Materials Science & Engineering C-Materials for Biological Applications. Volume:104. November 2019

Graphene and graphene oxide functionalisation with silanes for advanced dispersion and reinforcement of PMMA-based bone cements

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Abstract— The reinforcement of PMMA bone cements using carbon based nanomaterials has demonstrated to be a potential solution to their poor mechanical properties. The achievement of an optimal dispersion of the nanoparticles within the polymeric matrix is a crucial but not easy stage in the production of high-quality reinforced materials. In this work, a useful route for the graphene (G) functionalisation, via silanisation with (3-methacryloxypropyl) trimethoxy silane (MPS), has been developed, providing a remarkable enhancement in dispersibility and mechanical properties. With the purpose to define the critical graphene surface oxidation parameters for an optimal silanisation, different routes were thoroughly analysed using infrared spectroscopy (FTIR), thermogravimetric analysis (TGA), X-ray photoelectron spectroscopy (XPS) and scanning electron microscopy (SEM). The results showed that the silanisation significantly improved the G dispersibility: whereas the pristine G dispersion fell down within the first 24?h, the silanised G showed an adequate stability after 5?days. Additionally, this improved dispersibility produced a notable increase in the mechanical properties of the G-reinforced bone cements: in comparison with the pristine G, the compression and bending strength of silanised G increased by 12% and by 13.7% respectively and the fracture toughness by 28%. These results provide very useful information on the relevance that the characteristics of the superficial oxidation of graphene have on the effectiveness of the silanisation process, besides an interesting functionalisation procedure for advanced dispersion and reinforcement of G-PMMA bone cements.

Index Terms— Bone cement; Graphene; Functionalisation; Silane; Reinforcement

Citation:
Paz, E.; Ballesteros, Y.; Forriol Campos, F.; Dunne, N.; del Real-Romero, J.C. "Graphene and graphene oxide functionalisation with silanes for advanced dispersion and reinforcement of PMMA-based bone cements", Materials Science & Engineering C-Materials for Biological Applications, vol.104. November, 2019.