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Carbon nanotubes used as a thermal stabilizer in polymers

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We began with the study of various surface-modified multiwalled carbon nanotubes (CNT) for a use as a radical scavenger. Electron spin resonance (ESR) and ultraviolet/visible spectrophotometer (UV/Vis) were used to measure radical scavenging efficiencies of the modified CNT for hydroxyl (OH.) radical and 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical, respectively. ESR, UV/Vis, and Raman spectra revealed that all CNT samples were good radical scavengers for both radicals and the radical scavenging efficiencies increased with increasing contents of defect sites on the modified CNT. We also investigated the radical scavenging efficiencies of silane-grafted CNTs for OH and DPPH radicals and found that the radical scavenging efficiencies decreased upon increasing the degree of the silane grafting, due to the steric bulk of the silane grafts on the surfaces of the CNTs. We used DSC to examine the effects of the silane-grafted CNTs on the exothermic peaks of the free radical–initiated crosslinking reactions of vinyl ester/styrene resins. The silane-grafted CNTs were found to retard the crosslinking reactions to various extents: a higher degree of grafting resulting in a lower crosslinking retardation. Finally, we assessed the surface-modified CNT (CNT, bmCNT, and CNT-COOH) as thermal stabilizers in poly (vinyl chloride) (PVC). Films of pure PVC, CNT/PVC, bmCNT/PVC, and CNT-COOH/PVC cast from tetrahydrofuran were subjected to thermal aging in N_2 in a test tube submerged in an oil bath maintained at 180°C for a certain time. FTIR and UV-Vis spectra and discoloration of aged PVC composites were investigated on the formation of conjugated polyene structure in PVC. The results found that all three types of CNT of small amounts (0.1 or 0.3 phr) could stabilize PVC against thermal degradation by resisting the formation of a conjugated polyene structure in the order of bmCNT > CNT > CNT-COOH. Moreover, Congo red test and pH measurement were investigated on the dehydrochlorination of PVC during the thermal aging. The bmCNT was also the most effective thermal stabilizer among the three types of nanotubes studied to resist degradation of HCl from PVC. This newly-developed PVC composite with CNT as an additive can provide an efficient route towards the development of highly thermal-stabilized PVC.

Biography

Yeong-Tarng Shieh is currently a professor at Department of Chemical and Materials Engineering of National University of Kaohsiung (NUK), Kaohsiung, Taiwan. He was the department head from 2014-2017. His research interest recently includes living free radical polymerizations, stimuli-responsive polymers, preparation of carbon dioxide-switchable nanoparticle dispersion, supercritical carbon dioxide fluids technology, and applications of carbon nanotubes.

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