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Melt-derived bioactive glass based on SiO_2-CaO-Na_2O-P_2O_5 system fabricated at lower melting temperature

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Abstract. This work addresses the development and fabrication of new bioactive glass composition based on SiO_2-CaO-Na_2O-P_2O_5 system that can be melted at lower melting temperature (1377°C and 1348°C) than 1400°C through melt-derived route. All BG compositions did not show significant differences on their particle size while retaining their amorphous structure. Formation of Si-O-Si (tetrahedral) functional group indicated that silicate based glass structure was established as discovered by Fourier transform infrared spectroscope (FTIR). Apatite formation was observed on bioactive glass surface though being fabricated at lower melting temperature upon soaking in Tris-buffer solution. Feature of carbonate (C-O) and P-O functional group was discovered from FTIR for all glass composition. Present of crystalline peaks was detected in X-ray diffraction (XRD) though fewer peaks were observed for glass fabricated at lower melting temperature. Morphology of apatite in crystal cluster form on the glass surface was identified through scanning electron microscope (SEM).

1. Introduction

New concept in biomaterial development for clinical application has been prioritized from tissue replacement to tissue regeneration purposes. Innovation in biomaterial development sees the ability of the biomaterial to stimulate biochemical response from the living tissue in enhancing biological fixation between implant material and defective tissue [1]. In addition, implant material for substitution in bone defects need to bond with living bone without being encapsulated by fibrous tissue which isolated them from the surrounding bone. Such requirement is successfully met by silica (SiO_2) based glasses containing calcium (Ca), sodium (Na) and phosphorus (P) oxides invented by Hench [2, 3]. The glass demonstrated high bone-bonding ability upon implantation and recognized as bioactive glass (BG). The golden standard of BG was known as 45S5 Bioglass® and composed of 45% SiO_2, 24.5% CaO, 24.5% Na_2O and 6% P_2O_5 (in weight percentage, wt %) [4].

BG is highly bioactive and manifests other properties such as osteoinductive and osteoconductive which allow them to be implemented in clinical application such as bone replacement and bone regeneration in dental and orthopedic treatment and even in tissue engineering [5, 6]. The ability of BG to integrate with living tissue is achieved through the development of biologically active apatite layer, hydroxyl carbonate apatite (HCA) [7]. The