

## Investigation of Gold Electrosorption onto Gold and Carbon Electrodes using an Electrochemical Quartz Crystal Microbalance

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### Abstract

The adsorption behavior of Au<sup>3+</sup> ions on metal electrodes has been studied using an electrochemical quartz crystal microbalance combined with the cyclic voltammetry technique. The experiments were carried out for HAuCl<sub>4</sub> using 0.1 mol·L<sup>-1</sup> HCl (pH~1) as a background electrolyte solution. The kinetics of electroreduction of Au<sup>3+</sup> ions on the rice husk based activated carbon and gold electrodes in chloride electrolytes by the cyclic voltammetry and the electrochemical quartz crystal microbalance with a variation of the scan rate in the range of 5–50 mV·s<sup>-1</sup> has been studied. The diffusion coefficient of Au<sup>3+</sup> ions for the tested solution on gold and carbon electrodes was determined by the cyclic voltammetry method on the basis of the Randles-Ševčík equation. It is found that electroreduction of gold goes via the discharge of AuCl<sub>4</sub><sup>-</sup> complexes to the formation of metallic gold with a current efficiency of 97–99%. The scanning electron microscopic images of the gold adsorbed carbon surface was taken to see gold particles and their morphology. In SEM images, it is clearly seen that the surface of carbon has a relief structure and gold has grown in the form of clusters. The smallest gold nanoparticles that could be examined were 100–250 nm in diameter on the surface of the carbon electrode.

## 1. Introduction

The electrochemical quartz crystal microbalance (EQCM) is a modern powerful method used in electrochemical experiments. EQCM monitors the change of frequency simultaneously with the electrochemical signal. The change in frequency is associated with changes in mass due to deposition or adsorption of a substance or dissolution of a substance from a working electrode [1].

The EQCM has been used simultaneously with quasi-steady state techniques like cyclic voltammetry (CV). Mass changes during electrolysis can be determined from A/(AmM) vs. potential curves, while A/(AmM) vs. charge density curves allow evaluating the number of Faraday exchanged per mole of electro-active species using Faraday's law of electrolysis. The change in the frequency of oscillation ( $\Delta f$ ) is sensitive to the change in mass de-

posited on the crystal surface ( $\Delta m$ ), thus meaning that any variation in the mass of the electrode will proportionally change the frequency at which the crystal oscillates [2]. The relationship between  $\Delta f$  and  $\Delta m$  is given by the Sauerbrey [3] Eq. (1):

$$\Delta f = -C_f \cdot \Delta m \quad (1)$$

where  $\Delta f$  is the change in frequency (Hz),  $C_f$  is the sensitivity factor of the crystal (0.0815 Hz·ng<sup>-1</sup>·cm<sup>-2</sup> for a 6 MHz at 20 °C) and  $\Delta m$  is the change in mass per unit area (g·cm<sup>-2</sup>).

$C_f$  is provided by Eq. (2), shown above, in which  $n$  is the number of harmonic at which the crystal is driven (this factor is set to 1, by design),  $f$  is the resonant frequency of the fundamental mode of the loaded crystal (Hz),  $\rho_q$  is the density of quartz (2.648 g·cm<sup>-3</sup>) and  $\mu_q$  is the shear modulus of quartz (2.947·10<sup>11</sup> g·cm<sup>-1</sup>·s<sup>-2</sup>).

$$C_f = \frac{2n \cdot f^2}{\sqrt{\rho_q \cdot \mu_q}} \quad (2)$$

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