

Abstract
Process Economics Program Report 51C
POLYMER NANOCOMPOSITES
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With the rush of interest in all things related to nanotechnology, polymer nanocomposites represent one of the emerging spin-offs of this exciting new technology. The push in nanocomposites is occurring worldwide with a large number of corporations and research institutions studying potential applications. Polymer nanocomposites are polymer either thermoset or thermoplastic reinforced with a small quantity (<10%) of nanometer-size particles. Nanocomposites offer new and improved properties compare to conventional plastics due to the interaction of nanoparticles on a nanometer scale with the polymer phase and the high aspect ratio of the nanoparticles. Because of the new product properties, the growth in polymer nanocomposite demand is expected to be strong with nanocomposites replacing existing conventional composites and higher performance products.

In 1987, Toyota Central R&D disclosed a nanocomposite composition consisting of nylon 6 and nanoparticles of organically modified montmorillonite clay. Ube, Unitika, Honeywell and Bayer have introduced nylon-based nanocomposites. Since then, a large number of companies have been developing nanocomposites for commercial applications. In the fall of 2001, GM with Basell launched the first commercial automotive application of nanocomposite thermoplastic olefin. More recently, widespread interest has been generated by carbon nanotubes as reinforcing fibers for composites. Because of its unique geometry, potentially a new generation of lightweight, high-strength composite can be produced.

This report will review the technological development in nanoparticles. It will principally focus on nanocomposites produced with nanoparticles of clay where most of the commercialization activities are occurring. Nanoclay and nanocomposite production, product properties, potential applications, current markets and producers will be reported. The process economics for production of nanoclay and nanocomposites will be evaluated. The status of other potential nanofillers, i.e., carbon nanotubes and polyhedral oligomeric silsesquioxanes, will be reviewed. Because this report focuses on the status and future direction of polymer nanocomposites, it will be of particular interest to producers of polyolefins.

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GLOSSARY

Symbol or Term	Definition
CEC	Cation exchange capacity
DWNT	Double-walled nanotubes
EVA	Ethylene vinyl acetate
HDT	Heat deflection or distortion temperature
HRR	Heat release rate
LOI	Loss on ignition
MAO	Methyl aluminoxane
MA-PP	Maleic anhydride modified polypropylene
meq/100g	Milliequivalent of cations per 100 g of clay (a unit for CEC)
MWNT	Multi-walled nanotubes
OTR	Oxygen transmission rate
PA	Polyamide (nylon)
PBT	Polybutylene terephthalate
PEEK	Polyether ether ketone
PEI	Polyetherimide
PET	Polyethylene terephthalate
PP	Polypropylene
PPO	Polyphenylene oxide
PPS	Polyphenylene sulfide
POSS	Polyhedral oligomeric silsesquioxanes
PUR	Polyurethane
ROI	Return on investment
sg	Specific gravity
SWNT	Single-walled nanotubes
TEM	Transmission electron microscopy
T _g	Glass transition temperature
TPO	Thermoplastic olefin
XRD	X-ray diffraction