Electrochemical Characterization of Screen Printed Au Electrodes

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Electrochemical detection has been widely used in a variety of sensor applications such as corrosion monitoring, solution composition control, environment monitoring and biomedical detection.[1] Screen printing has been adopted to manufacture these electrodes, especially for biomedical sensor applications, because of its low cost, ease of fabrication, and, more importantly, the process compatibility with bio-reactive agents such as enzymes. Among them screen printed gold and carbon are two of the most used examples. Because of the nature of the screen printing process, the surface properties of the screen printed electrodes (SPEs) can be highly dependent on the processing. In this study, two commercially available screen printed Au electrodes cured at two different temperatures were electrochemically studied to understand the impacts of annealing temperature on the Au electrode property. Evaporated Au thin film electrodes were used for comparison.

Experiments were carried out using a potassium ferro-cyanide and ferri-cyanide redox pair in sulfuric acid solution.(2) Two commercial Au electrodes screen printed on ceramic substrates were used, one cured at 120C and the other at 800C, a much higher temperature incompatible with bioactive reagents. Evaporated Au thin film electrodes were also studied for comparison.

Figure 1 shows the cyclovoltammograms of the two screen printed Au electrodes in 1 mM $K_3[Fe(CN)_6]$ solution. The oxidation current transients of ferrocyanide are the same on both electrodes except for a slightly smaller effective area on the SPE cured at lower temperature. On the other hand, the reduction behaviors of ferricyanide are more different on the two electrodes. A lower cathodic peak current together with a slower decay of the cathodic current was observed on the SPE cured at 120C. Surprisingly, this sluggish current decay was also observed on the evaporated Au thin film electrodes, indicating a difference not inherited from the screen printing process. Figure 2 shows the impedance spectra of the two screen printed Au electrodes in a solution containing 100 mM $K_3[Fe(CN)_6]$ and 100 mM $K_4[Fe(CN)_6]$. The much higher concentration was used to avoid a dominant mass transport effect on the impedance analysis. An unexpected negative resistance value was observed at high frequency and more detailed studies will be presented for understanding. While a two-semicircle spectrum was observed for both electrodes, the dependence of the spectrum on the applied potential is different. This difference is believed to relate to the different charge transfer kinetics of the $K_3[Fe(CN)_6]$ / $K_4[Fe(CN)_6]$ pair on the two SPEs. In addition, an inductor was included in the equivalent electrical circuits to better simulate the non-ideal semicircular pattern at high frequency regime, consistent with a process involving an adsorbed intermediate.(3-6) Detailed results will be presented during this talk for discussions.

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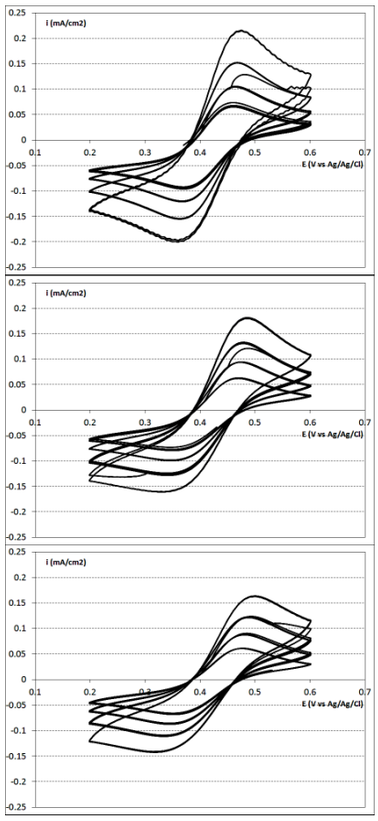

Fig. 1: (from top to bottom) Cyclovoltammograms (scan rate = 25 – 200 mV/s) of 1 mM $K_3[Fe(CN)_6]$ solution on screen printed Au electrode cured at 800C, screen printed Au electrode cured at 120C, and evaporated Au thin film electrode.

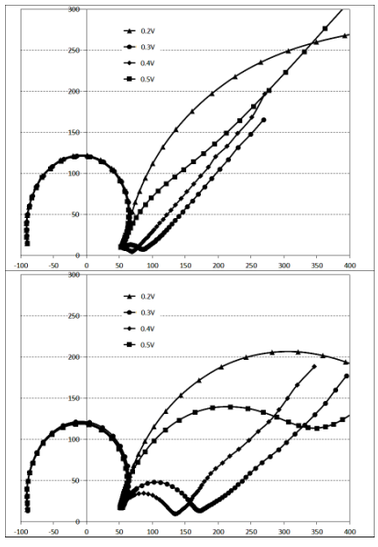

Fig. 2: Electrochemical impedance spectra at different potential for (top) the screen printed Au electrode cured at 800C and (bottom) screen printed Au electrode cured at120C.