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Fabrication of a regenerable Ni supported NiO-MgO catalyst for methane steam reforming by exsolution

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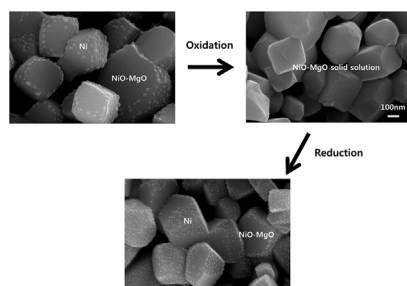
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HIGHLIGHTS

- Ni nanoparticles supported on NiO-MgO solid solution were synthesized by exsolution.
- The growth of Ni nanoparticles depended on the homogeneity of the solid solution.
- The catalytic activity was not to be degraded appreciably for 1000 h of operation.
- The metallic nickel moved reversibly to and out of the parent solid solution.

GRAPHICAL ABSTRACT



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ABSTRACT

Nickel nanoparticles supported on a NiO-MgO solid solution are fabricated using the exsolution process. Upon reduction, the nickel nanoparticles are exsolved from a $\text{Ni}_{0.4}\text{Mg}_{0.6}\text{O}$ solid solution powder. From the results obtained from transition electron microscopy (TEM) and temperature programmed reduction (TPR) measurements, it is concluded that the size and dispersion state of the nickel nanoparticles strongly depend on the homogeneity of the parent solid solution. Sintering the parent solid solution powder at a high temperature results in a homogeneous solid solution, which leads to a decreased reducibility of the nickel ions and, consequently, well-distributed Ni nanoparticles are successfully obtained. The metallic nickel moves reversibly to and out of the parent solid solution in response to a specific atmospheric condition. The methane steam reforming over the as-synthesized nickel nanoparticles are evaluated and appreciable degradation (1000 h) of the catalytic activity is not found for the catalyst sample that is sintered at 1000 °C followed by subsequent reduction to 800 °C.

1. Introduction

There are two important issues to consider when designing a catalyst for industrial use; one is the catalytic activity and its associated selectivity, determined directly by its bulk and surface chemical

composition, microstructure or morphology, and phase composition [1]. The other is the thermal and mechanical stability which ensures the successful implementation when used in catalytic systems [2,3]. Various preparation methods have previously been studied and implemented for creating efficient catalytic materials with potential

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