

A material revolution

RICHARD WHATLEY thinks Bioactive glasses are the future of dental restoration. Here, he explains why...

Most dentists are familiar with the fluoride release of Glass Ionomer Cements (GICs) and the protective effect of fluoride against secondary caries. However, GICs generally lack the command cure and mechanical properties required for use as posterior fillings. Whilst GICs release fluoride it's better to release calcium and phosphate in addition to fluoride in order to form tooth mineral.

The average life expectancy of posterior composite resin restoration is reported to be as little as six years, far below that achieved with a traditional amalgam restoration. The major problem with conventional composites is due to shrinkage on setting resulting in marginal gaps leading to leakage and secondary caries. These problems are compounded by the need for a dry operating field and incremental build up of the restoration. The goal is to develop an easy to use, durable material that is less technique sensitive.

However, with the implementation of the Minamata Convention, amalgam restorations will be phased out over the coming years and longevity of alternative restoratives is of increasing importance. Over the past year, scientists on both sides of the Atlantic have published studies considering the incorporation of bioactive glasses in resin composites to try to increase their average lifetime expectancy. Until now dental composite materials have incorporated inert glass particles within a resin matrix. The scientists undertaking these research projects have substituted inert glass particles with bioactive glasses.

A team from Oregon State University under Prof. Jamie Kruzic has shown that the inclusion of bioactive glass in dental composites inhibits bacteria decay and promotes remineralisation. Referring to the scientific paper published in *Journal of Dental Materials*, Prof Kruzic further states "the bacteria in the mouth which cause cavities don't seem to like this type of glass and are less likely to colonise on fillings which incorporate it". It is thought that bioactive glasses probably inhibit cariogenic bacteria by raising the pH in the

marginal gaps and the cariogenic bacteria proliferate in an acidic environment.

A multinational research group coordinated by Dr Salvatore Sauro undertook a review of the effects of composites containing bioactive glasses on demineralised dentine that was published recently in *Journal of Dental Research*. The objective was to determine whether the inclusion of fluoride ions in a high phosphate loaded bioactive glass formulation would have any significant effect on the performance of the composite restorative material. They concluded that fluoride-containing phosphate-rich calcium bioactive glass incorporated as a micron-sized filler in dental composites may offer greater beneficial effects than standard, non-fluoride containing Bioglass 45S5 (containing just calcium and lower level phosphate) in reducing the enzyme-mediated degradation and promoting the remineralisation of demineralised dentine.

The similar fluoride-containing phosphate-rich bioactive glass is the basis of one of BioMin Technology's patents that are licensed from Queen Mary University of London. These patents are based on the wealth of knowledge surrounding bioactive glasses developed by Professor Robert Hill and his co-workers over the past 2 decades resulting in 9 PhD theses and 25 Masters projects. This research won the 2013 Venture Prize from the Worshipful Company of Armourers and Brasiers and enabled the commercialisation of the technology to proceed. Earlier in his career, Professor Hill worked alongside the inventor of the Glass Ionomer Cements, Dr Alan Wilson and subsequently with the inventor of bioactive glass, Professor Larry Hench. Much of Professor Hill's research has surrounded the structure of glasses used in GICs and how to keep fluoride in the glass matrix. This background has proved invaluable in the development of fluoride containing bioactive glasses. Prof Hill and his co-workers have also developed analytical techniques, such as Magic Angle Spinning Nuclear Magnetic Resonance Spectroscopy, which was not available at the time of Dr Wilson or Prof Hench's work.



Fig 3 and 4(inset): Typical demineralisation after orthodontic treatment

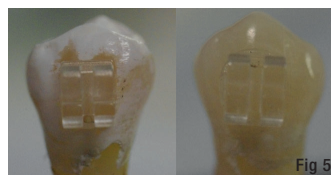


Fig 5

Recent research from the team, much of which was presented at the International Association for Dental Research in San Francisco earlier this year, has shown it is possible to produce a composite resin capable not only of filling a cavity but also of re-mineralizing the area around hard carious lesions following minimally invasive removal. This new generation of filling material consists of 80 per cent bioactive glass with resin and slowly releases fluoride, calcium and phosphate ions to form fluorapatite in the presence of moisture. The ion exchange process at the surface raises the pH in the mouth, neutralising the acids and discouraging further bacterial growth and caries. Additionally, apatite forms and in-fills any marginal gaps at the tooth-resin interface, potentially preventing bacteria from entering and causing secondary caries. These processes can be observed in the SEM images in Figs 1 and 2.

Applications in orthodontics are also being studied. Often plaque will accumulate around the brackets where good oral hygiene is difficult. Following removal of orthodontic appliances, the incidence of white spot lesions due to demineralization around the brackets is evident in between 50 per cent and 90 per cent of cases. Trials using brackets bonded with a bioactive glass composite, releasing fluoride, calcium and phosphate, have shown no demineralisation around the bracket and no visible white spots as shown in Figs 3 and 4.

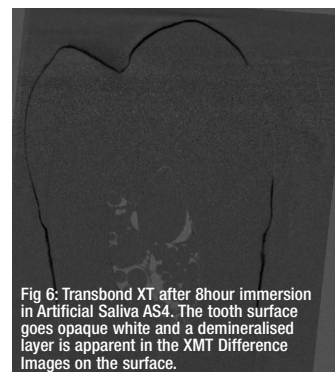


Fig 6: Transbond XT after 8-hour immersion in Artificial Saliva AS4. The tooth surface goes opaque white and a demineralised layer is apparent in the XMT Difference Images on the surface.

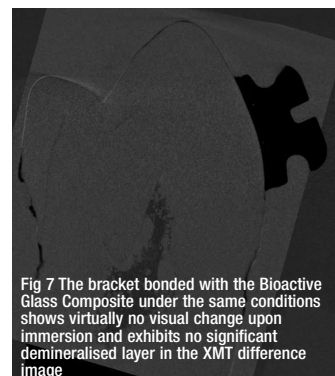


Fig 7 The bracket bonded with the Bioactive Glass Composite under the same conditions shows virtually no visual change upon immersion and exhibits no significant demineralised layer in the XMT difference image

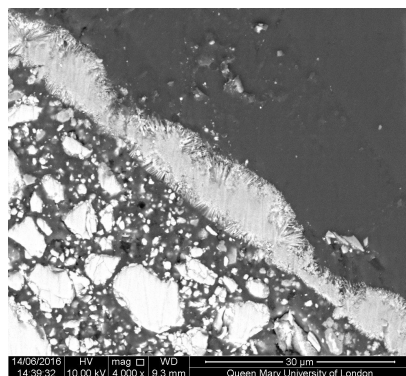
As shown in Figs 5, 6 and 7, these new BioMin based resin materials will be introduced through leading dental manufacturers in the coming years. There will be further uses developed for which the benefits of bioactive glass may be considered. It's slow release capability means that it could have applications in a wide variety of settings. ■

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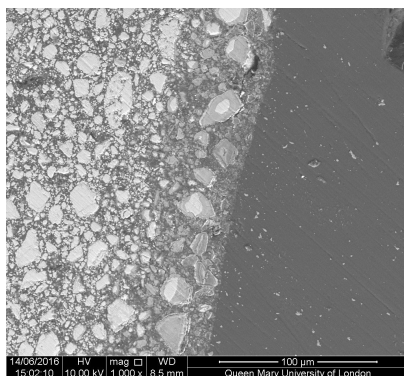
About the author

Richard Whatley was appointed Chief Executive Officer of BioMin Technologies Limited in April 2015 to help commercialise bioactive glass

technology developed by researchers at the Dental Institute, Queen Mary University of London over the past decade. This technology is based on the controlled release of mineral ions for both toothpaste and professional dental applications.



Far left, Fig 1: Back Scattered SEM Cross-Section BG Composite ReMin AS pH=7



Left, Fig 2: Back Scattered SEM Cross-Section of BG Composite Disc AS pH=4