Recyclability of the Sintered YSZ Supports for Synthesis of Carbon Nanofibers

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Among the various types of nanostructured materials, carbon nanomaterials are of great importance because of their various novel properties leading to new applications. Recently carbon nanofibers(CNF), which have a similar shape with CNT but different internal structures from CNT, have been studied. In this experiment, two kinds of porous compacts were prepared for a catalyst support in order to synthesize CNF. One is a compact from the milled mixture of nickel oxide (NiO) and yttria-stabilized zirconia, and the other is the compact of the YSZ dopped by nickel nitrate. After the reduction of both supports, ethylene gas acting as the carbon source of CNF was blown with hydrogen gas into the same tube keeping at the temperature of 600°C.

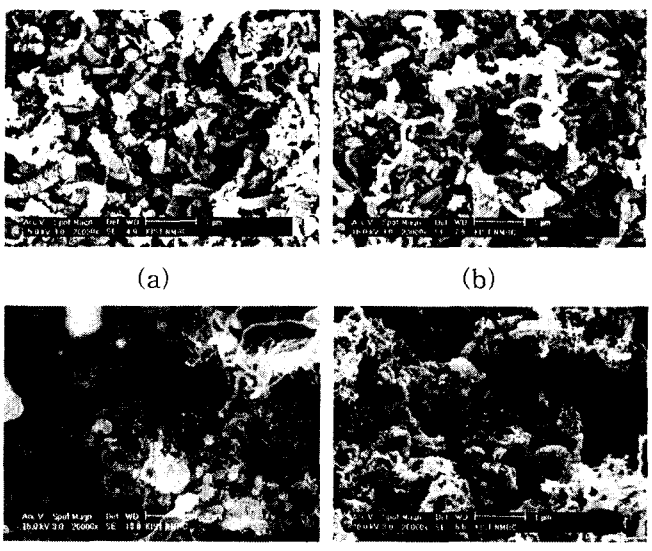

Fig. 1. Morphologies of CNF formed on the NiO-YSZ supports sintered at (a) 950°C, (b) 1200°C, (c) 1300°C, and (d) 1400°C.

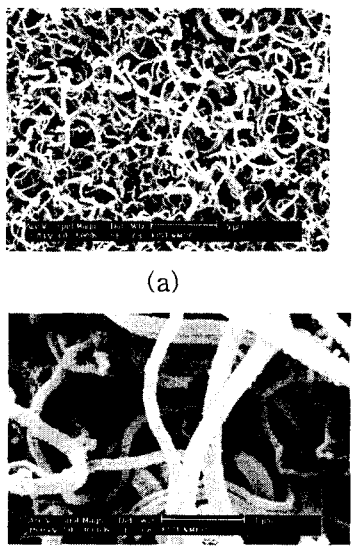

Fig. 2. Morphologies of CNF formed on the doped supports:
(a) low and (b) high magnification.

Fig. 1 shows the morphologies of CNF formed on the supports of NiO-YSZ. With increasing the sintering temperature of supports, the CNF tends to become thinner and a fraction of thin CNF increases. The feature of CNF formed on the YSZ support depends sensitively on the suface structure of support. The rapid growth of YSZ grains at high temperature caused the NiO particles with various sizes and subsequently gave a condition for formation of CNF with high irregularity. In order to obtain more fine and homogeneous nickel particles imbedded on the surface of fully densified or porous support, the YSZ grains should be suppressed to grow as slow as possible.

Fig. 2 shows the CNF formed on the YSZ support dopped by Ni precursor. The CNF synthesized is very homogeneous and looks like spaghetti. Comparing with the irregular CNF formed on the NiO-YSZ supports in Fig. 1, the CNF on the Ni dopped support looks relatively much more uniform. Recycling feasibility of the NiO-YSZ support sintered at 1200°C was tested successively three times as shown in Fig. 3. The morphology of CNF was changed slightly and hairy thin CNF increases. Total amount of CNF decreases slowly along with the repetition of synthesis reactions.

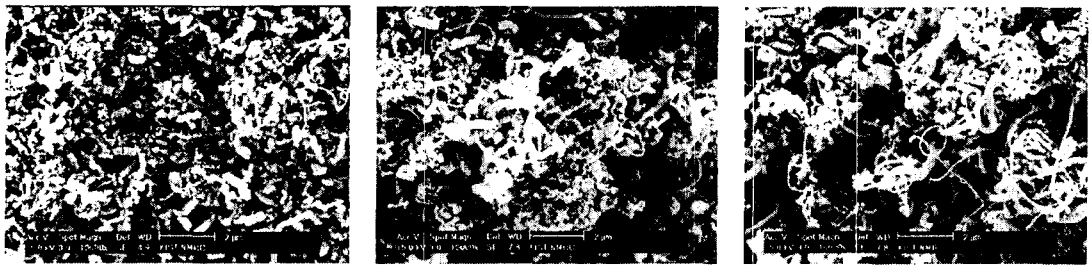

Fig. 3. Morphologies of CNF formed on the NiO-YSZ support sintered at 1200°C: (a) first run, (b) second run, and (c) third run.

In conclusion, it was proved that the porous sintered compact of YSZ could be used as a stable support for nickel catalyst particles in the CNF synthesis. The sintered YSZ support admixed with NiO powder had coarse aggregated catalyst particles as a result of rapid growth of YSZ grains during densification, which provided a growth condition of very irregular CNF. The NiO-YSZ supports could be applied three times for synthesizing the CNF. The chemical doping of Ni element using nickel nitrate leaded to fine grain and open structure in the compacts, and it was more adequate to synthesize the CNF with high quality.