



## Materials Research Bulletin

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Synthesis of uniformly porous NiO/ZrO<sub>2</sub> particlesRatna Balgisa<sup>a</sup>, Ferry Iskandar<sup>a, b</sup>, Takashi Ogi<sup>c</sup>, Agus Purwanto<sup>d</sup>, Kikuo Okuyama<sup>a</sup>,  <sup>a</sup> Department of Chemical Engineering, Graduate School of Engineering, Hiroshima University, 1-4-1 Kagamiyama, Higashi-Hiroshima 739-8527, Hiroshima, Japan<sup>b</sup> Department of Physics, Bandung Institute of Technology, Jalan Ganesha 10, Bandung 40132, Indonesia<sup>c</sup> Department of Chemical Engineering, Osaka Prefecture University, 1-1 Gakuen-cho, Sakai, Osaka 599-8531, Japan<sup>d</sup> Department of Chemical Engineering, Sebelas Maret University, Jalan Ir. Sutami 36 A, Surakarta 57126, Indonesia<http://dx.doi.org/10.1016/j.materresbull.2011.01.019>, [How to Cite or Link Using DOI](#)[Permissions & Reprints](#)

## Abstract

Porous NiO–ZrO<sub>2</sub> particles were successfully synthesized using a spray-drying method with polystyrene latex (PSL: 400 nm) as a template and starting materials that included NiO powder (7 nm) and ZrO<sub>2</sub> sol (1.2 nm). Porous particles with an average diameter of 4.5 μm and nearly spherical, narrow pores with an average size of ~300 nm were obtained from the precursor at a pH of 3.7. The Brunauer, Emmett and Teller (BET) surface area of the prepared particles was relatively high—about 27 m<sup>2</sup>/g. When the solution pH was increased to 9.7, the particle morphology became completely spherical, indicating that the morphology of prepared particles can be controlled by adjusting the pH. Calcinations at 900 and 1200 °C were carried out to estimate the thermal stability of the prepared particles, which had shrinkage of less than 36%. The existence of these pores means that various applications, such as electrodes and catalysts, will be possible for the prepared particles.

## Graphical abstract

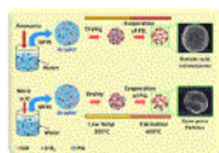


Figure options

## Research highlights

- ▶ NiO–ZrO<sub>2</sub> porous particles were successfully synthesized using spray drying method.
- ▶ Solution pH influences the morphology of NiO–ZrO<sub>2</sub> particles.
- ▶ The specific surface area decreases with an increase of calcination temperature.
- ▶ NiO–ZrO<sub>2</sub> porous particles have a good thermal stability.

## Keywords

A. Composites; B. Chemical synthesis; C. Thermogravimetric analysis (TGA); C. X-ray diffraction; D. Surface properties