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Enhancement of Equilibrium Shift in Dehydrogenation Reactions Using a
Novel Membrane Reactor

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ABSTRACT

A modified electroless deposition method was used to deposit quality Pd-film on microporous ceramic and stainless steel substrates. The method uses the osmotic pressure as the driving force to make the solvent of the plating solution get into the tiny holes (pores) of the substrate to help plate palladium onto the wall of the holes, then block them with the growth of the palladium film. Several membrane specimens were prepared on microporous stainless steel substrate by the modified electroless deposition of Pd-film. Further work is needed to refine the method.

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EXECUTIVE SUMMARY

In developing Pd-ceramic membranes, eight porous ceramic and stainless steel substrates were investigated to find the influence of the substrates to the morphology of the Pd membranes plated on them. The results indicated that the pore size and coarseness of the substrate are the most important factors when choosing the right substrate for good Pd membrane plating. A modified electroless plating procedure had been developed for stainless steel substrate.

INTRODUCTION

The overall objective of this project is to develop inorganic and composite membranes for in-situ separation of hydrogen and equilibrium shift in catalytic membrane reactors. The specific objectives of this research are to:

1. Design and fabrication of catalytic membrane reactor using thin film palladium-composite membrane for dehydrogenation of cyclohexane to benzene
2. Conduct dehydrogenation reaction experiments to study the equilibrium shifts and hydrogen permeation characteristics
3. Develop a theoretical foundation for equilibrium shifts and hydrogen transport in the membrane reactor

Membrane Reactor-Separator in Planar & Tubular Configurations

In our previous report, we reported dehydrogenation of cyclohexane in our Pd-ceramic disc membranes in membrane reactor configuration. In an attempt to fabricate tubular Pd-ceramic membrane for membrane reactor, we had serious problem with end-seal. In an effort to improve the quality of the tubular membrane, we investigated Pd-film deposition on porous stainless steel substrate.

RESULTS AND DISCUSSIONS

In developing Pd-ceramic membranes, eight porous ceramic and stainless steel substrates were investigated to find the influence of the substrates to the morphology of the Pd membranes plated on them. The results indicated that the pore size and coarseness of the substrate are the most important factors when choosing the right substrate for good Pd membrane plating. A modified electroless plating procedure had been developed for stainless steel substrate. The membrane plated by this method is much better than the conventional one. But it still needs improvement to make a defect free Pd membrane.

In the final report, the details of the work performed over four years of this US DOE funded project is reported.

CONCLUSION

We developed a modified electroless deposition method to deposit quality Pd-film on microporous ceramic and stainless steel substrates. It used osmotic pressure as the driving force to make the solvent of the plating solution get into the tiny holes (pores) of the substrate to help plate palladium onto the wall of the holes, then block them with the growth of the palladium film. Secondly, osmotic pressure would press palladium onto the substrate to make the membrane compact and robust.