Bioactive Glasses: Controlling Dissolution & Ion Release via Modifier Ionic Radius

Delia S. Brauer*[1]

[1]Otto Schott Institute of Materials Research, Friedrich Schiller University Jena – Fraunhoferstr. 6, 07743 JEna, Germany

Abstract

The most famous glasses used as implant materials are undoubtedly bioactive (phospho-) silicate glasses. Invented by Larry Hench in the late 1960's, they have been in continuous clinical use for over 30 years now. These bioactive glasses undergo surface reactions and degradation when implanted, resulting in formation of a mineralised surface layer of biomimetic apatite. This surface layer allows for formation of a strong interfacial bond between glass and both hard and soft body tissue. In addition, as the amorphous structure of glass is less dependent on a specific stoichiometry than crystals are, it allows for the incorporation of a wide range of ions of potentially therapeutic benefits. These ions can be released during the bioactive glass degradation process to perform their therapeutic action. If glass is to be used as a biomaterial to regenerate tissue, it therefore needs to react with aqueous solutions, release ions and degrade over time. The "network connectivity" or polymerisation of the silicate network has usually been described as the key structural parameter to control bioactive glass degradation, ion release and bioactivity. Here it is shown that the types of modifiers used, and particularly their ionic radii, can have a pronounced effect on the degradation behaviour, too. This effect is particularly pronounced when using different alkali metal cations (lithium, sodium or potassium) where an increase in ionic radius of the modifier ion results in faster ion release and vice versa. Interestingly, this effect appears in mixed alkali bioactive glass compositions as well, rather than the expected mixed alkali effect.

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*Speaker