Smart Dental Fillings with Ruthenium Nanoparticles-enhanced Photobiomodulation Therapy for Pulp-Dentin Regeneration

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**Statement of Purpose:** Dental pulp trauma, especially in deep carious lesions, is a formidable challenge in clinical dentistry. The use of calcium hydroxide has had a long clinical history as a biocompatible liner and hermetic restorer. Other options include Mineral Trioxide aggregate and nanocalcium silicate that are often still very expensive. A new class of smart dental biomaterials and biotechnologies are enabling regenerative dentistry.\textsuperscript{1} The use of low dose laser treatments, termed Photobiomodulation (PBM) therapy, has been shown to promote dentin formation.\textsuperscript{2} Ruthenium [Ru(bipy)\textsubscript{3}]\textsuperscript{2+} is a red-emitting chromophore (620nm) that absorbs strongly at (450 nm) blue light, a wavelength commonly used for light curing dental composites.\textsuperscript{3}

**Objectives:** To develop a Ruthenium-based dental biomaterial system to promote dentin induction by odontoblasts using PBM therapy

**Methods:** Polylactic-coglycolide (PLG) microspheres containing ruthenium (Ru-PLG) were synthesized using a double emulsion technique. Microspheres were analyzed using SEM-EDS for effective composition. Tissue culture plates were coated with the Ru-PLG microspheres, washed and UV sterilized followed by seeding with an odontoblast, MDPC-23 cell line.

**Figure 1:** PLGA [Ru(bipy)\textsubscript{3}]\textsuperscript{2+} in a 12 well plate illuminated by a blue (~450 nm) light before cell insertion.

Plates were treated with blue and red LED and near-infrared (NIR) laser. After 24 hours, cells were lysed and assessed for total protein with Bradford’s assay and analyzed for mineralized tissue differentiation using Alkaline Phosphatase (ALP) enzyme assay.

**Results:** SEM-EDS analyses demonstrated inclusion on Ruthenium in PLGA microspheres (Figure 1). Average microsphere diameter ranged from 25-100u.

**Figure 2:** (A) SEM (20kV) and (B) EDX of PLGA [Ru(bipy)\textsubscript{3}]\textsuperscript{2+}

We observed significant odontoblastic mineralized differentiation with blue LED assessed with normalized ALP levels (p < 0.05). Treatments with Ru-PLG and Red LED treatments also demonstrated a similar significant increase in normalized ALP levels indicating their ability to promote mineralized differentiation in MDPC-23 cells (p < 0.05).

**Conclusions:** Several technologies are enabling a new era of biomaterials for pulp-dentin regeneration.\textsuperscript{4} Our results demonstrate the functionality of the Ru-PLG systems for PBM treatments beyond the initial clinical pulp exposures. These novel light-emitting biomaterials could enable sustained PBM therapy beyond initial clinical pulp exposure and treatments.

**References:**