



Impressive low reduction temperature of synthesized mesoporous ceria via nanocasting



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ABSTRACT

Ceria or cerium oxide, with high surface area and ordered structure, was prepared by the nanocasting method using MCM-48 porous material as a hard template. Optimal conditions were investigated to obtain ordered mesoporous ceria having high surface areas of 224.7 m²/g and ordered structure with 50% weight ceria using 30 min stirring time at 100 °C evaporation temperature of solvent. The mesoporous ceria was characterized using various techniques. The Temperature-programmed reduction results provided only surface reduction temperatures at 400°–600 °C.

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1. Introduction

Cerium oxide or ceria (CeO₂) has also been widely used for oxygen storage capacity [1] and environmental catalysis [2]. The most important application of ceria is as a three-way catalysis promoter in catalytic converter, for the elimination of toxic auto-exhaust gases [3,4–6]. Ceria has two characteristics [4] appropriate for use in three-way catalysts: (1) an oxidation state between Ce³⁺ and Ce⁴⁺, CeO₂/Ce₂O₃, under oxidizing and reducing conditions and (2) oxygen storage and release properties.

The catalytic performance of cerium oxide can be increased by its structural properties, such as surface area and crystal shape. Ceria with mesoporous structure and high surface areas has been synthesized by nanocasting method with various templates, both soft and hard [7,8]. The hard templates have shown many advantages over the soft ones, especially for producing highly crystalline walls, predictability and controllability [4,7]. Moreover, the hard templates can provide well-ordered structure of frameworks, leading to high surface areas of replica.

In this study, the ordered mesoporous (MSP) ceria materials were synthesized via nanocasting process using a hard template MCM-48 directly synthesized from home-made silatrane and the structure directing agent CTAB at 140 °C for 16 h [9]. Optimal conditions of the nanocasting method were investigated to obtain ordered MSP ceria having high surface areas. Physical and reduction properties were characterized using X-ray diffraction (XRD), X-ray fluorescence

spectrophotometer (XRF), N₂ adsorption/desorption analysis, Transmission electron microscope (TEM), Field emission scanning electron microscope (FE-SEM), X-ray fluorescence spectrophotometer (XRF), and Temperature programmed reduction (TPR).

2. Experimental

The MCM-48 and inorganic cerium nitrate (50%, 60%, 70%, and 80% weight of ceria) were dissolved in 5 ml of ethanol. After stirring (30 min, 1, 2, and 4 h), the ethanol in the mixture was removed by evaporation in an oven (50°, 100 °C) or at ambient temperature. The process was repeated to get the two and three filling cycles of ceria. The obtained powder was heated in a ceramic crucible at 550 °C for 6 h to decompose the nitrate species. The silica hard template was removed by using 2 M NaOH at 50 °C three times, and the mixture was centrifuged to obtain the product. The product was washed by deionized water and centrifuged until the washing was neutral and dried at 100 °C. The products were characterized by XRD. The morphology of the products was characterized using SEM and TEM. Specific surface area, pore volume, and average pore size were determined using the Brunauer–Emmett–Teller (BET) method on a Quantasorb JR instrument. The element contents in products were analyzed by XRF. The reducibility of products was analyzed by TPR.

3. Results and discussion

Nanocasting process:(Effect of cerium oxide percentage by weight). The ordered MSP ceria at 50–70% weight of cerium oxide

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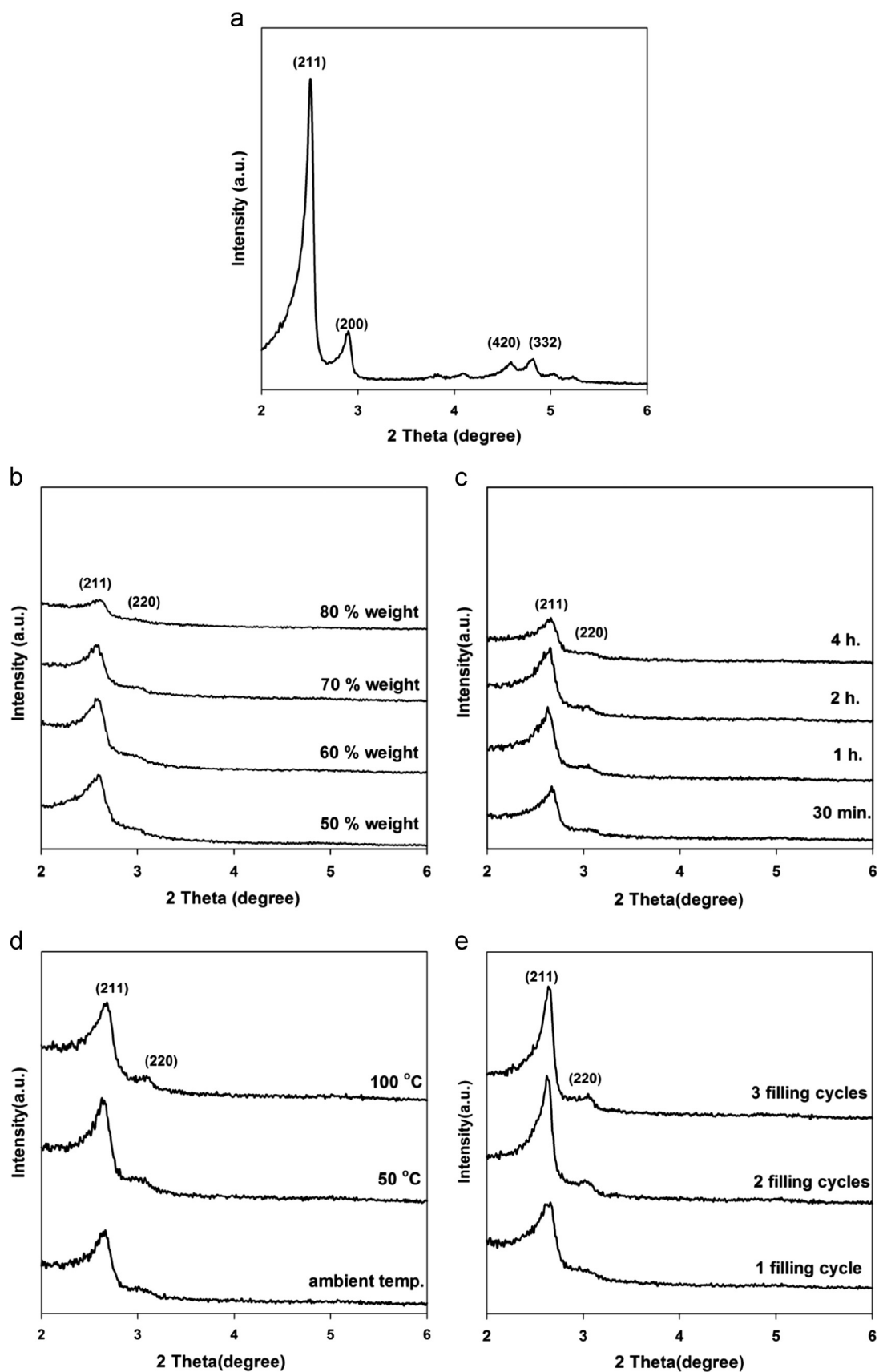


Fig. 1. XRD patterns of (a) MCM-48 and the ordered MSP ceria resulted from various (b) ceria percentages by weight, (c) stirring times, (d) evaporation temperatures of solvent, and (e) filling cycles.

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