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Breathable polyethylene/ sepiolite nanocomposite films

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Polyethylene/sepiolite nanocomposite films provide a new material with high elongation at break and transparency, increased Young's modulus and strength, and higher gas permeability.

Polyethylene (PE) films are very widely used—for example, to make bags and other types of packaging—and improving their mechanical and permeability properties would further promote and enhance their utility, as well as enable more advanced applications.[1] One way to improve the properties of PE is by combining it with a nanoscale filler to obtain a nanocomposite. To this end, a promising filler material is sepiolite, a hydrated magnesium silicate with acicular (needle-shaped) morphology, and high surface area and porosity. Nanocomposites of PE and sepiolite are of great potential interest because they could combine the properties of the two components in a synergetic manner to yield new materials with enhanced properties.[2–4] Such PE/sepiolite nanocomposites could be processed to obtain films capable of neutralizing odors and/or absorbing the lixiviated oil in waste bags, for example.

To pursue this idea, we carried out a systematic study on the structure-property relationships of nanocomposite films to investigate the influence of sepiolite content on various final properties of the films.[5] Nanocomposite films containing 1, 3, 5, and 10% by weight (wt%) sepiolite were prepared by cast film extrusion and tested. We demonstrated that good dispersion and distribution of the sepiolite filler was obtained in the films, although sepiolite agglomerates began to appear at the higher nanofiller loadings (10wt%). We also found that the sepiolite particles oriented themselves in the flow direction, as can clearly be seen in Figure 1.

Figure 1. *Transmission electron micrograph of polyethylene (PE) nanocomposite containing 1% by weight (wt%) sepiolite.*

We observed the crystallization behavior of the films by x-ray diffraction and atomic force microscopy: see Figure 2. Our results showed that addition of sepiolite increased the degree of polymer crystallization and induced changes in its crystal morphology and orientation. More specifically, the presence of sepiolite increased the thinner crystal population and favored crystallization in monoclinic phase perpendicular to the film flow direction.

We found that the mechanical properties of the nanocomposites were improved with respect to pure PE, and to a greater extent with increasing filler content. There was an approximately 80% increase in modulus for nanocomposites containing 10wt% sepiolite, and sepiolite loading also produced an increase in strength, as is reported in Figure 3. On the other hand, the elongation at break was somewhat reduced, although the nanocomposite films still remained flexible for all the studied compositions, with an elongation at break greater than 300%. We also observed a difference in tear propagation behavior. Whereas in films prepared with pristine PE the tear propagated transversally to the direction of the cut, in the nanocomposite films the tear propagated along the same direction as the notch. However, no difference in the tear strengths of the different films was detected.

The above-reported property changes were obtained without any significant impairment of the transparency of the film, although addition of the filler did cause the films to lose shine and produced some clouding at the higher sepiolite loadings, where formation of agglomerates is possible (see Figure 3). Finally, we found that film barrier properties were also modified by the addition of sepiolite. Oxygen permeability increased with increasing content of nanofiller, owing to the porous structure of sepiolite with a surface hydroxyl (OH) group. This particular behavior is very desirable for applications where gases must be able to move into and out of the film, e.g., breathable packaging for products such as fruit and vegetables.

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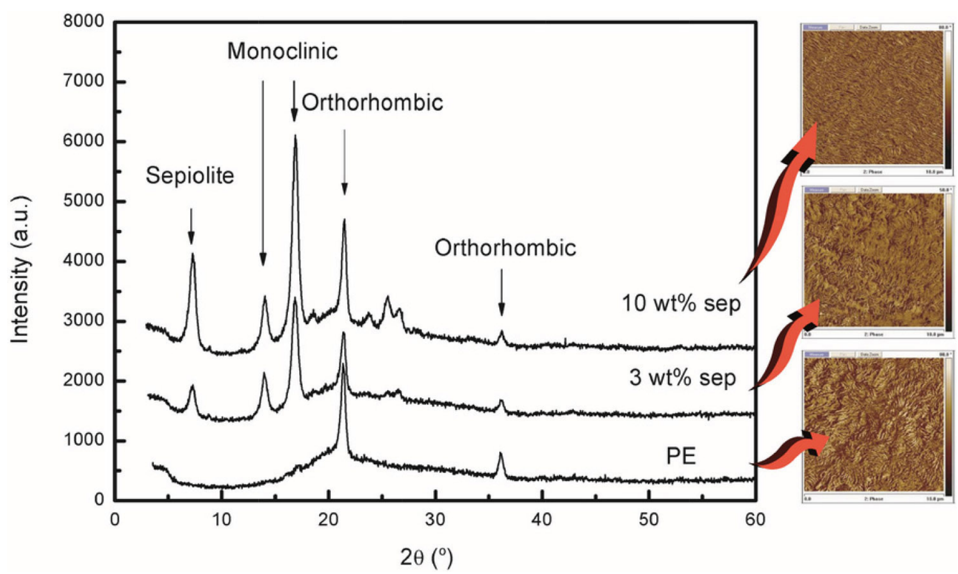

Figure 2. *X-ray diffraction patterns and atomic force microscopy images of nanocomposite films prepared with different sepiolite (sep) loadings, compared with pure PE. a.u.: Arbitrary units. 2θ: Scattering angle.*

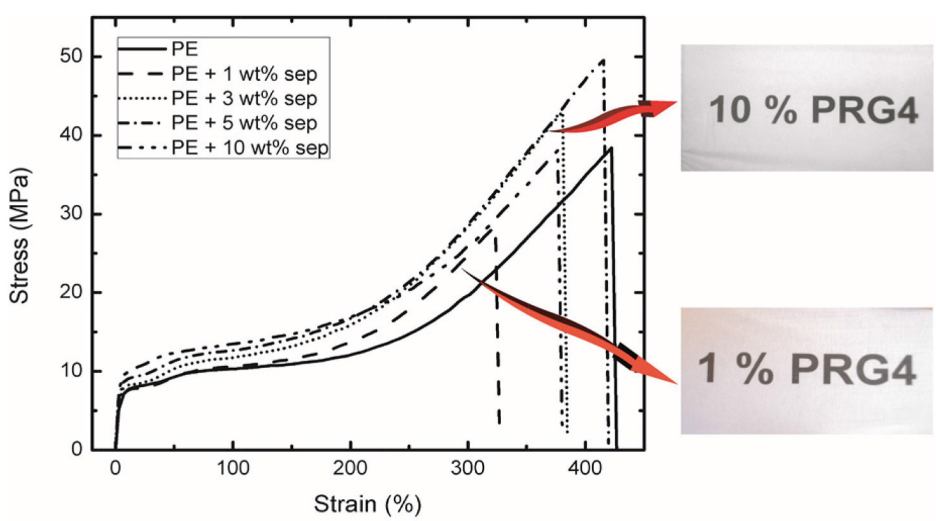

Figure 3. *Left: Stress-strain curves of the nanocomposite films. Right: Photographs showing the optical properties of films with 1 and 10wt% sepiolite (here labeled PRG4).*

In conclusion, we obtained PE/sepiolite nanocomposite films by cast extrusion that exhibited high flexibility and transparency, enhanced mechanical properties, and modified barrier properties. Such nanocomposites would also enable PE film to be used in packaging applications that call for higher gas permeability or greater absorbency. We propose to follow up this work by also investigating the preparation of PE/sepiolite nanocomposite fibers, and by analyzing different sepiolite surface modifications to enhance the polymer-clay compatibility.

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