Development of luminescent bioactive glass for multimodal diagnostic imaging

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INTRODUCTION: Bioglasss is glass-ceramic biocompatible material that contains silica, calcium, sodium, and phosphate, as main ingredients. It has excellent bioactivity and is widely used for scaffolds, implant devices and for repair of bone defects, among others [1]. Current research aims to develop luminescence bioglass, which will comprise different rare earth (RE) elements and open possibilities for its use in multimodal imaging diagnostics [2].

MATERIALS and METHODS: The materials used were calcium nitrate tetrahydrate ($Ca(NO_3)_2{\times}4H_2O$, Carlo Erba, ≥99 %), ethanol (EtOH, Sigma Aldrich, 96 %), hydrochloric acid (HCl, Macron, 35-38 %), ammonium hydroxide (NH_4OH, NRK Inženjering, 25 %), distilled water (H_2O), rare earth nitrates: $Yb(NO_3)_3{\times}5H_2O$, $Er(NO_3)_3{\times}5H_2O$, $Eu(NO_3)_3{\times}5H_2O$, $Gd(NO_3)_3{\times}6H_2O$ (all obtained from Sigma-Aldrich, 99.9 %), sodium phosphate dibasic dodecahydrate ($Na_2HPO_4{\times}12H_2O$, Exôdo Científica, 99 %) and tetraethyl orthosilicate (TEOS, Sigma Aldrich, 98 %). Preparation of RE-doped SiO_2-CaO-Na_2O-P_2O_5 bioglass by sol-gel process relies on modified Stöber method [3], with the addition of corresponding rare earth nitrates. The obtained powders were characterized by X-ray powder diffraction (XRPD, Philips PW 1050 diffractometer), Fourier transform infrared spectroscopy (FTIR, Nicolet iS10 FT-IR Spectrometer), photoluminescent measurements (TE-Cooled CCD Fluorescence spectrometer, Glacier X, BWTEK, USA) and MTT assay.

RESULTS AND DISCUSSION: Analysis of crystal structure confirmed obtaining of glassy-amorphous system in undoped sample, while the RE-doped samples possess low crystallized RE-oxides and phosphates. FTIR spectroscopy revealed vibration modes of quaternary glass of desired composition, beside the bands of RE oxides. Photoluminescent measurements confirmed emission capability: up-conversion emission for Gd/Yb/Er doped sample and down-conversion emission for Gd/Eu sample. MTT tests implied that samples are not cytotoxic and can be used in medicine.

CONCLUSIONS: Applied sol-gel procedure resulted in formation of luminescent and biocompatible powders with promising use in multimodal bioimaging, cell labeling, and bone reconstruction.

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