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# Characterization and processing of High Density Polyethylene/carbon nano-composites

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ABSTRACT

In the present study, different series of High Density Polyethylene (HDPE)/carbon nano-composites were prepared using melt blending in a co-rotating intermeshing twin screw extruder. The morphological, thermal, rheological, viscoelastic, mechanical, and fracture toughness properties of the nano-composites were analyzed. The microscopic examination of the cryogenically fractured surface found a good distribution of carbon nano-particles in the HDPE matrix. The melting temperature was not significantly affected by the addition of nano-carbon. Whereas, the crystallization percentage was slightly affected by adding carbon nano-particles into the matrix. The complex viscosity increased as the percentage of carbon increased. The Dynamic Mechanical Analysis (DMA) showed that the storage modulus increased with increasing the carbon nano-particles ratio and with increasing the testing frequency. The tensile test results showed that with increasing the carbon nano-particles contents, the Young's modulus, yield strength of HDPE nano-composite increased while the strain at fracture decreased. Similarly, the fracture toughness and the strain energy release rate decreased proportional to the carbon content.



## 1. Introduction

High Density Polyethylene (HDPE) is a commodity thermoplastic polymer that has been widely used in different packaging applications. Its outstanding features such as regular chain structure, combination of low cost and low energy demand for processing, excellent biocompatibility and good mechanical properties make HDPE expand its application continuously [1–4]. Even in heat transfer application, where the materials should have superior thermal conductivity like steel and many other metals, the demand for HDPE in this field is also growing. For example, in the big dams cooling systems, HDPE pipes are used instead of steel pipes [5]. The superiority of HDPE pipes to other metals pipes could be attributed to their lighter weight, high corrosion resistance and low costs. The main problem of HDPE in such applications is its poor thermal conductivity.

Generally, the HDPE thermal, mechanical and bioactivity properties can be improved by the addition of inorganic particles into the polymer matrix [6–10]. In the traditional HDPE composites, a large amount of microfillers (>20 vol.%) is generally required to improve the composite properties [1,11–15], However, these improvements are usually accompanied with severe losses in the material ductility and toughness.

In order to overcome the decrease in the traditional HDPE composite ductility and toughness due to the addition of microfillers, HDPE filled with nanofillers have attracted great interest nowadays, in both industrial and biomedical applications. The polymer nano-composite is characterized by using reinforcement with nano-dimensions, which is added in small quantities compared to traditional polymeric composites. In these composites, a relatively small amount of nanofillers (<3 vol.%) such as carbon nanofibers, carbon nanotubes, carbon nano-particles have been used to improve the composite properties with minimum effect on the material ductility [1]. Also, a key point for improving the polymeric nano-composites properties is to induce a fairly good distribution and dispersion of these nanofillers in the polymer matrix.

Many types of fillers have been used with HDPE in order to improve its properties. Recently, graphite and carbon nano-particles have been used to develop HDPE nano-composites for some important applied cases. Over the past few decades, many researchers have paid attention to the electrical and thermal properties of HDPE/graphite and carbon nano-composites [1,5,10,11]. Atypical use of carbon particles in polymer is to improve its laser weldability [16]. However, there are no sufficient details or experimental results in the literature about the effects of carbon nanoscale fillers

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