Carbon materials and their role as reinforcement in composite materials

Abstract

The study of composite materials goes far in time, and their applications are plentiful in almost all fields of engineering. Wattle and daub is one of the oldest man-made composite materials, at over 6000 years old, while some of the most up-to-date applications involve the use of carbon allotropes, that are being extensively studied in the recent years. In fact, carbon fibers, graphene and carbon nanotubes can significantly improve the mechanical, electrical and thermal properties of the matrix in which they are used. These materials have brought tremendous progress in the field of technology. In cement matrix, composites with carbon fibers and carbon nanotubes allows a self-monitoring of the structure. In polymers, the use of graphene can increase not only the mechanical properties but also the thermal ones.

From various studies analyzed over the years, it has emerged that there is a key role of the dispersion of reinforcement in the matrix. In some cases, a bad dispersion can even create a defect in the structure causing a worsening of the properties of materials. Another important point is the interaction between matrix and reinforcement: only with a high interaction there will be a significant increase in properties.

In recent years, it was demonstrated that a chemical treatment on the reinforcement surface can increase the dispersion and the interaction with the matrix. In this work, we studied the effect of chemical treatments on the surface of the reinforcement, with the goal of improving both dispersion and interaction with the matrix. For this goal, we used different matrices, different reinforcement and various approaches. On one side, we tried to understand what is the best chemical treatment for reinforcements that can improve both mechanical and electrical properties of a cement-matrix composite. On the other hand, we tried to demonstrate that a hierarchical arrangement of nano and micro reinforcement can bring to better mechanical properties, overcoming interaction problems between a polymer matrix and carbon-based reinforcement. In fact, we showed that grafting the nanotubes onto the carbon fibers considerably improves their interface interaction with the matrix, effectively doubling their apparent strength. At the same time, the addition of nanotubes to microfibers reinforcement helps to improve the composite toughness, reaching more than twice the value obtained for the conventional, non-hierarchically reinforced composites.