Forming and Sintering of Alumina-based Ceramics by New Eco-friendly Process

Takaaki Nagaoka, Takahisa Tsugoshi, Kimiyasu Sato, Yuji Hotta,
Masaki Yasuoka, Koji Watari
National Institute of Advanced Industrial Science and Technology (AIST).
E-mail: t.nagaoka@.aist.go.jp,
http://unit.aist.go.jp/amri/group/astech/ja/astech.html

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Introduction

Organic substances are important additives that are widely used in ceramic fabrication processes. For example, polyvinyl alcohol, latex, methylcellulose and starch etc. are important additives that serve as organic binders in ceramic fabrication. Acrylic beads, carbon powder, and starch are widely used as fugitive materials for creating pores in porous ceramics. However, these organic binders and fugitive materials must be completely thermally decomposed so that they do not remain in the sintered body as carbon or ash. Moreover, large volumes of gases such as carbon dioxide (CO_2) and hydrocarbon species are emitted from the green body during heating. CO_2 is believed to be one of the greenhouse gases responsible for global warming, while emitted hydrocarbons can be malodorous as well as harmful. It is necessary to pyrolytically decompose the hydrocarbon species further to defuse them, which requires thermal energy as well as causes further increasing CO_2 emissions. Therefore, it is important to develop an eco-friendly ceramic fabrication process employing inorganic substances that can reduce the amounts of organic substances used.

Methods

Hydraulic alumina (HA), an intermediate alumina and water were used as the inorganic binder and fugitive material. The HA powder was mixed with distilled water to make HA slurry. The HA slurry was cast into molds followed by cured at room temperature. The setting time of the HA slurry was measured using a Vicat needle apparatus. Compressive strength measurements of the hardened HA slurries (green bodies) were conducted using a crosshead speed of 0.5 mm/min at room temperature. The major gas species evolved by pyrolysis of the hydrated HA samples prepared by this new process and a conventional α-Al_2O_3 sample with an organic binder and fugitive material were investigated by means of evolved gas analysis-mass spectrometry (EGA-MS).

Results and Discussion

The HA slurry was hardened by the formation of boehmite 3-D network during HA hydration. Even without the addition of an organic binder, green bodies containing the 3-D network demonstrated high compressive strength. Furthermore, the water acted as a fugitive material in the green bodies. Consequently, the open porosity of the sintered alumina ceramics could be controlled over a wide range by the addition of water without the use of organic fugitive materials. The results of evolved gas analysis-mass spectrometry measurements showed that the emissions from the hardened green body consisted mostly of water. Consequently, the new fabrication process for porous alumina ceramics was confirmed to be eco-friendly.

About Myself

Name: Takaaki Nagaoka

Nationality: Japanese

Hometown: Nagoya, Aichi, Japan

Affiliation: Advanced Sintering Technology Group,
Advanced Manufacturing Research Institute,
National Institute of Advanced Industrial Science and Technology (AIST).
2266-98 Anagahora, Shimo-Shidami, Moriyama-ku, Nagoya 463-8560, Japan
Tel: 81(52) 736-7156, Fax: 86(52)736-7405
E-mail: t.nagaoka@aist.go.jp
Web: http://www.aist.go.jp/index_en.html

Title: Senior Research Scientist