Nanoporous Ni Surface Modification by Electrochemical Dealloying

Taner Özdal¹ and Fatih Pişkin¹,²
¹Energy Materials Laboratory, Muğla Sıtkı Koçman University, Turkey
²Metallurgical and Materials Engineering, Muğla Sıtkı Koçman University, Turkey

INTRODUCTION
316L porous stainless steel (PSS) is a suitable support material for thin-film Pd-based membranes due to its high thermal, oxidation resistance and having a similar thermal expansion coefficient with Pd. However, commercially available PSS have often very large surface pores (>20µm) that affect the final thickness of the membrane deposited on it. That’s why the membrane thickness deposited on the PSS can reach several tens of microns in order to create a porous-free membrane.

There are several studies that focus on applying an interlayer between PSS and thin-film membrane so as to reduce the size of pores at the PSS surface, and thus reduce the thickness of the membrane. However, it is often not easy to control the size of surface pores and keep their size under a threshold. Any remaining large pore at the surface of support material causes the formation of pin-holes in the membrane and this might result in a reduction in hydrogen selectivity. That’s why modification of PSS surface has to be employed in a controlled manner and should be reproducible.

The current study concentrates on surface modification of PSS as a support material in order to enable thin-film membrane (<1µm) deposition on PSS. In this respect, 316L foil was used as a model system to determine the application parameters for the formation of a nanoporous Ni surface layer on the PSS. 316L foils were initially electroplated by Ni-Cu alloys using plating solutions with different Ni:Cu concentrations. Subsequently, the Ni-Cu surface layers on 316L foils were subjected to an electrochemical dealloying process in order to dissolve Cu back into the plating solution and remain a nanoporous Ni layer.

EXPERIMENTAL
Electroplating and electrochemical dealloying processes were performed under ambient conditions in a three-electrode cell. Ni₅Cuₓ₄ alloys were electroplated on 50µm 316L foils. Ni seed layer was initially electroplated on all 316L foils in the study using 0.8M NiSO₄·7H₂O solution for 5 min at -1.0V. Electroplating of Ni₅Cuₓ₄ alloys was performed at the same potential in plating solutions composed of NiSO₄·7H₂O and CuSO₄·5H₂O for up to 30min. The concentration of NiSO₄·7H₂O was kept constant at 0.8M while CuSO₄·5H₂O ranged from 0.01M to 0.1M in the plating solutions in order to obtain different NiSO₄·7H₂O-CuSO₄·5H₂O ratios, so the different Ni₅Cuₓ₄ alloys. The alloys were then subjected to electrochemical dealloying in their respective plating solutions at +0.5V up to 15min.

RESULTS AND DISCUSSION
The methodology described resulted in a Ni layer having pores less than 100nm in diameter on a 316L foil surface. The porous Ni surface obtained via Ni-Cu electroplating and subsequent electrochemical dealloying of Cu was investigated by SEM, Fig. 1.

Fig. 1. Nanoporous Ni layer deposited on 316L foil.

CONCLUSION
In the current work, a sequential Ni-Cu electroplating and electrochemical dealloying process were applied to obtain a nanoporous Ni surface layer on 316L foil. In this respect, several plating solutions with different Ni-Cu concentrations were prepared. The electrochemical dealloying of Cu was performed on each Ni-Cu alloy deposited by different plating solutions and the ideal conditions were identified so as to obtain a porous Ni surface layer having pores less than 100nm in diameter on 316L foil.

REFERENCES
   https://pubs.acs.org/doi/10.1021/ie049349b.

ACKNOWLEDGMENTS
The authors gratefully acknowledge the financial support of this research from the Scientific and Technological Research Council of Turkey (TUBITAK) with project number 119M636.

Presenting author: Taner ÖZDAL, e-mail: tanerodal74@gmail.com, tel: +90 545 738 43 93