Electrochemical switching for tunable devices

H. Randriamahazaka, C. Fave, Y. Leroux, G. Trippé, V. Noël, J-C. Lacroix.

Interfaces, Traitements, Organisation et Dynamique des Systemes (ITODYS),

Université Paris Diderot - Paris 7, CNRS UMR 7086, 1 rue Guy de la Brosse, 75005 Paris, France
randria@itodys.jussieu.fr

During the last two decades, there has been considerable interest for using organic materials in optical, electronic, and electromechanical devices. Among organic materials, conjugated polymers (CP) are proposed. One of the most important properties of CPs is their ability to switch upon chemical or electrochemical doping between two states with different electronic properties. Their electrochemical switching has been demonstrated to be an easy means for controlling the physico-chemical properties of grafted molecules [1], metallic nanoparticles [2], and thin film for actuators [3-4]. In our group, we investigate the effects of the medium on the switching dynamics of these systems. In this communication, we present the electrochemical switching of two types of devices: active plasmonic system and a monolayer junction based on conjugated oligomers.

Plasmonics is an emerging branch of photonics which uses nanostructured materials that support surface plasmons. Some metal nanoparticles such as gold are known to exhibit unique optical properties in the visible and Ninfrared due to excitation of surface plasmons. Lythographically designed nanoparticle arrays are model systems useful to investigate some of the factors that affect the frequency and shape of the plasmon resonance. Among plasmonic devices, filters, wave guides, polarizers and nanoscopic light source have been reported but active plasmonic systems such as switches and modulators are still lacking. Here, we report on new active molecular plasmonic devices in which the electrochemical switching of a nanometric film of conductive polymer between its reduced and oxidized state is used to control, switch and modulate the surface plasmon of gold nanoparticle arrays [2].

A monolayer junction based on conjugated oligomers with a well defined Metal/oligomer interface retaining reversible on/off switches capabilities controlled by the redox state of the conjugated oligomer would be of interest for molecular electronics. We report here the properties of ultra-thin organic films on glassy carbon (GC) or polycrystalline gold obtained by electroreduction of conjugated oligomer diazonium salts [1]. Electrochemical behaviours of these modified GC electrodes toward reversible outer sphere redox species are not usual. No current is observed in the potential range where redox probe reactions on bare electrodes usually occur. The organic layer totally blocks the electrode in such a potential window. Above a threshold potential, the current dramatically increases and an “irreversible” wave is observed. This peculiar electrochemical response will be discussed in term of various mechanism and we will show that the observed results reveal that this new organic electrode reversibly switch between conducting and totally blocking states with a threshold voltage which can be tuned by nature of the molecule used.

References

[1] Leroux, Y. R.; Lacroix, J. C.; Chane-Ching, K. I.; Fave, C.; Felidj, N.; Levi, G.; Aubard, J.; Krenn, J. R.; Hohenau, A. *J. Am. Chem. Soc.*, **2005**, *127*, 16022- 16023.

[2] Fave, C.; Leroux, Y.; Trippe, G.; Randriamahazaka, H.; Noel, V.; Lacroix, J.-C. *J. Am. Chem. Soc.*, **2007**, 129, 1890-1891.

[3] Randriamahazaka, H.; Plesse, C.; Vidal, F.;, Gauthier, C.; Teyssié, D.; Chevrot, C. *Proceeding of SPIE, The International Society for Optical Engineering in elecroactive actuators and devices*, **2004**, 5385, 294-301.

[4] Otero, T. F.; Grande, H-J.; Rodriguez, J. *J. Phys. Chem. B*, **1997**, 101, 3688-3697.