to generate monodisperse silica nanospheres with diameters ranging from 12 to 153 nm. The nanoparticles were subsequently melt mixed with a compatibilizer, Polybond (3150), and polypropylene in a Brabender "Plasticorder" at 190 °C. The composites were pressed to obtain plaques and the physical properties measured. As suspected, it was found that even in the nanoregime size matters. A comparison of the composite material Young's modulus revealed that the incorporation of the smallest particles (12 nm) resulted in no change, while the incorporation of larger particles (42 nm) resulted in an increase of 5%. In many cases the strain at break is adversely affected upon incorporation of inorganic materials. In the case of the silica nanospheres, the smallest particles again resulted in the worst properties. The strain at break of the composite containing 12 nm particles decreased by 46%, while the material containing the larger particles (36 nm) decreased by only 17%. Perhaps one of the more interesting results is that the incorporation of the largest particles (153nm) actually resulted in an increase in the strain at break of 7.5%. The gas permeability of the composites was affected with the incorporation of the nanospheres, with the permeability of the materials increasing in all cases. The larger particles, however, favored the permeation of oxygen over nitrogen resulting in a change in the selectivity ratio.

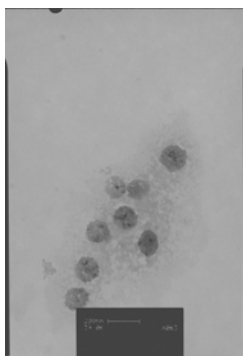


Figure 1: TEM of 150 nm Silica nanospheres



Figure 2: TEM of 42 nm Silica nanospheres

### References

[1] . Brown, G.E. and J.W. Blackwell, *Composition of Matter for Soles of Shoes* US 460,842, 1891: USA.