

Effect of Particle Size on Carbonate Apatite Cement Properties Consisting of Calcite (or Vaterite) and Dicalcium Phosphate Anhydrous

Arief Cahyanto^{1,2,a*}, Riki Toita^{1,b}, Kanji Tsuru^{1,c} and Kunio Ishikawa^{1,d}

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

²Department of Dental Materials Science and Technology, Faculty of Dentistry, Padjadjaran University, Jl. Raya Bandung Sumedang KM 21, Jatinangor 45363, Indonesia

^aacah_drg@dent.kyushu-u.ac.jp, ^btoita@dent.kyushu-u.ac.jp, ^ctsuru@dent.kyushu-u.ac.jp, ^dishikawa@dent.kyushu-u.ac.jp

Keywords: Carbonate apatite cement, calcite, vaterite, dicalcium phosphate anhydrous

Abstract. Calcium carbonate (CaCO₃) has been known as one of the components of carbonate apatite (CO₃Ap) cement. Calcite is one of the polymorph of CaCO₃ with big particle size and excellent stability. In contrast, vaterite has small particle size and a metastable phase. To discover the effect of particle size on the properties of CO₃Ap cement, this study investigated the different particle size of vaterite; calcite from vaterite, which has almost similar particle size and shape with vaterite; grounded calcite and ungrounded calcite. The powder phase of calcite or vaterite combined with dicalcium phosphate anhydrous (DCPA) was mixed with 0.8 mol/L of Na₂HPO₄ solution in 0.45 liquid to powder ratio. The paste was packed into a split stainless steel mold, covered with glass slide and kept at 37°C and 100% relative humidity for a period of time. XRD and FT-IR analysis revealed that CO₃Ap cement consisted of vaterite and DCPA transformed to pure B-type CO₃Ap in 72 hours while CO₃Ap cement that consisted of calcite with different particle size was not completely transformed to CO₃Ap even until 240 hours. We concluded that CO₃Ap cement consisted of vaterite with small particle size and metastable phase properties is more effective as starting material due to its fast transformation to CO₃Ap.

Introduction

Calcium carbonate (CaCO₃) has been extensively used as one of the components of starting material of carbonate apatite (CO₃Ap) cement. Calcite is a polymorph of CaCO₃ that is more thermodynamically stable than vaterite. Since setting reaction of CO₃Ap cement is based on dissolution-precipitation reaction [1] and vaterite has smaller particle size compared to calcite, particle size become one of important factors for transformation to CO₃Ap. Cahyanto *et al.* [2] reported that vaterite and dicalcium phosphate anhydrous (DCPA) mixed with sodium phosphate solutions could be set and transform to full CO₃Ap. The essential element for developing CO₃Ap cement is to use starting materials which has a metastable phase, for a thermodynamically stable apatite under body environment [3]. However, the effect of the CO₃Ap cement starting materials, especially vaterite; calcite from vaterite (v), which has almost similar particle size and shape with vaterite; grounded calcite (g) and ungrounded calcite (ug) has not been clear. Therefore, the present study investigated the effect of particle size on CO₃Ap cement properties consisting of calcite (or vaterite) and DCPA.

Materials and Methods

Preparation of CO₃Ap cement powder. Vaterite and DCPA (J.T. Baker Chemical Co., NJ, USA) were used as CO₃Ap cement powder. The vaterite powder was derived on the basis of previous report [4]. In brief, 50 g of Ca(OH)₂ was mixed into 500 mL of methanol and 25 mL of distilled water. The suspension was blown with CO₂ gas at a rate of 1 L/min for 120 minutes where the temperature was 20°C. The obtained particles were collected by filtration and dried at 110°C.