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Modification of Peek/Carbon Nano-Tubes Nano Composites, Evaluation of Mechanical and Morphological Properties - An in Vitro Study¹Vaisey D L, Dental Surgeon.²Hsueh T K, Dental Surgeon.³Gomez E D, Dental Surgeon.**Correspondence Author:** Vaisey D L, Dental Surgeon.**How to Cite This Article:** Vaisey D L, Hsueh T K, Gomez E D, “Modification of Peek/Carbon Nano-Tubes Nano Composites, Evaluation of Mechanical and Morphological Properties - An in Vitro Study”, IJDSDR – January – February - 2023, Vol. – 2, Issue – 1, P. No. 19 – 22.**Open Access Article:** This is an Open Access article that uses a funding model which does not charge readers or their institutions for access and distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>) and the Budapest Open Access Initiative (<http://www.budapestopenaccessinitiative.org/read>), which permit unrestricted use, distribution, and reproduction in any medium, provided original work is properly credited.**Type of Publication:** Original Research Article**Conflicts of Interest:** Nil**Abstract**

PEEK, which has good thermal and mechanical qualities, is a thermoplastic with great performance. Thermo plastic vulcanized (TPV) was used and combined with PEEK matrix to increase the toughness and flexibility of the material. The multi-walled carbon nanotubes (MWCNTs) were combined using melt mixing to create nanocomposites. The findings of the mechanical tests revealed that adding TPV up to 10% increased the flexibility and that adding CNT nanoparticles boosted the tensile strength of the nanocomposites. Observations using scanning electron microscopy showed that the CNT nanoparticles were evenly dispersed throughout the PEEK matrix. An extremely tough nanocomposite that contains 10 w%

TPV and 0.5 w% CNTs was successfully synthesized and showed the best mechanical capabilities.

Keywords: PEEK, CNT, MWCNT, TPV.**Introduction**

The semi-crystalline polymer polyether ether ketone (PEEK) has exceptional mechanical, chemical, and thermal qualities that enable its usage in a wide range of industrial applications, particularly as a metal substitute, medical equipment, and aircraft components. The stability of the aromatic backbone and the malleable polar ether segments in the chain are responsible for PEEK's exceptional thermal characteristics. Different blends based on PEEK have been created, however due to the high processing temperature of PEEK, no elastomer, or thermoplastic elastomer (TPE) addition has been made. To strengthen the matrix's toughness, rubber

and TPE are essentially combined with a thermoplastic, however these materials, like TPEs, can breakdown when PEEK melts at a temperature between 340 and 360 °C. The large family of thermoplastic elastomers includes thermoplastic vulcanizates (TPVs) (TPEs)(3). They are commonly created by a dynamic vulcanization process, in which an elastomeric phase is selectively cross-linked while melting with a thermoplastic, allowing for processing of the material as thermoplastic polymers while it is still in the molten form. Because of its cross-linked and cured structures, TPV has more thermal stability than the other TPEs and may be less likely to degrade when mixed with a high-performance plastic like PEEK. Nanocomposites are used in a variety of sectors nowadays. Fundamentally, the addition of CNTs to a polymer matrix can significantly increase the strength and modulus of structural materials. As toughening a high-performance plastic with the mo. plastic elastomer was rarely addressed in the literature, PEEK/ CNT- nanocomposites were created in this study, and TPV was also used to increase the toughness of the nanocomposites.

Materials and methods

The matrix was bought from European Virtex High-performance Materials Trading Co. and is called polyether ether ketone (PEEK 450CA30). Before combining, it was dried at 120 °C for three hours. The Nanocyl 7000 unaltered multi-wall carbon nanotubes (MWNTs) were purchased from Nanocyl Co. in Belgium and used exactly as supplied. Its average length was 1.5 micron, and its average diameter was 9.5 nm. A co-rotating twin-screw extruder was used to melt all of the blends and nanocomposites. The L/D was approximately 32, the screw rotated at 200 revolutions per minute, and the extrusion temperatures ranged from 310 to 350 °C. In the beginning, PEEK/TPV-based

blends were created, with TPV content varying from 5, 10, 20, and 40 weight percent, and the maleate polyethylene concentration being roughly 5 weight percent for all of the blends. Due to its ideal qualities, the mix containing 10 w% TPV was chosen as the matrix to manufacture nanocomposites. Finally, the nanocomposites were produced, with varied CNT contents of 0.1, 0.3, 0.5, and 1 wt. %. The ASTM standard tensile and Izod impact specimens were produced by injection molding the granular blends and nanocomposites after mixing. An injection molding device from Hai Tian with a 24 L/D was used to complete this moulding. The molding conditions were as follows: temperature of 350 to 380 °C, mold temperature of 90 to 100 °C, and molding pressure of 40 to 50 MPa. Tensile trial was done by ASTM D638 using a Zwick 1485 universal testing machine. Displacement velocity was about 5 mm/min. The Izod impact test was also performed on notched impact specimens according to ASTM 256 using a Toyoseiki machine. For each blend, five specimens were tested and the average value was given (standard deviation of lower than 5%).

Results

Mechanical properties

As previously indicated, polyether ether ketone was mixed with TPV in the beginning to increase the flexibility and impact strength of the PEEK. The best PEEK/ TPV blend was then selected, and it was reinforced with multi-wall carbon nanotubes. It is preferred that polyether ether ketone and polyolefin, such as TPV, be compatible with one another. Thermoplastic vulcanizates should be used to toughen PEEK.

By adding more TPV to the PEEK matrix, the mixes' tensile strength at break was reduced. This resulted from TPV's lower elastic modulus when compared to PEEK's

elastic modulus. Additionally, the addition of TPV up to 10 w% to the matrix boosted the blend's elongation at break, which enhanced impact strength. It was because TPV's flexibility allowed for more energy to be absorbed during the fracture, which improved the material's elongation and impact strength. Furthermore, the blend's elongation and impact strength decreased as TPV increased from 20 to 40 w%.

This resulted from PEEK and TPV's immiscibility in this TPV loading range. In actuality, high TPV loading—between 20 and 40 w%—is insoluble in the PEEK matrix. As a result, the blend containing 10 w% TPV was chosen as the ideal blend and matrix to create the nanocomposites. Carbon nanotube (CNT) inclusion increased tensile strength at break and impact strength by up to 0.5 w%. According to Kontou et al., nanofillers essentially serve as reinforcing agents to boost the tensile strength and impact strength of the PEEK nanocomposite. The tensile and impact strength of the nanocomposite tend to decrease with larger nanoparticle contents, such as 1 w% of CNT, due to the aggregation of CNT nanoparticles in the PEEK/TPV matrix.

Furthermore, it is evident that using CNT decreased the elongation of the nanocomposites. Nanofillers, which restricted the polymer chains' movement during the fracture, were also to blame. But because of the improvement in impact resistance brought about by the rise in tensile strength, the nanocomposites might be made tougher.

Morphological properties

The secret to creating nanocomposites with superior thermal and mechanical properties is to achieve a sufficient dispersion of the MWCNTs in the matrix. Due to the CNTs' propensity to collect and form bundles, this task is typically challenging. The fracture surfaces were

studied by SEM to determine the degree of TPV and CNT dispersion in the blend and the nanocomposites.

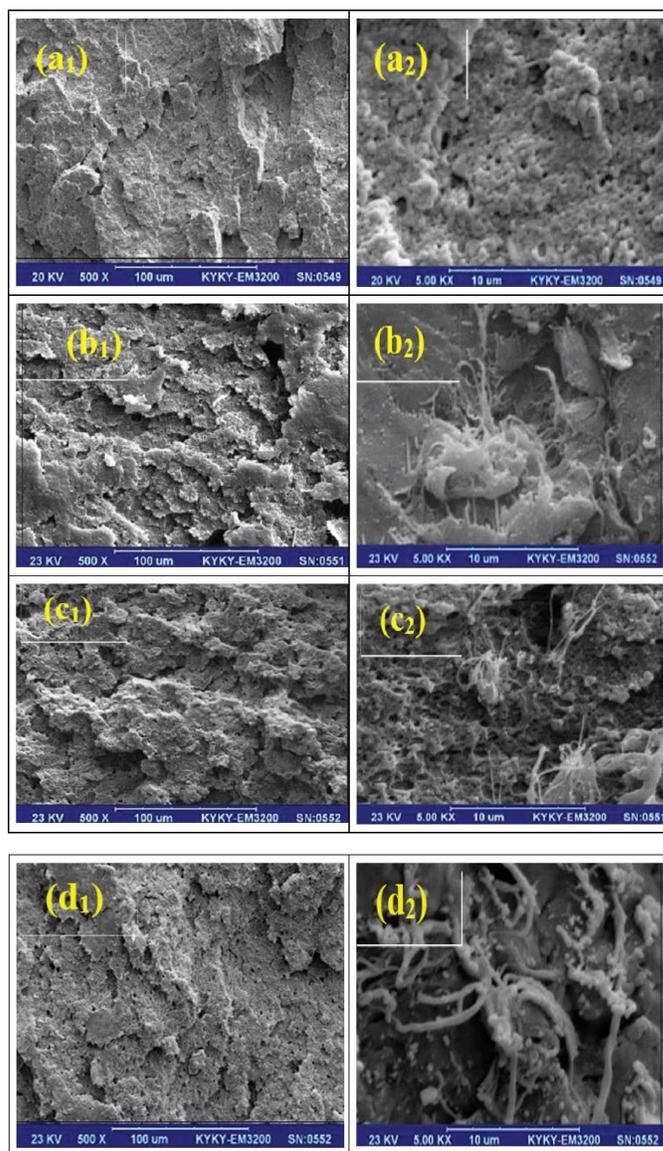


Figure 1: SEM images of the PEEK/TPV blend (a1 and a2) and nanocomposites with 0.1 w%, 0.5 w%, and 1 w% CNT (b1 and b2), where 1 represents 500 X and 2 represents 5000 X

SEM micrographs of the PEEK/TPV mix, which contained 10 w% TPV in the PEEK matrix, are shown in figures a1 and a2. The TPV was finely dispersed in the PEEK matrix, and the average TPV particle size is less than 1 micron, according to the micrographs. Additionally, the pictures of the nanocomposites show a uniform distribution of CNTs throughout the PEEK/TPV

matrix, with an average bundle diameter of 70 to 120 nm, particularly in the nanocomposite that contained 0.5 weight percent of CNT. However, at high CNT concentrations, such as in nanocomposite materials containing 1 w% of CNT, it is evident that the bundle diameter increased as a result of the inclination to aggregate. In fact, the mechanical characteristics of the 1 w% CNT-based nanocomposite were reduced as a result of this inefficient dispersion.

Conclusions

The effect of thermoplastic vulcanizate on the toughening of polyether ether ketone and the level of MWCNT loading in the PEEK/TPV blend have both been examined. The flexibility and impact strength of the mix with 10 w% TPV exhibited an improvement in the mechanical properties. The tensile and impact strength of the PEEK/TPV blend were improved by adding CNT nanoparticles up to 0.5 w%. A study of the morphological behavior of nanocomposites revealed that the CNT nanoparticles were dispersed in the PEEK/TPV matrix in a fine, homogeneous manner. Additionally, CNT loadings of 0.1 w% demonstrated a weaker impact than those of 0.5 w%.

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