Universidad Carlos III de Madrid

# OO/UC3M/49- POLYMER REINFORCEMENT WITH NANOPARTICLES

The Polymers and Composites research group belongs to the Materials Science and Engineering and Chemical Engineering Department of the University Carlos III of Madrid, Spain. Its objective is the development and characterization of polymeric materials, focussed in their reinforcement through the dispersion of nanoparticles. Following this method, very small additions of nanoreinforcements usually improve mechanical, electrical and optical properties, as well as the service performance of these materials. The research group is looking for companies interested in applying nanotechnologies to polymers of industrial interest.

## Description and special features

Overall, the characteristics of polymeric composites loaded with nanoreinforcements, as compared with reinforcements conventionally used in the industry, are:

a) Very low percolation limits (~0.1 – 2%). The effects (in any property topology dependent) can be manifest with very small quantities of nanoreinforcements
b) The correlation between orientation and position of the particles appear at very low volume fractions
c) The number of particles per volume unit is very large ($10^6$ – $10^8$ particles /$\mu m^3$)
d) Very large interfacial surface per particle volume unit
e) Distances between particles are very short (10-50 nm), comparable to the dimensions of the polymeric chains

Nanoparticles can be classified according to different criteria. For instance, spheres, layers and tubes or rods can be distinguished attending to their geometry. From a mechanical behaviour point of view, the highest reinforcing enhancement corresponds to one-dimensional nanoreinforcements. From the perspective of the functionality of nanocomposites, it is a known fact that maximum functionality is achieved by controlling not only the particle dimensionality, geometry and composition of but also the way in which particles are assembled.

The most important factors to consider in the development of nanocomposites are: the surface area per volume unit (and the associated surface chemical functionality) and the geometric anisotropy (aspect ratio). Assuming that the structure of a composite material is composed of three phases: matrix, reinforcement and interface, the surface area per volume unit controls the amount of matrix in the interfacial region that can reach a 100%, and its properties. The second factor controls the positional correlation between particles, that is, the local anisotropy, as well as those properties related to percolation (electrical conductivity, for instance). The desired nanocomposite functionality, which determines the selection of nanoreinforcements, has to be added to those two factors.

The research group, with a long trajectory in the study of polymeric materials, has specialized in the dispersion of nanoparticles in thermosetting and thermoplastic matrices, both with or without previous surface treatments, the preparation of microscopic size samples and their thermal, mechanical and electric characterization.

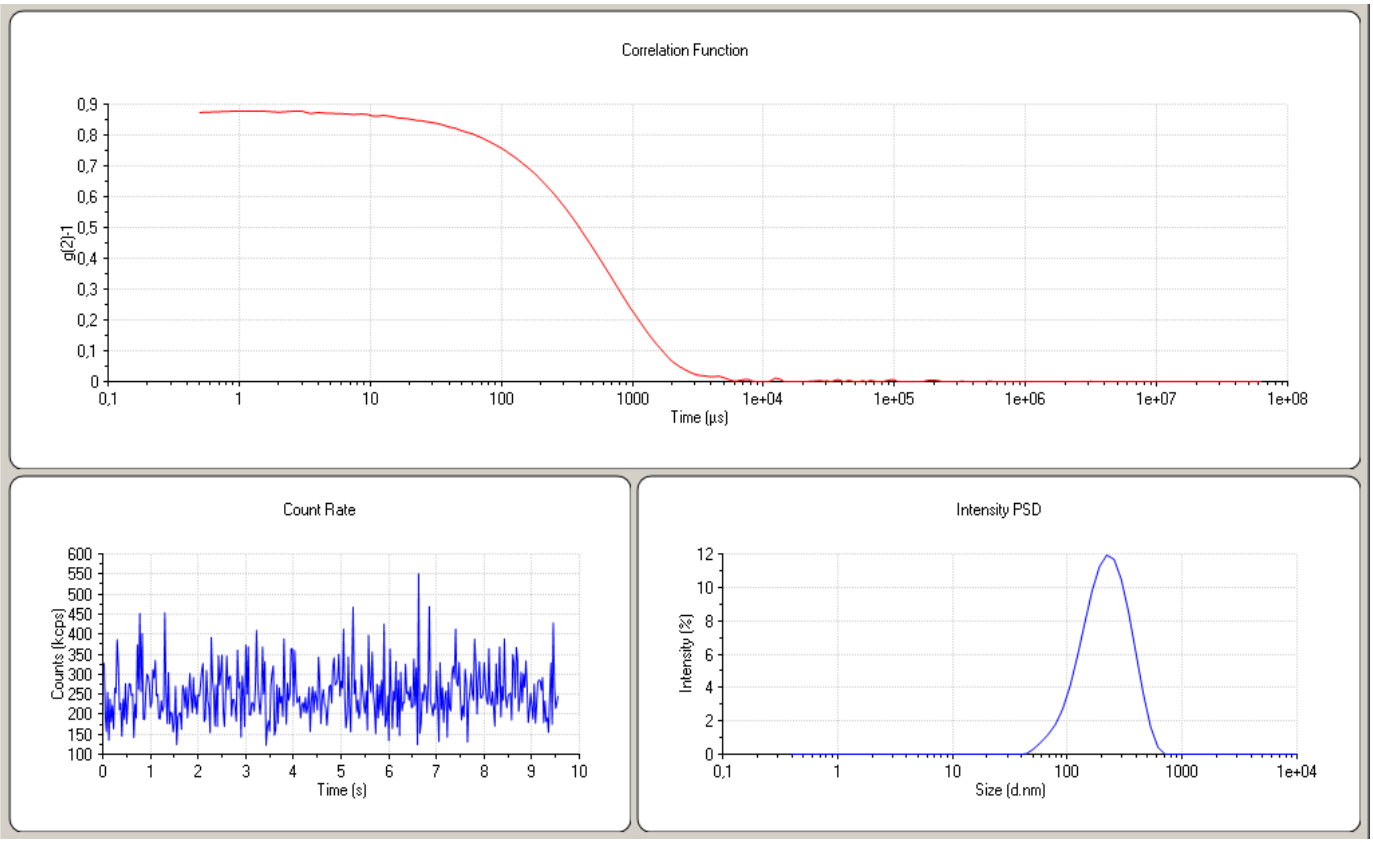


Fig.: Size distribution measurement of an aqueous $SiO_2$ nanoparticle dispersion after surface treatment

| **Innovative aspects** |
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| • Important effects in their properties can be achieved with very low quantities of nanoreinforcements.<br>• Due to the nanometric scale of the reinforcements, aesthetical and optical properties can be tuned within a certain interval.<br>• Materials with tailored properties can be prepared. |

| **Competitive advantages** |
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| The potential improvement of some properties allows broadening the field of application of some polymers, substituting ceramics and metals in some developments. Environmentally, the substitution of various materials by nanocomposites is not only less polluting with respect to processing and generation of toxic waste but also simpler energetically cheaper. |

| **Technology Keywords** |
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| Materials Technology; Composite Materials; Polymers, Plastics |

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