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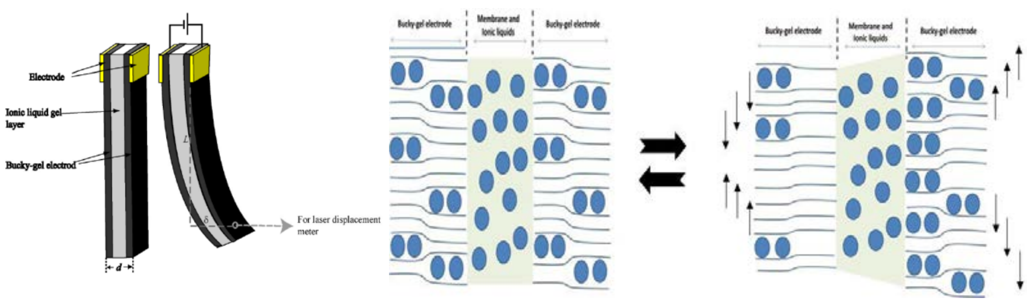
Chemo-Electro-mechanical Model for Electrochemical Actuators

Much attention has been focused on soft materials that can transform electrical energy directly into mechanical work, because they allow a wide range of applications including actuators and artificial muscles, and micro- and nano-electromechanical systems. Herein, the interplay of mechanical and electrochemical effects within various flexible electrochemical systems is analyzed. In these systems, the double-layer formation plays a crucial role because the local concentration of ions controls the volume change of the flexible electrode.

We have investigated various kinds of electrochemical actuators based on bucky-gel containing carbon nanotubes [1-2], and interpenetrating conducting polymer networks [3], containing ionic liquids by means of electrochemical impedance spectroscopy and bending displacement measurements [4]. We developed theoretical model to rationalize the electromechanical properties of flexible electrochemical systems. The model takes into account the electrochemical stress due to the intercalation (de-intercalation) process which generates the strain and bending of the actuators. The relationship between the strains and the real part of the complex capacitance by introducing the strain-capacitance coefficient ξ_C. This coefficient is related to the electrochemical stress and the amount of the ionic adsorption (desorption) at the double-layer [1-2]. Also, two new parameters are introduced and determined experimentally: the strain-potential coefficient ξ_V and the electromechanical coefficient Δ_{e-m}. This theoretical model provides a thermodynamic explanation of the mechanical deformation (strain) due to the surface stress associated to the ionic intercalation [3]. The proposed model can be considered as a new tool allowing the rationalization and the improvement of electrochemical actuator design.



References:

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2. H. Randriamahazaka, K. Asaka, *Faraday Discuss*., 2017, 199, 405-422.
3. C. Plesse, F. Vidal, H. Randriamahazaka, *in preparation*.
4. H. Randriamahazaka, K. Asaka, *J. Phys. Chem. C*, 2010, 114, 17982-17988.

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