

论文

## 多壁碳纳米管填充高密度聚乙烯复合材料的导电性和动态流变行为

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**摘要** 对多壁碳纳米管/高密度聚乙烯(MWNTs/HDPE)复合材料的导电性和动态流变行为进行了研究. 发现复合材料的复数粘度 $\eta^*$ 随MWNTs含量 $\phi$ 的增大而增大. 当 $\phi > 3\text{wt}\%$ 时,  $\eta^*$ 发生突变, 在低 $\omega$ 区域表现为非牛顿流体行为, 出现强烈的剪切变稀现象. 将其称为流变渗流现象, 对应的填料含量即渗流阈值 $\phi_c$ . 在动态储能模量( $G'$ )、损耗模量( $G''$ )与频率( $\omega$ )关系曲线上, 随 $\phi$ 增加出现“第二平台”, 第二平台的出现表明MWNTs与MWNTs之间、MWNTs与聚合物之间存在相互缠结形成网络的结构. 同时发现, 在 $\tan\delta \sim \omega$ 曲线上的低 $\omega$ 区出现凹谷. 认为这是由于MWNTs长链结构在低 $\omega$ 时伸长/收缩, MWNTs与MWNTs相互接触形成了次级网络造成的. 经过不同时间热处理后的 $\omega$ 扫描以及动态时间扫描的结果证实了这种结构的存在. 研究结果表明复合材料的流变渗流阈值与电渗流阈值相一致(均在3%~5%之间), 动态流变行为与导电性存在一定的相关性.

**关键词** [多壁碳纳米管](#) [高密度聚乙烯](#) [导电性](#) [动态流变行为](#) [渗流](#)

分类号

## ELECTRICAL AND DYNAMIC RHEOLOGICAL BEHAVIORS OF MULTI WALLED NANOTUBES-FILLED HIGH-DENSITY POLYETHYLENE COMPOSITES

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**Abstract** Studies on the dynamic rheological behaviors and electrical properties for multiwalled nanotubes filled high-density polyethylene composites were carried out. An obvious shear thinning phenomenon in  $\eta^*$  vs  $\omega$  was found for composites of MWNTs content beyond 3%. A specific viscoelastic behavior, i. e. the so-called “second plateau”, appeared at low frequency region in cases of  $\psi > 3\%$ . This phenomenon could be regarded as a rheological threshold, and could be attributed to the formation of some kind network structure due to MWNTs aggregation and the interaction between MWNTs and polymer matrix. A minimum was found in the low  $\omega$  region for the  $\tan\delta \sim \omega$  curves, which also was believed to be induced by the formation of network structure. Results of dynamic frequency sweep after heat treatment of different time length and results of dynamic time sweep approved the previous postulation. Ultimately, the rheological threshold coincided with the electrical percolation threshold which was found for the composites containing MWNTs of 2 wt% and 3 wt%.

**Key words** [MWNTs](#) [HDPE](#) [Electrical properties](#) [Rheological behavior](#) [Percolation threshold](#)

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