Carbon Nanotube Modified Gold (Au) Electrode for Anodic Oxidation of H_2S.

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Introduction

Gold electrodes are frequently used for H_2S and NOx electrochemical sensors [1]. Modification of the gold electrode with carbon nanotubes (CNT) will change sensing characteristics. Generally carbon nanotubes have unique electronic and mechanical properties with high chemical stability [2]. In this study the amperometric gas sensor (AGS) with a gold electrodes modified with multi wall carbon nanotube (MWCNT) was investigated.

Experimental

The gold electrode was prepared by e-beam evaporation of a 700 Å film of 99.999% Au onto a porous Teflon membrane. CNTs were deposited on the gold surface from alpha terpineol solvent (Fisher Scientific, Fair Lawn, NJ) and dried in a vacuum oven at room temperature. Nafion®, 5% ethanol solution (Aldrich, Milwaukee, WI), was put on the top of electrode and dried at 80 ^oC. The CNTs loading was 5.9 mg/cm^2 and the gold electrode formed the WE in the sensor and gas flow system shown in Fig. 1. The sample gas contact area of electrode is 78.5 mm^2. Two platinized platinium wires were used for Counter and reference electrode and 30% H_2SO_4 was used as the electrolyte. Cyclic voltammetry (CV) with different gases were run using a Gamry PHE200 system (Gamry Inc., Warmister, PA). The CV scan rate was 100mV/sec and run between 0.1 to 1.2 V *vs.* Pt/air-QRE. Tests of H_2S and NO_2 were obtained at fixed potential using a lab built potentiostat with LabView® data acquisition system. Sample flow rate was fixed at 100cc/min over the back side of the porous WE.

Results

Figure 2 illustrates characteristic voltammograms with Air, CO, NO_2, and H_2S gases. The H_2S CV shows large anodic currents above (anodic to) 0.5 V *vs.* Ag/AgCl The NO_2 CV clearly shows two oxidation peaks in the region around at 0.6 V and 1.0 V *vs.* Ag/AgCl as well as reduction currents in excess of the air background. But the CO CV overlapped air and the electrode was virtually inert to CO at this concentration and in this scan range. Selectivity for CO, H_2S, and NO_2 can be achieved by CV analysis with this electrode system using the CNT decorated Au WE.

The sensor response to multiple exposures of a 50 ppm H_2S/air mixture is shown in Fig. 3. The H_2S signal size is improved almost ten times compared to pure gold electrode sensor with the same size WE an d gas exposure path [4] but some instability in the steady state signals is observed for the first four exposures during these long duration exposures. This behavior would be observed as long and short term drift if this sensor were used in an instrument without compensation for this effect.

Both NO_2 and H_2S sensitivity was improved by CNT modification of gold electrode. NO_2 sensitivity at 0 mV *vs.* Pt/air-QRE is – 405.6 nA/ppm and R^2 = 0.9913 and H_2S sensitivity at 500 mV *vs.* Pt/air-QRE was 3320 nA/ppm and R^2 is 0.4311.

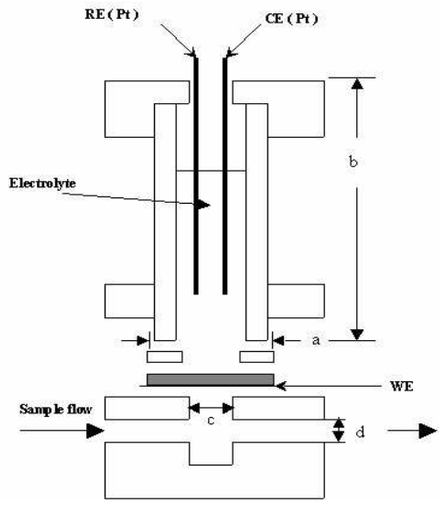

Fig. 1. Sensor diagram with gas sample flow path. Dimensions; a = 31, b = 3, c = 10, and d = 3.2 mm.

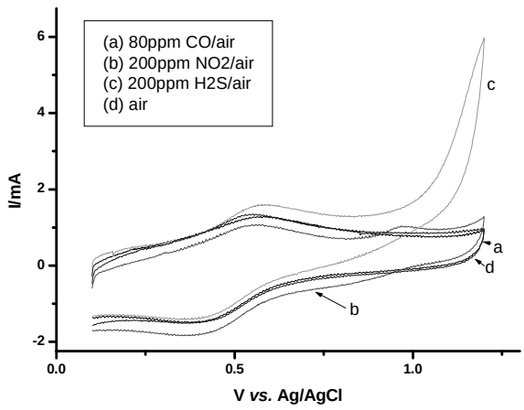

Fig. 2 CVs of CNT modified Au electrode with NO_2, H_2S, CO and filtered/cleaned room Air.

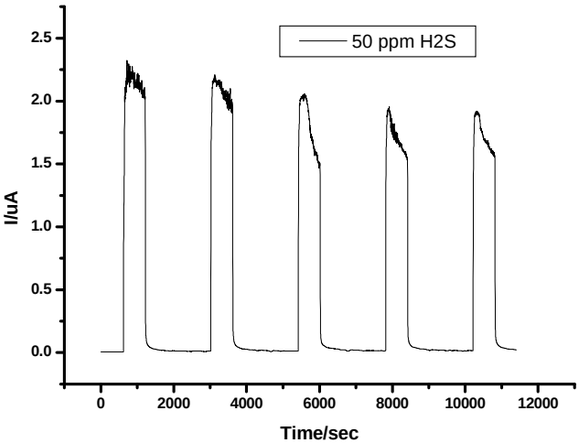

Fig.3. Response of multiple 50 ppm H_2S exposure to CNT/Au electrode sensor applied bias at 500 mV vs. Pt/Air-QRE, and 100 cc/min

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