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Influence of h-Boron Nitride on the thermo-mechanical properties of out-of-autoclave manufactured silica fiber reinforced phenolic composites

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Directionally oriented fiber-reinforced composite materials are increasingly finding applications, both as structural materials and as ablatives, for thermal protection systems. Silica fiber reinforced phenolic resins matrix composites are of interest due to their superior light weight, renewability, high strength, high stiffness, good corrosion resistivity, enhanced energy recovery and lower fabrication cost. Although silica/phenolic composites provide excellent thermomechanical or mechanical properties, numerous applications and fields demand improved mechanical behavior as well as the presence of additional properties such as thermal conductivity, radiation tolerance, and optical transparency. Therefore, the development of nanoparticle entrained fiber reinforced composites is gaining interest to take advantage of the ability to design the individual constituents (fibers and nanoparticles) to improve mechanical properties as well as add additional functionality. In these materials, properties enhancement and added functionality are tailored and tuned by material composition. To add multifunctionality, such as increased thermal conductivity and thermomechanical properties, the appropriate fillers need to be incorporated into a composite in a manner that does not degrade the mechanical properties. Boron nitride (BN) is an ideal candidate to add multifunctionality, while maintaining mechanical properties, due to its extraordinarily high Young's modulus, high thermal stability, outstanding thermal conductivity, and unlike graphene based materials, a wide bandgap and low leakage current. Therefore, this work aims to study the incorporation of BN nanoplatelets into silica fiber reinforced phenolic laminates and the associated effect on the final mechanical, fracture, thermal, and thermomechanical properties. Laminates were manufactured by means of a modified out-of-autoclave vacuum bag technique that utilizes a hot press to apply high pressures during laminate consolidation. The laminates were modified with varying amounts of BN nanoplatelets: 0 vol%, 5vol%, and 10 vol% and subjected to the same processing conditions. The relationship between BN loading and mechanical properties was determined via three-point bend testing and short beam shear testing. The fracture properties were analyzed using optical and scanning electron microscopy. The thermal properties were investigated using thermogravimetric analysis and laser flash analysis. Finally, the thermomechanical properties were explored using dynamic mechanical analysis. All details are presented.

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