Ballistic-Mitigant Metal-Ceramicized Carbon Fiber Lightweight Nanocomposites as Body Armors

It is well-known that particle reinforced aluminum-matrix composites (AMC) are particularly attractive for automobiles and aircraft industries due to their lightweight, high strength, good wear resistance and high modulus of elasticity. The earlier favorites (whiskers or fibers of alumina and/or silica with high aspect ratio) have been replaced by carbon nanofibers and nanotubes with exceptional mechanical and electrical properties in the next generation composites. An additional advantage of carbon fibers is the solid lubrication provided by them which helps in achieving good wear resistance at elevated service temperatures as well.

However, the greatest practical challenge in the way of developing such a novel composite is the non-wetting of the CNFs by, and the possibility of a reaction with, the molten aluminum; the latter leads to the formation of a rather brittle aluminum carbide ($\text{Al}_4\text{C}_3$) phase, which seriously compromises the integrity of the structure in it entirety. A plausible way of overcoming this deterrent is to synthesize a CNF-alumina composite as a fiber from a suspension of CNFs in a suitable precursor of the latter. The resulting reinforcement which consists of alumina encapsulated CNFs in the form of nanorelics could then be dispersed effectively and randomly in the molten aluminum matrix wherein the incorporation of alumina ceramic is quite facile, without compromising the integrity and/or functional characteristics of the CNFs, while protecting them from making direct contact with molten metal matrix.

It is proposed to fabricate mats of alumina encapsulated CNFs by a proprietary technique developed by the advisor, and study their nanostructural and mechanical features as well as those of their composites in aluminum matrix. This project would give the student a unique opportunity to get excellent hands-on experience on the fabrication and processing techniques, mechanical evaluation and characterization by XRD and, scanning and transmission electron microscopy.

The project is available as an honors research or special topic project for undergrads. If interested, please contact Dr. Abdul-Majeed Azad at: Abdul-Majeed.Azad@UToledo.Edu or 530-8103.