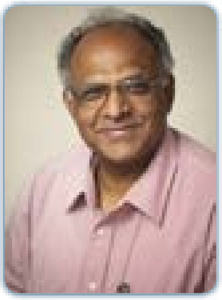
Animesh Jha, Nano Res Appl 2018, Volume 4
DOI: 10.21767/2471-9838-C3-014

25th Nano Congress for Future Advancements
&
12th Edition of International Conference on
Nanopharmaceutics and Advanced Drug Delivery

August 16-18, 2018 | Dublin, Ireland



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Restoration of damaged dental enamels using nano-scale iron-calcium phosphate minerals and femtosecond pulsed near-IR lasers

Dental enamel is a cellular and a vascular mineralized tissue with more than 95% mineral content. Although, the underlying softer dentine is connected with the microvasculature via the soft tissue therefore, possesses intrinsic regenerative capacity for mineralization which lacks in the enamel tissue. Consequently, the oral acid induced erosive damage on enamel is irreversible, and leads to lesion formation. Unattended lesion may lead to hypersensitivity and feeling of pain. Advanced stage of eroded enamel with symptoms of hypersensitivity might lead to tooth loss in adults. Traditional clinical strategies for the repair of acid-eroded enamel include the use of BIS-GMA polymeric materials which has incompatible mechanical properties with the adjoining hard minerals, and this type of bonding leads to failure of restored enamel area in a challenging oral environment. Modern toothpastes provide temporary relief from hypersensitivity; however, there is no long-term solution for treating early stages of acid erosion which may lead to sensitive teeth. Another condition, which affects especially the ageing population, is the tooth wear, which leads to tooth thinning and weakening in the lingual areas of mouth. Rebuilding the entire damaged tissue region remains a challenge. In the absence of any intrinsic regenerative means of restoring damaged tissue, our proposal focusses on developing a novel exogenous tissue re-engineering methodology, in which the mineralization of tooth surface involves: i) application of nano- and amorphous iron-calcium phosphate minerals (e.g. hydroxyapatite, fluorapatite and brushite) in the form of colloidal paste; which is then ii) bonded with the surrounding healthy enamel by irradiating with a femtosecond pulsed near-IR laser. The presence of a homogeneous dispersion of nano-scale of iron oxide in the calcium-iron phosphate matrix acts as resonant antennae for absorbing near-IR pulsed laser radiation, and helps in the dispersion of thermal energy uniformly in the irradiated region without causing damaged to the healthy tissue. The two steps (i) and (ii) are illustrated in Figure 1. The mechanisms of phase transformation and dissipation have been analyzed for different irradiation conditions (e.g. at 1040 nm wavelength, 1 GHz repetition rate and 0.4 W average power), and the resulting phase transformation is compared for understanding the bonding and potential radiation induced damage mechanisms including ablation, thermal and toxicity effects. Potential opportunity for micro-surgical device engineering is discussed for ultimate clinical use. The mechanical properties including brushing trials on restored surfaces of bovine enamels are also reported.

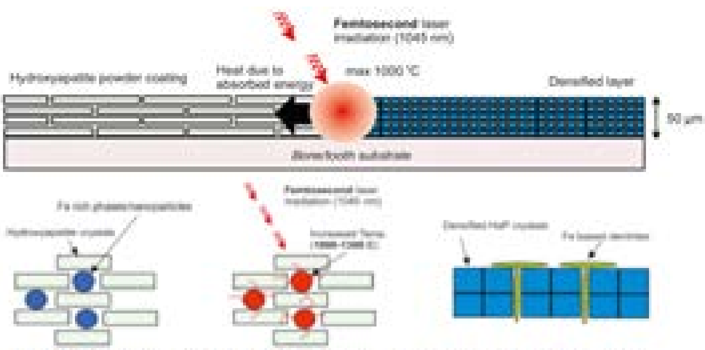

Figure 1: Process of sintering and densification of iron rich calcium phosphates after laser irradiation

Biography

Animesh Jha is Professor of Applied Materials Science with special research interest in glass based and nano-scale materials, photonic materials, laser gain medium engineering and laser-matter interaction. He obtained his Bachelor and Master of Engineering Degrees in Metallurgy from the University of Roorkee (UP, India) and the Indian Institute of Science Bangalore (India) in 1979 and 1981, respectively. In 1981, he joined the Imperial College of Science & Technology, London for his PhD in thermodynamics of sulphide minerals for metal processing, and acquired significant interest in heterogeneous chemical reaction kinetics and multiphase equilibria. After finishing PhD in Oct 1984, he pursued his interest in the area of phase equilibrium and transformation kinetics in metallic and inorganic glasses as a post-doctoral research fellow at the University of Sheffield (UK) until April 1989, after which he was appointed as a lecturer at Brunel University in Uxbridge (UK). In March 1996 he joined the University of Leeds (Leeds, UK) as a Reader where he has been undertaking original research in nanoscience approaches for bio-materials, glass engineering and 2D-materials technology for device engineering. AJ became Professor in Aug 2000. He is author of more than 400 research papers and has also written a book on “Inorganic Glasses for Photonics” which was published in 2016. He is also inventor/co-inventor on more than 45 patents. AJ was awarded the Fellowships of Institute of Physics (London) and the Royal Society of Chemistry in 2010 and 2016, respectively. He has also won innovation awards (SMART, Yorkshire Concept) for technological demonstration of advanced glasses and fibres for lasers and amplifiers, and their applications. He is actively involved in PhD and PDRF training and promotes emerging scientists in achieving career goals via Marie-Curie and other prestigious Fellowship schemes.

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