

Influence of shear and residence time in twin-screw extrusion of PCL – CNT composites

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In order to get electrically conductive polymer composites based on conductive fillers a network formation (percolation) of the filler within the matrix is needed. This is desired at low fractions of the filler, for which carbon nanotubes (CNT) are very suitable due to their very high aspect ratio. The distribution and dispersion of CNT is influenced by the incorporation technique whereby melt mixing is an appropriate way to individualise CNT from primary agglomerates. However, a limited knowledge exists about the influence of melt mixing conditions in extruders. In this study, the influence of screw configuration, rotation speed, and throughput on the macro dispersion of CNT in polycaprolactone (PCL, CAPA 6800) based masterbatches (later used for dilution) having 7.5 wt% multi-walled CNT (Nanocyl[®] NC7000) is discussed. A Berstorff ZE25 twin-screw extruder with a modular assembly was chosen. It was found, that the choice of the screw elements like kneading or mixing has a significant influence on the minimum residence time of PCL during extrusion. The use of kneading blocks result in longer minimum residence times in comparison to mixing elements, because these elements exhibit an active conveying effect. This effect is independent of rotation speed. The further addition of back conveying elements led to a significant increase of the minimum residence time which was found as well for dispersive as for distributive screw profiles. The largest effect on the minimum residence time was achieved with increasing the extruders processing length to $L/D=48$. Although distributive screw profiles exhibit shorter minimum residence times in comparison to dispersive ones, the use of these screws led to significantly better CNT dispersions. This finding can be related to the much higher mixing efficiency of such mixing elements. Furthermore, the design of screw profiles to have distributive mixing elements resulted in significantly lower specific mechanical energy (SME) inputs.