

Voltamperometric manifestations of coherent multiple electron exchange by the gold-deposited sub-nanometer-thick bilayered quasi-excitonic films kept in contact with the electrolytic environments

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So called “liquid-type” voltamperometric (electrochemical) cells performing through the three-electrode configuration, in which the “working” electrodes may be coated by the atomically-determined 2D sub-nanometer films of different types (including the inorganic, organic, biomolecular, or hybrid origins), and kept in contact with the liquid-phase electrolytic environments, are the ideal systems for studying the electron transport and exchange physical mechanisms at, or near room-temperature conditions under the secure film preservation regime. The methodology of respective voltamperometric experiment is well-elaborated regarding both, the instrumental and data processing techniques, and the methodology-related theoretical background, as well, allows for a reliable determination of the targets’ key physical parameters such as: the surfacial concentration of redox-active species (such as the ions of transition metals, or redox-active proteins) immobilized inside or above the self-assembled monolayer films (SAMs), the total charge being exchanged, number of electrons being transported within the single act, the rate constant of charge transport, the medium’s reorganization energy, etc. In our earlier paper [1] we reported on the electron exchange system composed of Au-deposited SAMs made of L-cysteine (L-cys) molecules nearly saturated by SAM-coordinated, fully redox-active Cu²⁺ ions, capable of acting as individual (statistically independent) redox-probes transferring a single electron per elementary act.

Later on [2], for the same system we discovered the intrinsic conversion to the isomeric configuration capable of coherent exchanging multiple electrons, which was manifested through the spectacular transformation of the broad, single-electron related voltamperometric cathodic and anodic peaks to unusually sharp multielectro-related peaks. The careful cross-analysis, based on the combination of complementary rate theories and contemporary 2D spintronic issues [3] allowed for the tentative conclusion the SAM-immobilized Cu²⁺ ions, under certain (rather mild warming) conditions may form the quasi-1D clusters, [(L-cys-CO₂⁻)₂Cu²⁺]_m (where: m = 2, 4, ...10 ...), presumably ordered together through the spin-implicated Boson condensation [2,3]. The number of Cu species forming the abovementioned clusters determines a number of electrons capable of collective coherent exchange between the Au and Cu related layers within the SAM film vicinity. These two layers can be imagined as parts of the quasi-excitonic elements capable of exchanging bosonic clouds [3].

References:

[1] D. E. Khoshtariya *et al.*, J. Phys. D: Appl. Phys. **48** (2015) 255402; [2] D. E. Khoshtariya The 2nd ECMOLS Conference Abstracts, p. 77 (Peniscola, Spain; 21/24.10.2018); [3] P. Eisenstein, Ann. Rev. Cond. Matt. Phys., **5** (2014) 159.