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Recent Advances in Polymer/Layered Silicate Nanocomposites: An Overview from Science to Technology

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A decade of research has shown that nanostructured materials have the potential to significantly impact growth at every level of the world economy in the 21st century. This new class of materials is now being introduced in structural applications, such as gas barrier film, flame retardant product, and other load-bearing applications.
Of particular interest is recently developed *nanocomposites* consisting of a polymer and layered silicate (LS) because they often exhibit remarkably improved mechanical and various other properties [1] when compared with pure polymer or conventional composites (both micro- and macro-composites). A primary progress in *polymer/layered silicate nanocomposites* (PLSNCs), a Nylon 6/LS hybrid reported by Toyota Central Research & Development Co. Inc. (TCRD), was successfully prepared by in-situ polymerization of ε-caprolactam in a dispersion of montomorrillonite (MMT). The silicate can be dispersed in liquid monomer or a solution of monomer. It has also been possible to melt-mix polymers with layered silicates, avoiding the use of organic solvents. The latter method permits the use of conventional processing techniques such as injection moulding and extrusion.
Continued progress in nanoscale controlling, as well as an improved understanding of the physicochemical phenomena at the nanometer scale, have contributed to the rapid development of novel PLSNCs. This lecture presents current research on PLSNCs with the primary focus of recent advances from basic science to technology, which was conducted by our research group.
We have established a research programme in advanced polymeric nanocomposites and nanocomposite processing. We studied the mechanism of nano-filler dispersion in polymeric matrices as well as the effect these particles have on flow and processing – on the non-linear viscoelastic behavior of these materials evidenced by strain hardening. It has been known that addition of solid filler to polymer reduces the strain hardening of matrices that originally showed this behavior (e.g., of LDPE) or even caused strain softening (never observed for neat polymers). We for the first time demonstrated that addition of nano-particles to melt results has an opposite effect – it results in a significant enhancement of strain hardening. This observation is particularly important for foaming with a huge cell density (~10^{14}/cm^3) and a small cell size (~200nm) in this technologically important field. Another important observation is the enhancing effect of nano-filler on biodegradability of linear polyesters, viz. polylacticacid, or poly(butylene succinate). As we showed, addition of nano-filler provides suitable means for controlling this phenomenon.

Reference

[1] Sinha Ray S, Okamoto M. *Prog. Polym. Sci*. 2003, *28*, 1539-1641.