

## Synthesis of Polyaniline/Gold Composite

John M. Kinyanjui, Justin Hanks, David W. Hatchett\*  
 Department of Chemistry  
 University of Nevada, Las Vegas  
 4505 Maryland Parkway, Box 454003  
 Las Vegas, NV 89154-4003

Anthony Smith, Mira Josowicz  
 School of Chemistry and Biochemistry  
 Georgia Institute of Technology,  
 Atlanta, Georgia 30332-0400

The *in-situ* synthesis of micro- and nano- gold particles in polyaniline (PANI/Au composite) using chemical and electrochemical methods has been compared. The direct chemical synthesis of PANI/Au is initiated via the spontaneous oxidation of aniline by  $\text{AuCl}_4^-$ . Gold colloid formation and subsequent reaction with PANI is monitored by *in-situ* UV/Vis spectroscopy. The emergent polymer nucleates on the gold as the PANI chain length increases, encapsulates the metal and precipitates as its solubility limit is exceeded (Figure 1). SEM images of these samples show relatively constant 1  $\mu\text{m}$  diameter gold particles (Figure 3b). Electrochemical PANI/Au synthesis is initiated by  $\text{AuCl}_4^-$  reduction into an *a priori* electrochemically deposited PANI film (Figure 2). This method also produces a nearly uniform dispersion of Au particles but with significantly smaller 150-300 nm particles (Figure 3a). The results indicate that electrochemical methods are more suitable for controlling particle dimensions. A minimal decrease in conductance is observed for the chemically formed PANI/Au when compared to PANI samples without the gold. However, a significant decrease in conductance is observed for the electrochemically formed composite. The large decrease in conductance is related to the decrease in proton doping and a greater number of oxidized units in the polymer upon electrochemical uptake and reduction of  $\text{AuCl}_4^-$ .

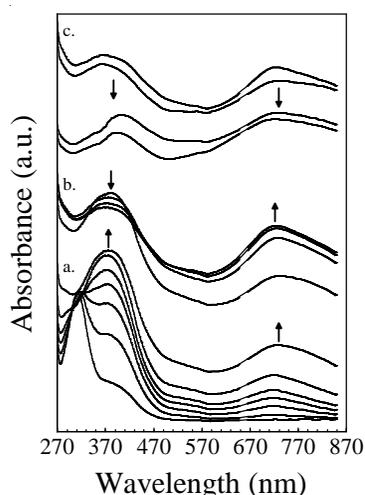


Figure 1. a. UV/VIS reaction of aniline/ $\text{AuCl}_4^-$ , 0 - 30 seconds (polymer initiation/growth). b. Conversion of band at  $\sim 370$  nm to PANI at  $\sim 711$  nm, 30 - 120 seconds. c. Precipitation of the polymer/metal composite observed as loss of signal,  $> 120$  seconds. Arrows show trends in absorbance over the time intervals.

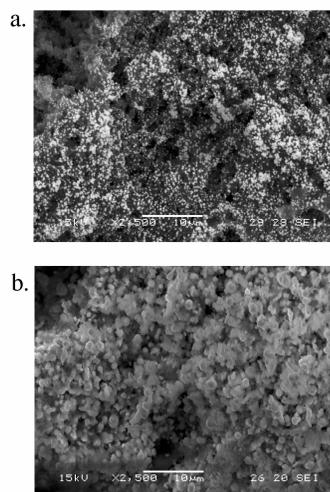


Figure 2. Cyclic voltammogram of a PANI electrode immersed in solution of 1 M  $\text{HClO}_4$  with no Au, bottom. Cyclic voltammetric response of the same PANI electrode immersed in a solution containing 5 mM  $\text{AuCl}_4^-$  in 1 M  $\text{HClO}_4$ , labeled scans 1 thru 6. Scan rate  $v = 10$  mV/s and electrode area =  $0.003$   $\text{cm}^2$ .

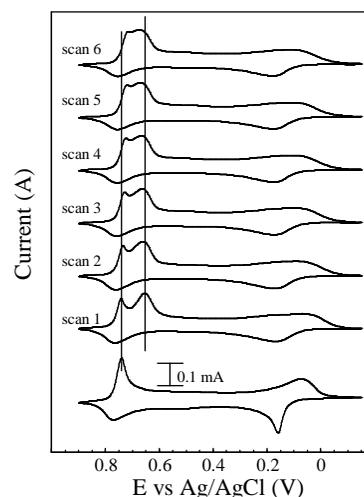


Figure 3. a. SEM image of PANI electrode after uptake and electrochemical reduction of  $\text{AuCl}_4^-$ . b. SEM image

of chemically prepared PANI/Au composite. Both images appear at the same magnification with the white bar = 10  $\mu\text{m}$ .