Structural Analysis of Gallium Based Glass Polyalkenoate Cements by Infrared Spectroscopy

Adel MF. Alhalawani[1,2], Declan J. Curran[1], Mark R. Towler[1,2].

[1]Department of Mechanical & Industrial Engineering, Ryerson University, Toronto, ON. Canada

[2]Department of Biomedical Engineering, Faculty of Engineering, University of Malaya, Kuala Lumpur 50603, Malaysia

Statement of Purpose: Glass polyalkenoate cements (GPCs) have been used in dentistry for over forty years and have potential in a range of orthopedic applications including stabilisation of a fractured or medially incised sternum. Gallium (Ga^{3+}) ions have known anti-microbial properties [1], as well as having chemotherapeutic potential [2]. Research is currently being conducted on gallium substituted zinc-based glass polyalkenoate cements (GPCs) to increase their therapeutic potential and clinical handling properties for ribcage closure, post sternomoty surgery. This abstract investigates the effect of gallium additions on GPCs using fourier transform infra-red (FTIR) analysis, and how this affects cement setting reactions.

Methods: Three glass compositions (Control, LGa-1 and LGa-2) were synthesized. Control is composed of 0.12CaO-0.40ZnO-0.48SiO_2, while LGa-1 and LGa-2 contain 0.08 and 0.16 mol% Ga, respectively, at the expense of zinc (Zn). GPCs were prepared by mixing 1 g glass with 0.375 g of poly(acrylic acid) (PAA) (Sigma-Aldrich, MI, USA), Mw ~120,000, and 0.375 ml of distilled water. The nomenclature of the glasses was carried over to the GPCs made from the glasses. Five cement cylinders (6 mm high and 4 mm diameter) were prepared from each glass type and aged for 1 day in distilled water before FTIR analysis. The analysis required a powder with a mean particle size <90 μm. Hence, a pestle and mortar were used to grind the cement. The spectra were collected and averaged for each cement formulation in ambient air (23 ± 1 °C). The spectra were collected using an FTIR spectrophotometer-Thermo Scientific-Nicolet iS10 (Thermo Fisher Scientific, Waltham, MA, USA) equipped with a room temperature Deuterated Tri-Glycine Sulfate (DTGS) KBr detector. Analysis was performed in the wave-number ranging from 650 to 4000 cm^{-1} with a spectral resolution of 4 cm^{-1}.

Results: Figure 1 shows the FTIR spectra for the cement series, obtained 1 day, post cement preparation and aging in distilled water.

The broad peak at ~3300 cm^{-1} was assigned to the O-H stretch of adsorbed water. The shoulder peak at ~1700 cm^{-1} was assigned to the un-reacted carboxyl (COOH) functional group in the PAA. The peak at 1550 cm^{-1} presents the level of cross-linking between the dissociated COO– group and metal cations, such as the Ca^{2+}, Ga^{3+} and Zn^{2+}. The 1070 cm^{-1} peak represents the Si–O–Si bridges of the cements.

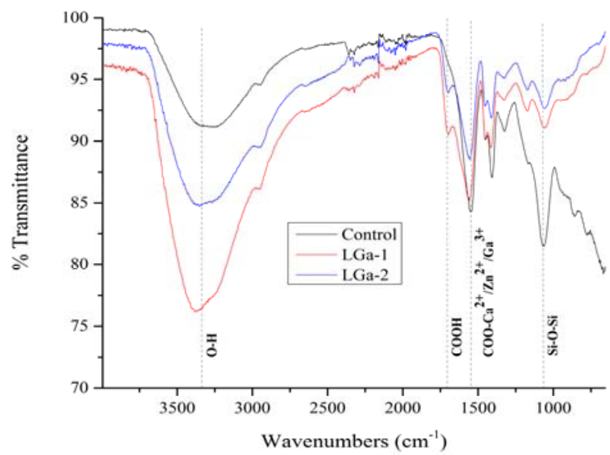

Figure 1: FTIR spectra of cement series, tested 1 day, post cement preparation

Conclusions:

The addition of Ga to the glass phase interrupts the cement network and increases water (O-H) content, observed by the fluctuation in the absorption spectrum from ~92%t for the Control to ~77%t and ~85% for LGa-1 and LGa-2, respectively. Further, observations from changes in the absorption spectra at 1700 and 1070 cm^{-1} implies that Ga incorporation inhibits COO- binding reactions, and delays the formation of Si-O-Si bridges. This implies a reduction of cross-link formation within the cement structure, attributed to the presence of un-bonded COO- functional groups.

Ga^{3+} ion incorporation into GPCs was shown to cause structural changes resulting in favorable delay of initial setting reactions, facilitating longer handling properties [3]. In addition, Ga ions are anti-cancerous, and anti-bacterial, and their release, during increased cement aging times, may result in therapeutic potential [3,4].

This initial study has shown that Ga based GPCs have the potential to be used for clinical purposes.

References:

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