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Preparation of Hydrogen Permeable Membrane using Nanoparticles Electrophoresis Technique

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Abstract

Hydrogen permeable membranes prepared by electrophoresis of nanoparticles were investigated. At first, nanoparticles were prepared from metal ions in aqueous solutions with ultrasonic irradiation, and then precipitated on a substrate disc under electric field in the same solution. White color of substrate before the electrophoresis process changed with brown color after the process. The obtained membranes exhibited H_2 gas permeance and permselectivity at room temperature.

Introduction

Stable supply of pure hydrogen is indispensable for practical uses of fuel cells, which are one of the most promising solutions to energy and environmental problems. If H_2 can be selectively removed from steam reforming reaction system through H_2-selective membranes, the thermodynamic equilibrium can be shifted to the product side, resulting higher conversion of CH_4 to H_2 will be achieved even at lower temperatures[1]. To realize the H_2 permeable membrane with high permeance rate, thinner metallic membrane has to be required. The objective of this work is to establish a noble preparation process of H_2 perm-selective thin membranes and to evaluate them.

Experimental

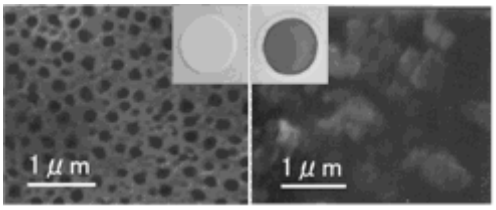
Ag Nanoparticles were prepared from $AgNO_3$ aqueous solutions with ultrasonic reduction[2]. $AgNO_3$ was dissolved in ultra pure water and stirred for 10min, and then Ar was bubbled into the solution for 30min because of substitute with Ar atmosphere. The color of solution changed gradually to browm with increase in the irradiation time. Finally, Ag nano colloided solution was prepared. Formation of nanoparticles was confirmed by UV-vis spectra. Morphology of nanoparticles was observed by high-resolution transmission electron microscope (HR-TEM). Pd nanoparticles were

prepared with similar process to the Ag nanopartocles preparation. The prepared metallic nanoparticles were deposited on the surface of anodic-oxidation alumina (AAO, pore size:20nm) disc by electrophoresis. The morphologies of the deposited membrane were observed by scanning electron microscope (SEM).

Hydrogen permeance of the prepared membranes at ambient temperature were evaluated by the H_2 pressure drop of high pressure side on membrane.

Results and Discussions

Average size of Ag nanoparticles that were prepared with ultrasonic reduction was evaluated ca. 5.5 nm by HR-TEM observation. It was clear that Ag nanoparticles were fixed on the surface of substrate because AAO disc colored to brown after the electrophoresis. SEM images of AAO disc before and after electrophoresis of Ag nanoparticles are shown in Fig. 1. It was observed that the nano-pores on AAO disc were completely covered with Ag nanoparticles. These results indicated that nanoparticles were successfully fixed on the surface of AAO by electrophoresis process.



(a) AAO disc (b) After electrophoresis

Fig. 1. Scanning electron micrographs of AAO membrane (a) before and (b) after electrophoresis of Ag nano colloid.

Table 1 shows the gas permeable properties of electrophoretic Ag and Pd membranes. The Ag membrane had almost the same permeance and separation factor of Pd membrane, which has excellent perm-selectivity of H_2. Unlike Pd, it's well known that H_2 can't dissolve in Ag metal. Therefore, it was considered that H_2 molecules passed through a gap between Ag nanoparticles. The permeable mechanism of Ag membran may differ markedly from the Pd membrane.

Table 1 Gas permeation properties of the Ag and Pd nanoparticles membranes

Metal	Permeance $\boldsymbol{R}$ [cm^3 ($cm^2 \cdot sec \cdot cmHg)^{-1}$]		Separation factor α (R_{H_2}/R_{N_2})
	H_2	N_2	
Ag	1.61×10^{-4}	5.20×10^{-5}	3.09
Pd	1.54×10^{-4}	4.91×10^{-5}	3.13

Conclusions

Thin nanoparticle membranes were successfully prepared by electrophoresis technique. Permeability of Ag nanoparticle membrane was as high as Pd nanoparticle membrane.

References

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