TECHNICAL BULLETIN: ADVANCES IN NANOTECHNOLOGY

1 Introduction

The use of nanocomposites in theory offers great advantages, since these nanostructures have excellent mechanical properties with stiffness up to 0.45 TPA (terapascal). However, there are still difficulties to overcome to maximize the benefits offered by these compounds, such as achieve a good intercalation of fibrils at the nanometer level or its exfoliation, which is key to obtain the benefits that these nanocomposites can offer, also the proper use of compatibilizers or functionalization of polymer to achieve a good adhesion between the phases.

Polyethylene is a material that has a very wide range of applications, however it has certain limitations such as: low resistance to cracking and depending on its density, high permeability to gases and water vapor. The use of nanocomposites provides a great opportunity to overcome the limitations that the PE can have.

Among the most commonly used types of nanocomposites are laminated silicates (clay), carbon nanotubes and nano-whiskers of cellulose, titanate ultra thin laminate.

2 Silicates laminates

The silicate laminates usually used in nanocomposite belong to the family called 2:1 Phyllosilicate (mica, talc, the montmorilonite, etc.) among which the most used are: montmorilonite, hectorite, saponite and laponite (1). The nanocomposites developed with the use of montmorilonita (MMT) have been extensively studied in recent years (1-6) and has been demonstrated its beneficial effect on the mechanical and chemical properties of polymer by adding small proportions of the inorganic material (˜3% in weight).

The polar nature prevailing in the MMT produces difficulties in its adhesion with the non-polar polymers such as PE, for this reason also has been investigated the changes of these clays organically (2). What is done is to convert the hidrophilic clay into an organophilic surface. This modification known as "ion-exchange reaction", is made through the use of surfactants as alquilammonium. Despite this change, the clay dispersion has not been good in the polymeric matrix of polyethylene, especially in the case of low density polyethylene due to its many-branched chains that prevent the proper intercalation of the clays in the polymer matrix.

Preparation and synthesis of these nanocomposites can be done mainly through three techniques:

a. Dispersion in solution.
b. In-situ polymerization.
c. Intercalation into molten state.

2.1 Dispersion in solution.

Nanocomposites of high density polyethylene and clays with modified surfaces have been prepared through the method of dispersion in solution (2), in the case of low density polyethylene, because of its many ramifications, this method does not provide good results.

2.2 In-situ polymerization.

In-situ polymerization has been achieved in PE and silicate nanocomposites with a rolled exfoliated morphology. Studies in this direction have been made by Peoples et al (4) and Qi et al (22), among others.

The work of Monasterios et al. (7) uses different clays treated with silanes of different features to evaluate the mechanical properties of several outcomes. Nanomaterials used were prepared through In-situ polymerization. Mechanical properties of mixtures showed a reduction in elastic modulus and strain at fracture.

2.3 Intercalation into molten state.

Using the method of melt intercalation had not provided good results in the preparation of nanocomposites of PE until the discovery of modified oligomers. Several investigations have been performed in this field due to the ease provided by this technique in the preparation of nanocomposites. Because the polyethylene does not include any polar group in terms of their chains, it is not possible to disperse the silicate laminates, which are hydrophilic in polyethylene without the use of a compatibilizing.

Reddy, M.M. et al (8) studied the relationship between the structure of nanocomposites of polyethylene grafted with maleic anhydride (PEgMA) with organo-modified MMT and the resulting rheological properties. In this work, we found a clear trend in increasing the viscosity of the melt at a higher degree of intercalation and / or even exfoliation of nanoarcilla, similarly the tensile strength increases and the permeability decreases.

Sanchez, Saul et al. (5) studied the preparation and the degree of exfoliation achieved in PE nanocomposites with clay used as compatibilizing PEgDA and PEgAOH, which were prepared by reaction of PE grafted with maleic anhydride (PEgMA) and a diamine (DA) or amino alcohol (AOH).

Other compatibilizers like EVA and polyethylene oxidized (PEO) have been tested to quantify the degree of intercalation in the polymer matrix (9-10). It is of particular interest that according to Durmus et al. (10), the properties of barrier to oxygen achieved through PEO with low molecular weight, are better than those achieved with compatibilizers like polyethylene grafted with maleic anhydride.

3 Carbon nanotubes (CNT)

Discovered by researcher Sumio Iijima in 1991, carbon nanotubes are the most promising nanomaterials due to their excellent mechanical properties, thermal and electrical. (1) Carbon nanotubes are rolled sheets in a cylindrical, hexagonal arrangement of carbon atoms, whose diameters range from a few Angstroms to a few tenths of nanometers. Can be configured for single-wall (SWNT) or multi-wall (MWNT), in which case there are multiple concentric cylinders of nanotubes.

The interaction of nanotubes and polyethylene is still in an incipient stage, some jobs can be found briefly explained and summarized in (1,2,11). Among the techniques investigated to improve the dispersion of nanotubes in the polymer matrix for different materials are:

- ✓ Functionalization of nanotubes in chemical solution.
- ✓ Coating the surface of the nanotubes through polymer
- ✓ In-situ polymerization of nanocomposites.
- ✓ Ultrasonic dispersion in solution.
- ✓ Molten processing.
- ✓ Through surfactants.

Of particular interest is the study of Tang, W. Z. et al. (12) who prepared mixtures of CNT and HDPE by melt processing, finding a good degree of intercalation.

4 Nanowhiskers cellulose

The cellulose nanowhiskers are the crystalline portion in cylindrical form of cellulose fibers that are extracted from the microcrystalline cellulose through a process of hydrolysis with sulfuric acid. Typical dimensions of length are in the range of 200 - 400 nm and less than 10 nm wide. This bio-nanocomposite can improve the properties of polymers such as mechanical (toughness, elasticity, and elongation at break), thermal stability, decreases permeability and improves bio-degradability.

To prepare this type of nanocomposites have been tested mainly two methods: dispersion in solution and mixing during the melt processing. (13, 14).

This field research is still very young and there are techniques that should be studied, improved and / or optimized. Among the challenges that must be overcome are: techniques for isolation of nano fibers / whiskers in large-scale, development of methods for drying, processing of compounds. It is also necessary to develop surface treatments for an appropriate dispersion of fibers in organic media.

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