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Influence of Specific Interactions and Reactive Coupling in Assessing the State of Dispersion of Multiwall Carbon Nanotubes in Co-continuous Polymer Blends

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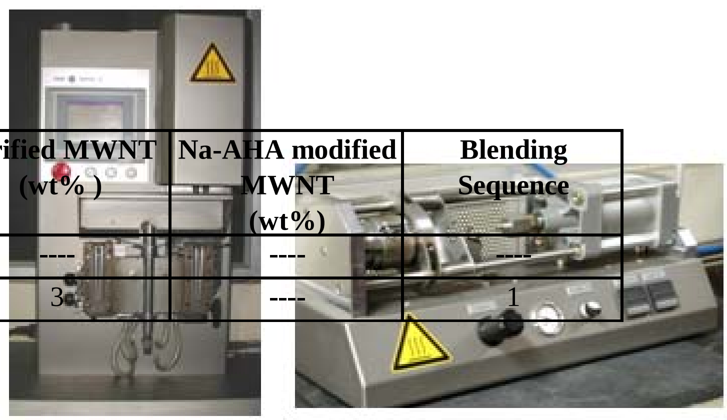
Extended Abstract : An efficient strategy to achieve electrical conductivity in melt-mixed co-continuous blends is to restrict the conducting filler in a particular phase in the blends next to forming a percolative 'network-like' structure in that particular phase. However, strong inter-tube van der Walls' forces often hinders the formation of percolative 'network-like' structure and in addition, the migration of the conducting filler during melt-mixing and the blending sequence significantly affects the bulk conductivity of the blends. To understand these complexities we studied the electrical conductivity of melt-mixed blends of polyamide6/Ionomer with multiwall carbon nanotubes (MWNT) prepared using a conical twin-screw microcompounder (see Figure 1a). The samples for electrical conductivity measurements were prepared using a mini-injection moulded machine (see Figure 1b).



a b

Figure 1: (a) DSM conical twin screw microcompounder; (b) DSM mini-injection moulding machine.

Table 1: Sample codes and compositions of PA6/Surlyn blends with MWNT

Sample code	PA6 (wt%)	Surlyn (wt%)	Purified MWNT (wt%)	Na-AHA modified MWNT (wt%)	Blending Sequence
N50S50	50	50	----	----	----
N50T3S50	50	50	3	----	1

S50T3N50	50	50	3	----	2
N50MT3S50	50	50	----	3	1
S50MT3N50	50	50	----	3	2

The detailed blends composition is listed in Table 1. We observed from the SEM micrographs that due to the existence of specific interactions ('cation-π') between the extended 'p-clouds' of MWNT and the ionic domains (Na^+) in the ionomer, the MWNT were localized in the vicinity of the ionic domains (see Figure 2a). However, we observed that the blends with even 3 wt% MWNT showed insulating behaviour irrespective of the blending sequence adopted (see Table 1).

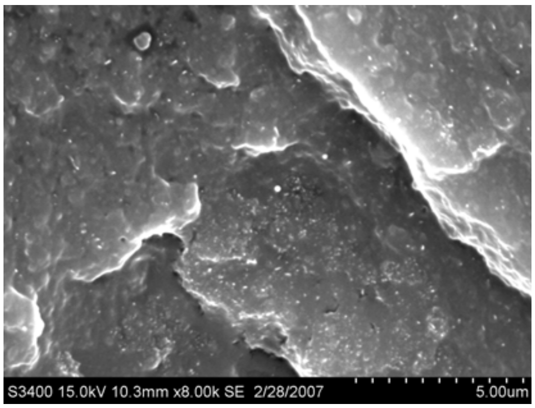


Figure 2: SEM of a) N50T3S50; b) N50MT3S50

We report here the key role of a reactive modifier (sodium salt of 6-amino hexanoic acid, Na-AHA) in facilitating uniform dispersion and subsequent 'network-like' formation by establishing specific interactions with MWNT. In addition, it was found that due to melt-interfacial reaction between the ~NH_2 functionality of Na-AHA and the ~COOH end groups of PA6 the MWNT is selectively localized in the PA6 phase in the blends manifesting in higher electrical conductivity (~10^{-5} S/cm at 3 wt% MWNT) related to a specific blending sequence. FTIR and Raman spectroscopic analysis also supported the existence of the specific interactions. The concept of specific interactions together with the reactive coupling also manifested in lower electrical percolation threshold (0.5 wt% MWNT) in melt-mixed co-continuous blends of PA6/ABS. Next to confinement of MWNT in the PA6 phase in presence of Na-AHA in PA6/ABS system, which was supported by solution experiments this strategy also manifested in the refinement of the co-continuous structure as observed from the SEM micrographs.

Key words : Polymer blends, MWNT, Electrical Conductivity