Transactions of the Materials Research Society of Japan 25 [2] 637-640 (2000)

Porous Ceramics Prepared by Mimicking Fossil Woods

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By mimicking fossil woods, porous SiC powder with wood-like microstructure was prepared as follows: (1) infiltration of tetraethyl orthosilicate (TEOS) into sawdust by vacuum-infiltrating; (2) hydrolysis of TEOS in the sawdust to form SiO_2 gel; (3) firing at 1600 ℃ in Ar to form β-SiC. The resulting SiC powder had the same external and internal forms of the original woods.

Key words: porous ceramics, wood, SiC, microstructure, sawdust

1. INTRODUCTION

Porous ceramics are very important for a variety of applications such as thermal insulation, filtration, absorption, and catalyst. Several methods have been developed to make porous ceramics. Commonly, they can be grouped in two techniques, that is, foaming method and polymeric-sponge method.[1] In the first method, porous ceramics are produced by mixing ceramic powders with an organic material, which burns away carbon oxide gas leaving pores in the ceramic body during the firing process. In the second method, a polymeric sponge, impregnated with a ceramic slurry, is burned out leaving a porous ceramic. We have been trying to prepare porous ceramics from wood instead of sponge.

The wood texture is characterized by cells and vessels filled water, with 3-0 and 3-1 conectivities, respectively. These features in wood make it an attractive template for making special porous ceramics such as filters, absorbent and catalyst substrates. A wood made of ceramic already exists in the natural world, i.e. fossil or silicified woods. R. F. Leo et. al. performed an artificial fossili-zation of wood by the use of tetraethyl orthosilicate (TEOS) solution.[2] The infiltrated TEOS was hydrolyzed to deposit an amorphous silica in the texture of wood. Further, we produced a wood made of SiC by firing such an artificial silicified wood at a high temperature in an inert atmosphere.[3] The resulting SiC wood had the same external and internal forms of the original wood. However, because of the insufficient conversion of C to SiC, it was difficult to prepare a large and strong specimen. In this paper, a pulverized wood was used as a raw material in order to take advantage of the SiC wood in a form of powder.

2. EXPERIMENTAL PROCEDURE

Sawdust of Sugi (Japanese cedar) or Katsura (Japanese Judas tree) was mainly used as a raw material. The size of sawdust ranged from 1 to 5 mm. After soaking with ethanol for 1 day, a mass of sawdust was vacuum-infiltrated with 20 to 100 vol% of TEOS in ethanol for 1 h. The infiltrated TEOS was hydrolyzed with 15 vol% ammonia solution in an ultrasonic generator for 1 h, and dried at 110 ℃ for 1 day to form SiO_2 gel in situ. The sawdust containing SiO_2 gel was fired at 1200 to 1600 ℃ for 2 h in Ar to form SiC. The removal of residual carbon was accomplished by oxidation at 700 ℃ in air, and then the yield of SiC in the product was calculated. The product was analyzed by a powder X-ray diffractometer (RIGAKU: RINT1100) and observed by SEM (JEOL: JSM6100).

3. RESULTS and DISCUSSION

Figure 1 shows the typical X-ray diffraction patterns of the Katsura sawdust after the treatment of TEOS infiltration, hydrolysis, drying and firing. β-SiC was formed at temperatures above 1400 ℃. The peaks of β-SiC increased with the increasing temperature and the increasing concentration of TEOS. Figure 2 shows the yield of β-SiC in the product. When the specimen was infiltrated with undiluted (100 vol%) TEOS and fired at 1600 ℃, the yield went up to 80% for Katsura and 60% for Sugi, respectively. It was thought that the difference of the yield between Katsura and Sugi was depended on their textures; Katsura (broadleaf tree) has thick vessels compared with Sugi (needleleaf tree).

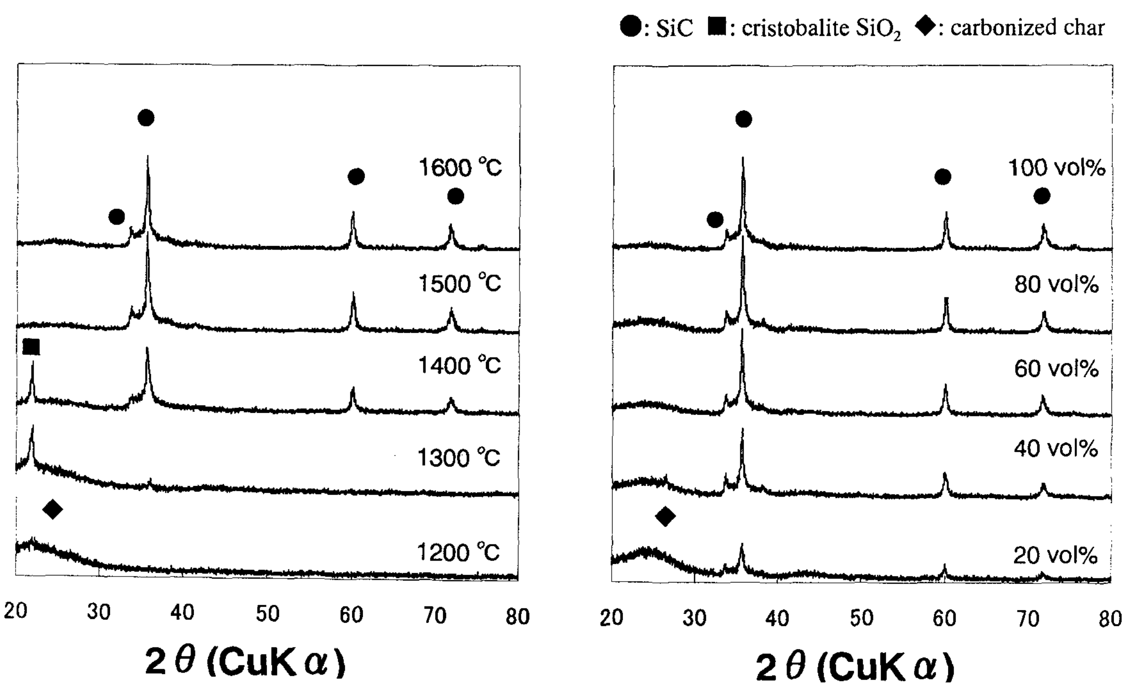

Fig.1. X-ray diffraction patterns of the Katsura sawdust (a) after the treatment of 100 vol% TEOS infiltration, hydrolysis, drying and firing at 1200 ℃ to 1600 ℃ and (b) after the treatment of 20 to 100 vol% TEOS infiltration, hydrolysis, drying and firing at 1600 ℃.

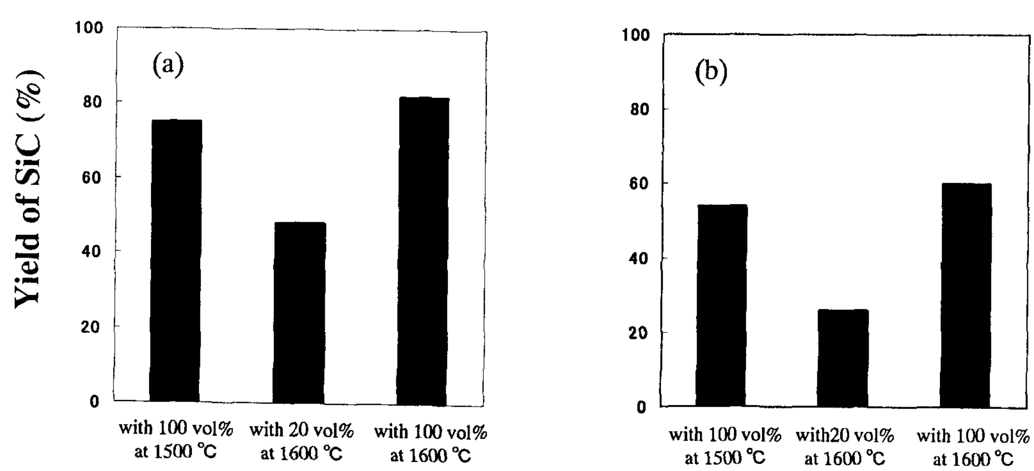

Fig.2. Yield of SiC in the product prepared from (a) Katsura and (b) Sugi.

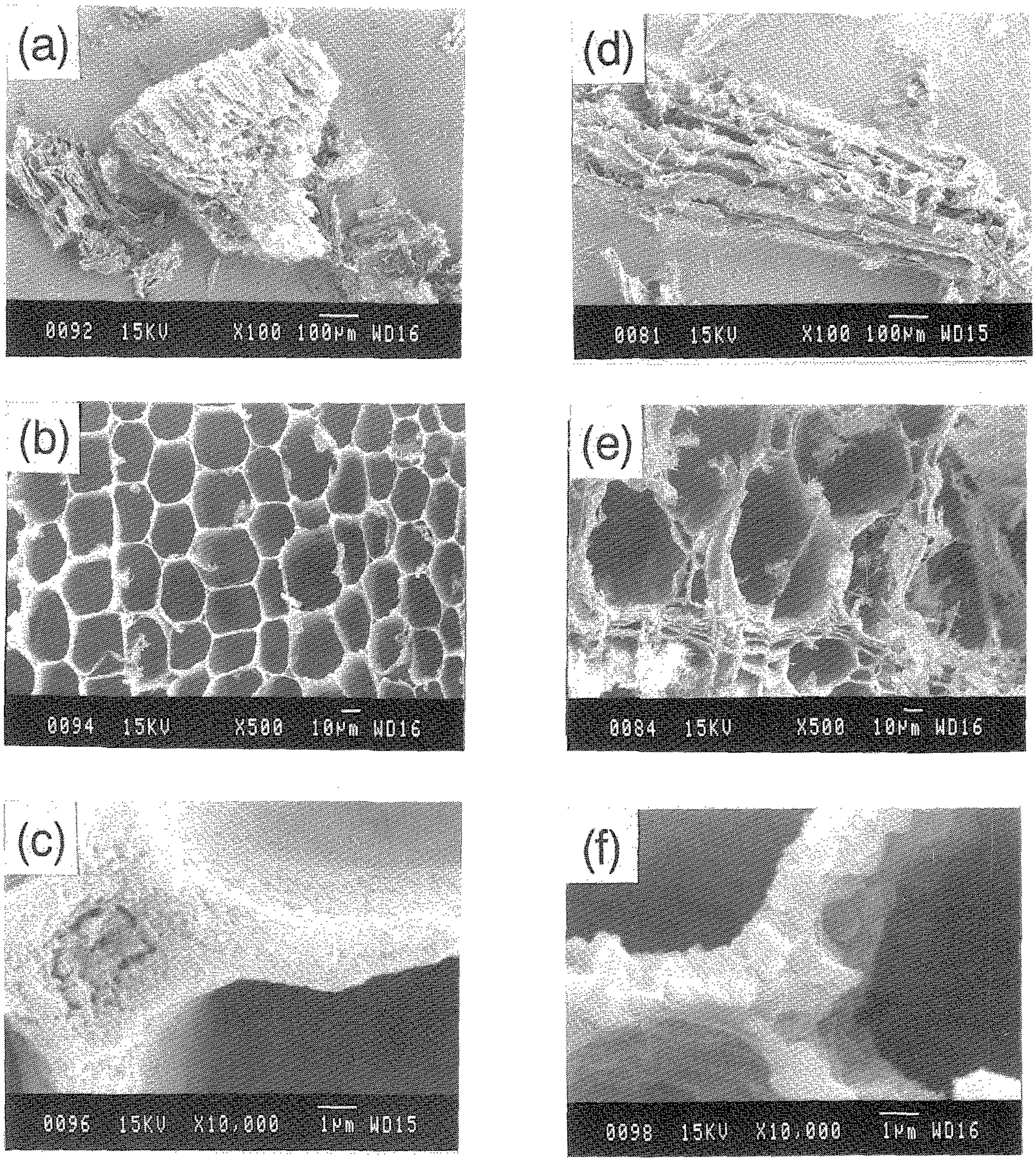

Fig.3. SEM photographs of sawdust (a) to (c) Sugi and (d) to (f) Katsura after the treatment of 100 vol% TEOS infiltration, hydrolysis, drying and firing at 1600 ℃.

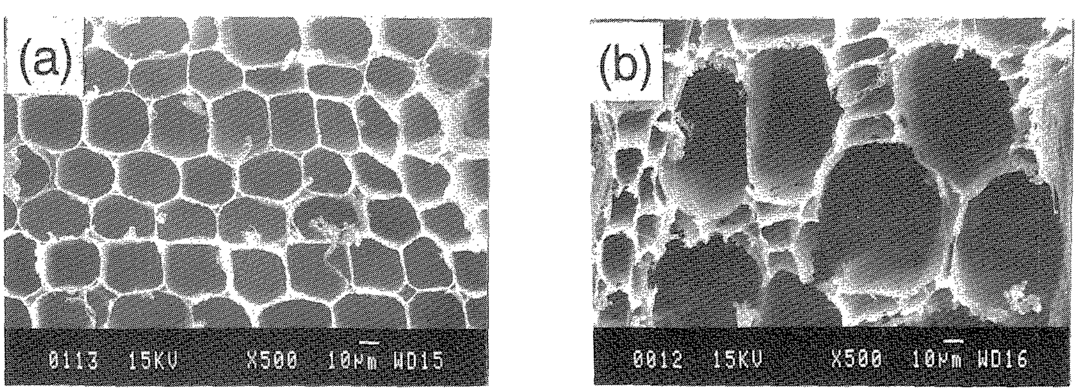

Fig.4. SEM photographs of SiC powder after the removal of residual carbon in the products prepared from (a) Sugi and (b) Katsura sawdust by firing at 700 ℃ in air.

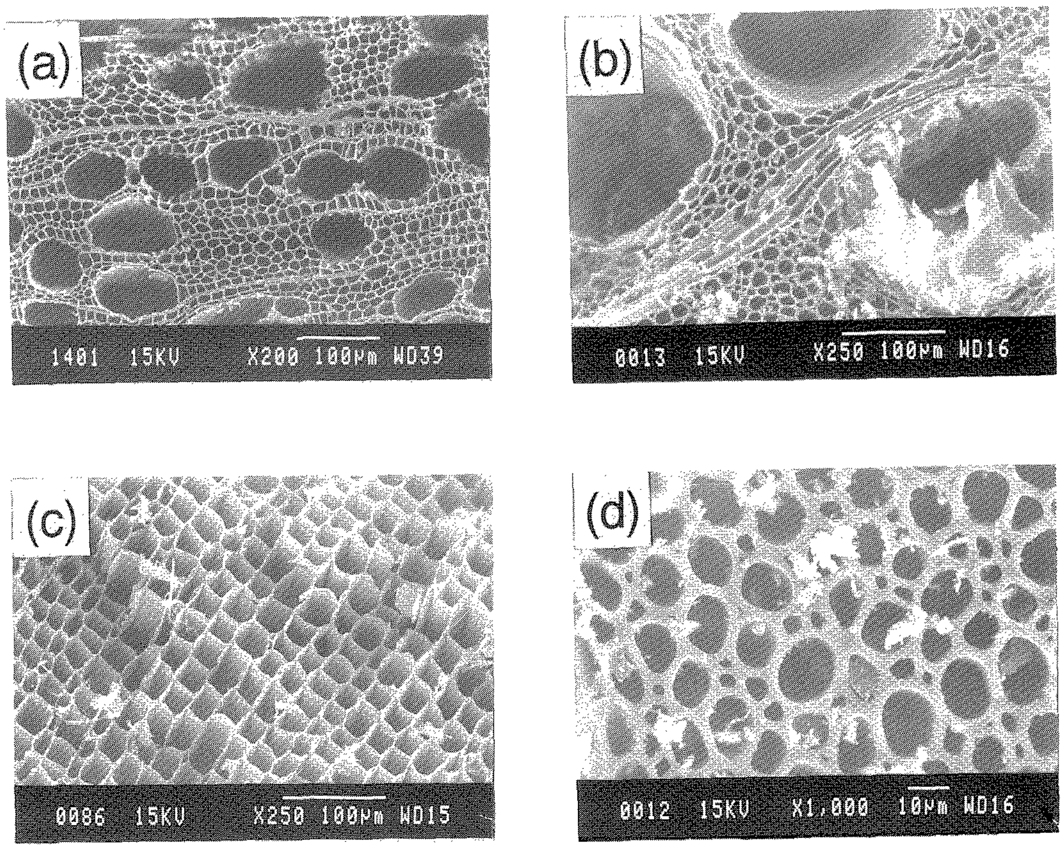

Fig.5. SEM photographs of various kinds of SiC woods: (a) Beech; (b) Balsa; (c) Fir; (d) Teak.

The external form and the microstructure of the products remained unaltered from the raw sawdust. Figure 3 shows the SEM photographs of the products prepared by firing at 1600 ℃. The texture of wood could be replicated very well in the products. At a higher magnification as shown in Fig. 3 (c) and (f), it was observed that the cell walls changed to an aggregation of SiC grains below 1 μm, and that the grains hardly sintered. When the products were burned at 700 ℃ in air, the external form and the microstructure was almost unaltered as shown in Fig. 4. Consequently, this porous SiC powder may be available for a stable absorbent in the higher temperature.

Figure 5 shows the microstructures of SiC woods prepared from various kinds of woods. Since the size of the cells and the diameter of vessels vary from species to species, any porous SiC powder with desired pore and porosity could be prepared by an appropriate choice of kind and size of the starting woods as raw materials. Further, this process could be applied into the production of porous ceramic powders made of many other substances besides SiC.

4. REFERENCE

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(Received December 16, 1999; accepted February 7, 2000)