

Optical and Electrochemical Sensing with Gold Nanoparticles

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Summary: Thin-film structures containing gold nanoparticles can be used to detect contaminants and target molecules in liquids by both optical and electrochemical means. An important stage in the development of sensors is the formation of a layer of gold nanoparticles with appropriate properties on the sensor surface. In the future, our aim is to develop a heavy metal detection sensor for easy evaluation of liquid samples at the sampling site. Such a technology would allow to reduce the logistical problems and time loss associated with the analysis of drinking water.

Keywords: electrochemistry, ellipsometry, gold nanoparticles, protein filaments, drinking water.

Motivation

Drinking water contaminated with heavy metal ions (especially arsenic) is a global health problem. We are working on sensor development related to this issue: using a new combined sensing device, it is possible to study the formation of gold nanoparticles during the formation of the layer using both optical and electrochemical techniques, and then to test the optical and electrochemical sensing in the same device. In this process, we create gold nanoparticles from solution in a controlled manner, using nanometre-sensitive optics to measure the surface area during layer formation, and then attach protein filaments capable of binding heavy metal (mainly nickel) ions to the sample after the appropriate layer has formed [1]. Special combined measuring cells and optical instruments are available for this work. Electrochemical experiments are carried out using cyclic voltammetry and chronoamperometry, while optical monitoring of the processes is performed using in situ ellipsometry. We evaluate the structural analysis of the resulting surfaces using scanning electron microscope images and energy-dispersive X-ray spectroscopy.

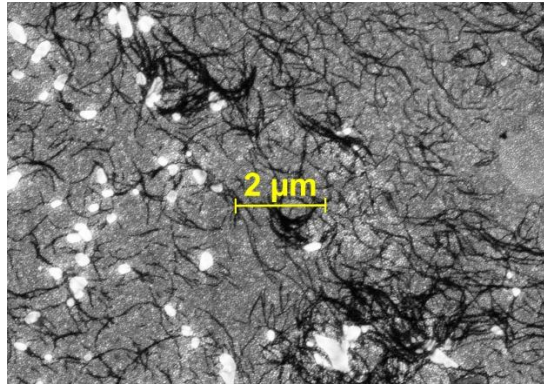


Fig. 1: SEM image of protein binding (1.25 mM, -450 mV sample) at 25000x magnification.

Results

Chronoamperometric technique is used for the deposition of gold nanoparticles in which we varied three main parameters - electrochemical potential, solution concentration and deposition time - to determine the optimal conditions for protein deposition. The results were evaluated using scanning electron microscopy imaging and a Matlab code processing ellipsometric data.

Afterwards, we carried out the deposition of the sensor protein using cyclic voltammetry. In addition to processing the data from real-time optical tracking in Matlab and analysing the electron microscopy images, we also evaluated the measurements by studying the voltammograms from electrochemical procedures. Finally, elemental composition analysis was used to declare with absolute certainty the presence of protein in the samples. We have gained useful knowledge that will enable me to carry out the initial steps necessary for the long-term goal of creating an effective heavy metal detection sensor for the on-site evaluation of liquid samples.

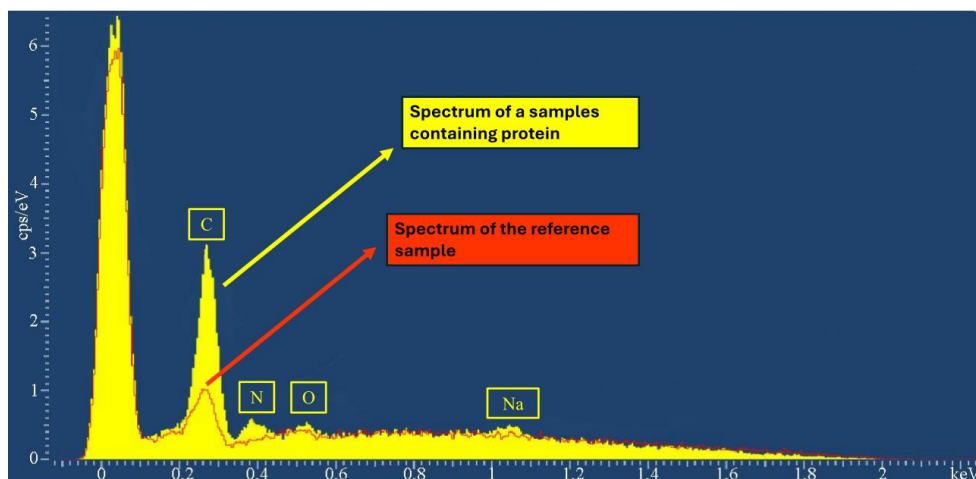


Fig. 2: Comparison of protein-treated and untreated surfaces by energy-dispersive X-ray spectroscopy.

References

- [1] Bakos Csaba J. (2022). *Diploma Thesis*. Budapest University of Technology and Economics, Faculty of Electrical Engineering and Informatics, Department of Electronics Technology.