

Strain Measurements on Polypyrrole Actuators in Aqueous Electrolytes

M.J.M. Jafeen^{1*} and M.A. Careem²

Department of Physical Sciences, South Eastern University of Sri Lanka.

Department of Physics, University of Peradeniya, Sri Lanka.

Corresponding Author: jafeenmi@seu.ac.lk

Polypyrrole films doped with the large immobile dodecylbenzene sulfonate anions, (PPy/DBS) films, have been prepared electrochemically on stainless steel electrode and peeled off to obtain free standing actuator strips. The actuator films operating in aqueous electrolytes of NaCl having concentrations ranging from 0.02 M to 4 M have been characterized by simultaneous cyclic voltammetry driven force-displacement measurements in order to investigate the effect of actuation frequencies of the system on the strain of the films. The mechanism of actuation in this type of actuators is the insertion/expulsion of counter ions, accompanied by a large number of water molecules, as the polymer is redox cycled between the reduced and the oxidized states. The expansion and contraction of the films during the redox process were measured under isotonic conditions at various actuation frequencies. The strain variation as a function of actuation frequency follows the same general pattern in all concentrations used and has three distinct regions. The strain is high and remains constant at low frequencies (< 0.002 Hz) whereas smaller and again remains constant at higher frequencies (> 0.1 Hz). At mid frequencies, the strain decreases considerably. These strain variations can be explained based on the two categories of water molecules that accompany the cations during the redox process: a smaller number strongly bound to the cation (corresponding to the inner solvation shell) and a larger number entering the film after the insertion of the cations because of forces related to osmotic pressure difference. The two processes have very different time constants: The solvated 1--120 molecules are associated directly with the cations, and are therefore inserted in a faster process, whereas the second type enters the film much more slowly.

Keywords: Polypyrrole, Actuator, Solvation shell, Cyclic voltammetry.