

Basic Properties of Carbonate Apatite Cement Consisting of Vaterite and Dicalcium Phosphate Anhydrous

Arief Cahyanto^{1,a}, Michito Maruta^{2,b}, Kanji Tsuru^{1,c},
Shigeki Matsuya^{2,d} and Kunio Ishikawa^{1,e}

¹Department of Biomaterials, Faculty of Dental Science, Kyushu University, 3-1-1 Maidashi, Higashi-ku, Fukuoka 812-8582, Japan

²Section of Bioengineering, Department of Dental Engineering, Fukuoka Dental College, 2-15-1 Tamura, Sawara-ku, Fukuoka 814-0193, Japan

^aacah_drg@dent.kyushu-u.ac.jp, ^bmaruta@college.fdcnet.ac.jp, ^ctsuru@dent.kyushu-u.ac.jp, ^dsmatsuya@college.fdcnet.ac.jp, ^eishikawa@dent.kyushu-u.ac.jp

Keywords: Carbonate apatite cement, vaterite, dicalcium phosphate anhydrous

Abstract. The aim of the present study is to fabricate bone cement that could transform to carbonate apatite (CO₃Ap) completely at body temperature. The powder phase of vaterite and dicalcium phosphate anhydrous (DCPA) was mixed with 0.8 mol/L of NaH₂PO₄, Na₂HPO₄, and Na₃PO₄ aqueous solution, respectively, with liquid to powder ratio (L/P ratio) of 0.45, 0.55, and 0.65. The paste was packed into split stainless steel mold, covered with the glass slide and kept at 37°C and 100% relative humidity for up to 96 hours (h). XRD analysis revealed that the cement became pure CO₃Ap within 24 h for Na₃PO₄, 72 h for Na₂HPO₄, and 96 h for NaH₂PO₄, respectively. FT-IR results showed that all of the obtained specimens could be assigned to B-type CO₃Ap. CHN analysis showed the carbonate content of the specimen were 10.4 ± 0.3% for NaH₂PO₄, 11.3 ± 0.7% for Na₂HPO₄, and 11.8 ± 0.4% for Na₃PO₄, respectively. Diametral tensile strength of the set CO₃Ap cement was 1.95 ± 0.42 MPa for NaH₂PO₄, 2.53 ± 0.53 MPa for Na₂HPO₄, and 3.45 ± 1.53 MPa for Na₃PO₄, respectively. The set CO₃Ap cement had low crystallinity similar to bone apatite since it was synthesized at body temperature. We concluded, therefore, that CO₃Ap cement prepared from the present method has higher possibility to be used as an ideal bone replacement.

Introduction

Calcium carbonate and dicalcium phosphate anhydrous (DCPA) are candidates for starting material to carbonate apatite (CO₃Ap) cement. However, Takagi *et al.* reported that the cement formed from the mixture of calcite and DCPA mixed with Na₂HPO₄ solution failed its full transformation to apatite [1]. This may be due to the limited solubility of calcite. Vaterite is one of the polymorph of calcium carbonate and also known to have higher solubility than calcite. CO₃Ap in the different form has been conducted by Daitou *et al.* In their study, CO₃Ap block was obtained by mixing calcite and DCPA with distilled water in 70°C [2]. Unfortunately, this method could not be employed in the case of apatite cement because its difficult to apply in 70°C. The key issue of apatite cement required body temperature to apply and to set. It has been reported that the inorganic element of bone is CO₃Ap (Ca₁₀(PO₄)_{6-x}(CO₃)_x(OH)_{2-x}) that contains of 4-8 wt% carbonate in apatitic structure [3]. The carbonate content in apatitic structure has a close relationship with osteoclastic resorption, that is, CO₃Ap shows higher solubility in the weak acidic condition produced in Howship's lacuna formed by the osteoclasts. Therefore, CO₃Ap is expected to become an ideal bone replacement material. On these bases, this study is assigned to examine the basic properties of CO₃Ap cement consisting vaterite and DCPA.

Materials and methods

Preparation of apatite cement (AC). Vaterite (Yabashi Industries Co., Ltd, Ohgaki, Japan) and DCPA (J.T. Baker Chemical Co., NJ, USA) were employed as AC powder. Average particle size of vaterite powder was approximately 0.7 µm. Particle size of commercially obtained DCPA powder