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Phosphate Based Glasses and Their Application in Biomaterials and Tissue Engineering

Abstract: Phosphate based glasses offer unique properties in that they are degradable and also the rate of degradation may be altered over several orders of magnitude by modification of the glass composition[1,2]. A detailed understanding of the structure has allowed us to more easily relate the subsequent biological properties to their structure. However the probes available to allow a detailed understanding of their structure is limited. We have utilized a number of methodologies including EXAFS, XANES and a range of NMR methodologies to allow us to try and gain a more complete understanding of the structure of the glass. This has also allowed us to probe the structure and investigate the role of particular dopants within the glass structure and their subsequent release[3]. Subsequent work has developed two areas, the first is the utilization of these glasses in fibre form for the regeneration of anisotropic tissue such as muscle and ligament. This fibre work has been further developed to allow the synthesis of collagen-glass fibre composites, which show great promise due to their improved mechanical and biological properties in both the short and long term. Of particular note is the ability of the composites to promote a transient hypoxia with subsequent cellular expression of VEGF to promote vascularization. The second area we have worked on is the development of the glasses via a sol-gel route. Due to the slow polymerization rates for the phosphate network, the reaction times are long. However the major advantage of this synthesis route is the low synthesis temperatures required to produce a glassy material. This has opened up the possibility of inclusion of therapeutic molecules and in particular we have focused on 4- and 6- coordinate platinum compounds for cancer therapy. Recent work has also developed these materials as nanoparticles via electropspraying for use as transient imaging contrast agents[4] and data will be presented on this area.

1. Knowles JC. Phosphate based glasses for biomedical applications. *Journal of Materials Chemistry.* 2003;13(10):2395.
2. Abou Neel EA, Pickup DM, Valappil SP, Newport RJ, Knowles JC. Bioactive functional materials: a perspective on phosphate-based glasses. *Journal of Materials Chemistry.* 2009;19(6):690-701.
3. Lakhkar N, Abou Neel EA, Salih V, Knowles JC. Titanium and Strontium-doped Phosphate Glasses as Vehicles for Strontium Ion Delivery to Cells. *J Biomater Appl.* 2011;25(8):877-893.
4. Foroutan F, Jokerst JV, Gambhir SS, Vermesh O, Kim HW, Knowles JC. Sol-Gel Synthesis and Electrospraying of Biodegradable (P2O5)55-(CaO)30-(Na2O)15 Glass Nanospheres as a Transient Contrast Agent for Ultrasound Stem Cell Imaging. *ACS Nano.* 2015.

Bio: Prof. Knowles has pursued the development of novel materials for hard and soft tissue regeneration. A significant proportion of his work focusses on soluble glasses and is proving very successful and has attracted a significant amount of sponsorship from the research councils (BBSRC and EPSRC and MRC) and also industrially. The work has made some significant contributions to the understanding of the materials and in particular the degradation processes where the current view in the literature has been shown to incompletely model the degradation process occurring, which has important consequences if the material is to be used *in vivo*.