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Effect of Tween 20 Concentration on Macropore Formation in Spherical Diopside Particles

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Abstract

We previously succeeded in fabrication of spherical diopside particles having a uniformly and continuously macroporous structure by heat treatment of silica gel particles impregnated with an aqueous mixed solution of $Ca(NO_3)_2$ and $MgCl_2$ above 900°C [Y. Nakamura, *et al*., *J. Ceram. Soc. Jpn*., **112**, 133 (2004).]. In preparing the mother silica gel particle, the nonionic surfactant, Tween 20, was employed as an emulsifier for maintaining an O/W emulsion of tetraethyl orthosilicate. In this study, we investigate influence of Tween 20 concentrations on macropore formation of spherical diopside particles. When silica gel particles prepared at Tween 20 concentration ranged from 0.75 to 15 wt% is impregnated with the $Ca(NO_3)_2$ and $MgCl_2$ aqueous mixed solution and is heat-treated at 950°C, spherical diopside particles having macroporous structure can be fabricated. However, silica gel particles produced at 0 and 25 wt% of Tween 20 are largely unable to condense Si-OH groups and cannot crystallize to form diopside by the heat treatment, forming no macroporous structure. The nonformation of the macroporous structure in the case of the silica gel particle produced at 0 and 25 wt% of Tween 20 may be attributable to the fact that the silica gel particle is difficult for the silica gel particle to be impregnated with the $Ca(NO_3)_2$ and $MgCl_2$ aqueous mixed solution.

Key-words: *Spherical diopside particle, Macropore formation, Silica gel particle, Nonionic surfactant, Viscous fluid*

1. Introduction

Diopside, CaO-MgO-2SiO_2, is well known as an excellent bioactive glass-ceramic[1-4]. When diopside is immersed in simulated body fluid, hydroxyapatite-like calcium phosphates are formed on its surface, giving a good bioactivity[5,6]; the sintered body of diopside seems to bond to living bone tissues more rapidly than hydroxyapatite[7,8]. Moreover, diopside has high mechanical strength and excellent bioloical affinity[9-11]. Diopside is therefore considered to have a potential as a biomaterial for artificial bones and teeth materials.

In developing the artificial bone material, porosity is often introduced into surface on the material. It enables us to more readily combine the artificial bone material chemically and biologically with living bone tissues[12,13]. In addition, porous biomaterials are expected to adsorb biomolecules; thereby, they can be applicable to a drug carrier and a scaffold in tissue engineering[14-17].

We previously succeeded in fabrication of spherical diopside particles having a uniformly and continuously macroporous structure by heat treatment of spherical silica gel particles impregnated with an aqueous $Ca(NO_3)_2$ and $MgCl_2$ mixed solution above 900°C[18]. In the heat treatment, the inorganic salts transform the silica gel body into viscous fluid[19,20], and irregular mesopores in the silica gel particle aggregate with each other to minimize excess surface energy between the pore and the viscous fluid, resulting in the formation of the macroporous structure[21].

In producing the mother silica gel particle, the nonionic surfactant, polyoxyethylene sorbitan monolaurate (Tween 20), was employed as an emulsifier for maintaining an O/W emulsion dispersion of tetraethyl orthosilicate. When we employed various concentrations of Tween 20, there was not much difference in particle size and in its distribution of resultant spherical diopside particles. However, the surfactant concentration was unexpectedly found to strongly affect the macropore formation of the diopside particle.

In this paper, we focus on dependence of macropore formation of spherical diopside particles on Tween 20 concentration. We fabricate spherical diopside particles with varying concentrations of Tween 20 and determine its morphology and chemical structure, discussing the effect of the Tween 20 concentration on the macropore formation of the diopside particle.

2. Experimental procedure

2.1 Materials

Tetraethyl orthosilicate (TEOS), ethanol, hydrochloric