Electrodeposition of Palladium-Containing Alloys in a Lewis Basic 1-Ethyl-3-methylimidazolium Chloride/Tetrafluoroborate Ionic Liquid

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Palladium is one of the most important metals for industrial applications such as electrical contact and catalysis because of its excellent wear resistance, good solderability and high catalytic activities for various chemical reactions.[1] To enhance the efficiency of Pd for different applications, it often requires the incorporation of a second metal to Pd to alter the properties of Pd. Electrodeposition should be an economical and convenient choice for the preparation of Pd and Pd alloys coating. However, it has been reported that Pd electrodeposition processes from aqueous baths suffered from the codeposition of hydrogen, leading to the formation of microcracks.[2] Therefore, efforts have been made to minimize this problem. One approach to circumvent this problem is to replace the aqueous baths with aprotic solvents.

Ionic liquids are normally aprotic so that complications associated with hydrogen evolution that occur in aqueous baths are eliminated in the ionic liquids. Thus, ionic liquids have been employed in the electrodeposition of pure metals and alloys, especially those that are difficult to prepare in aqueous electrolytes.[3] In general, the ionic liquids are either water-reactive or water-stable. The latter are apparently easier to work with and are becoming the trend of recent research. Examples on the electrodeposition of metals, alloys from the water-stable ionic liquids have been reported in the literature.[4]

In this report, the electrodeposition of Pd-Au and Pd-Ag alloys were investigated in an ambient temperature ionic liquid electrolyte, 1-ethyl-3-methylimidazolium chloride-tetrafluoroborate system. A cyclic voltammogram of a solution containing 6.5 mM Au(I) and 25 mM Pd(II) in the basic EMI-Cl-BF4 melt at a GC electrode at 30 ^{o}C is shown in **Fig. 1a**. The reduction of Au(I) occurs at C_1, whereas the reduction of Pd(II) occurs at C_2. The presence of multiple stripping peaks during the scan reversal suggests that the deposits may contain different phases that have different Pd/Au compositions. The temperature effect on the voltammetric behavior of the Au(I)/Pd(II) solution is illustrated in **Fig. 1b**. As the temperature was increased, the multiple stripping peaks that were observed at lower temperature (Fig. 2a) merged into a sharp and symmetric peak, indicating that increasing the temperature resulted in a homogeneous Pd-Au solid solution. **Fig. 2** shows the XRD patterns of the Pd-Au films that were electrodeposited from solution of 6.5 mM Au(I) and 24.8 mM Pd(II) with a current density of 0.52 mA/cm2 at different temperatures. This figure reveals that homogeneous solid solution was obtained at high temperature. These observations are in consistent with the cyclic voltammograms shown in **Fig. 1**.

References

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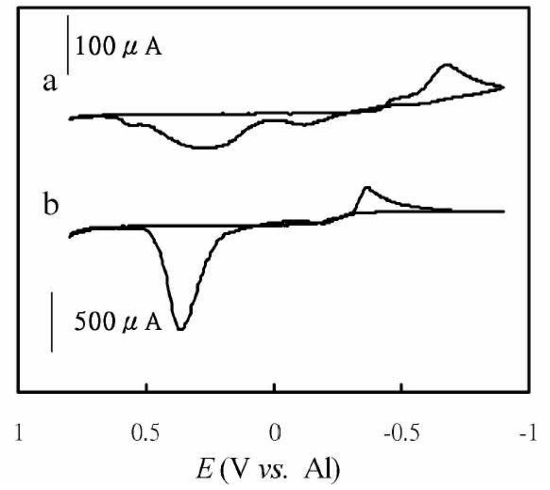

Fig. 1 Cyclic voltammograms recorded at a GC electrode for a EMI-Cl-BF4 ionic liquid containing 6.5 mM Au(I) and 25 mM Pd(II) at (a) 30 ^{o}C, and (b): (- - -)50 ^{o}Cand (____)120 ^{o}C. Scan rate = 100 mV s^{-1}.

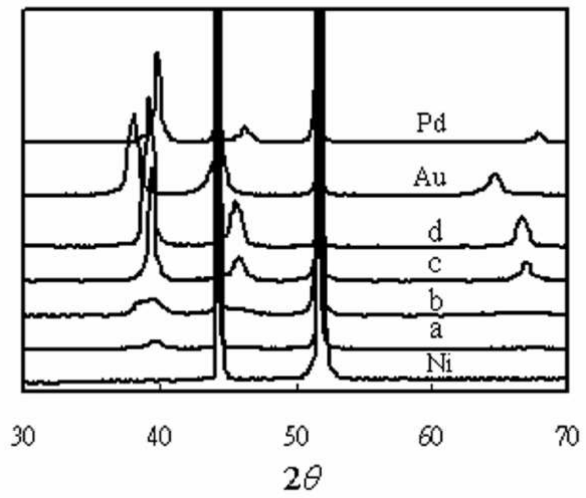

Fig. 2 XRD patterns (Cu K_{α}) of Pd-Au sample prepared on nickel substrate from EMI-Cl-BF4 ionic liquid containing 25 mM Pd(II) and 6.5 mM Au(I) at : (a) 30, (b) 50, (c) 80, and (d) 120 ^{o}C. The current density was 0.52 mA cm^{-2}.