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Replicating biological functions from multistep electrochemical molecular machines

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Human and animal muscles sense while working mechanical, thermal or chemical working conditions: they are haptic muscles. Currently the origin and nature of the sensing signal has not been clarified. While most of the researchers try to clarify this dual activity have been focused on the localization of the different physical sensors working in a muscle [1], some researchers suspect that the actuating reaction is the origin of some sensing signals sent back to the brain [2].

Electrochemical reactions of conducting polymers, and other electroactive materials, sense the working conditions, mimicking many biochemical reactions involving macromolecules as reactants and originating biological functions. Our group has been working from the end of the past century on the sensing properties of the electrochemical reactions of conducting polymers, carbon nanotubes or graphenes [3]. While the sensing properties have been demonstrated empirically using different dual sensing/actuating devices based on conducting polymers (smart membranes, smart windows, artificial muscles..) [4] the origin and nature of the sensing signal has not been clarified yet.

It is our aim to do a deep study of the electrochemical reactions involving this multistep macromolecular machines, in order to demonstrate that the sensing signal is an inherent property of the reversible electrochemical reactions involving conducting polymers during actuation. Formulating a new sensing principle by similitude with the Le Chatelier and Nerst sensing principles for chemical or electrochemical equilibrium: any change or perturbation of the reaction energetic conditions is sensed by the energy consumed during the reaction.

In order to achieve our aims, a deep study of the response during actuation of polypyrrole film coating a platinum electrode under different chemical, electrical and thermal perturbations will be performed. The polymeric material will be submitted to potential sweeps, potential square waves and current square waves in order to determinate the evolution of the potential reached, current peak and consumed charge while actuating in diverse working environment, getting the energy consumed by the electrochemical reaction as a sensing magnitude. Finally a deeper study is programmed to do using different materials, as well as different electrolyte and solvent. The new theoretical description would clarify the electrochemical origin of the dual sensor and actuator nature of this biomimetic materials, and inspires the development of new dual sensing/actuating devices.

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