**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 |