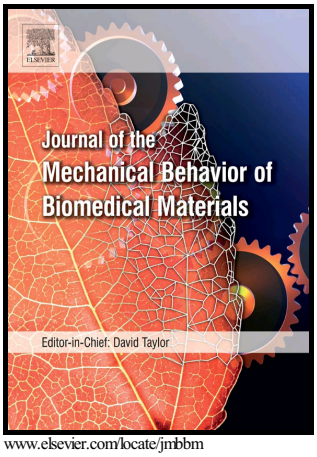
# Effect of graphene on setting and mechanical behaviour of tricalcium phosphate bioactive cements

Carmen Baudín, Teresa Benet, Pilar Pena




www.elsevier.com/locate/jmbbm

PII: S1751-6161(18)31079-8
DOI: https://doi.org/10.1016/j.jmbbm.2018.09.002
Reference: JMBBM2967

To appear in: *Journal of the Mechanical Behavior of Biomedical Materials*

Received date: 23 July 2018
Revised date: 28 August 2018
Accepted date: 2 September 2018

Cite this article as: Carmen Baudín, Teresa Benet and Pilar Pena, Effect of graphene on setting and mechanical behaviour of tricalcium phosphate bioactive cements, *Journal of the Mechanical Behavior of Biomedical Materials,* https://doi.org/10.1016/j.jmbbm.2018.09.002

# Effect of graphene on setting and mechanical behaviour of tricalcium phosphate bioactive cements

Carmen Baudín, Teresa Benet, Pilar Pena

Instituto de Cerámica y Vidrio, ICV-CSIC. Kelsen 5, 28049 Madrid, Spain

Abstract

The potential reinforcing effect of graphene on calcium phosphate cements (CPCs)-based for injectable bone substitutes and scaffolds is presented. The influence of graphene (0-3.84 vol.%) on the microstructural development during setting and the resultant mechanical properties of CPCs constituted by α+β-tricalcium phosphate is analysed. Optimum setting conditions were established using uniaxial compression strength of CPC and composites with pristine and functionalized graphene and liquid/solid ratios (L/S = 0.5-0.6 mL/g) that allowed the mixing and spatulation of the powders. Tensile strength of optimised materials has been determined using the Diametric Compression of Discs Test (DCDT). X-ray diffraction, Raman spectroscopy and FE-SEM-EDS on fracture surfaces were used to investigate phase composition and morphological changes in set specimens. Strengthening occurs for functionalized graphene additions up to 1.96 vol.% due to different toughening mechanisms. Crack deflection, bridging and branching by graphene and, finally, the pull-out of the unbroken graphene sheets have been identified. Interlayer sliding between the graphene before pulling-out is an additional toughening process. Main effect of graphene on strength is the increase of reliability.



Key Words: Calcium phosphate cements; Graphene; Composites; Setting; Microstructure; Mechanical properties

## 1. Introduction

Calcium phosphate (CaP) based ceramics are currently used in clinical practice for bone repair (e.g., dentistry, traumatology, and maxillofacial surgeries) due to their biological behaviour -biocompatibility, bioactivity and osteoconductivity- (see references [1-4] for review). In particular, α- and β-