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BILAYER ACTUATORS (ARTIFICIAL MUSCLES) BASED ON POLYPYRROLE

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Various conducting polymers, including polypyrrole (PPy), undergo significant dimensional changes upon electrochemical doping (oxidation) and dedoping (reduction). These changes are linked with the movement of ions and solvents in and out of the polymer during those processes. The conformational changes occurring here are reversible and it has been suggested that this behaviour can be applied in a range of devices such as electrochemically driven mechanical actuators (artificial muscles), micro-structures. These artificial muscles are termed as electrochemomechanical actuators since they work with electric pulse which generate the electrochemical reaction ultimately converted into mechanical energy.

In this work, we report about the fabrication of a bilayer artificial muscle with conducting polymer as active layer and a non-conducting polymer as the passive layer. Force measurements were done using the bending beam method, which was used to study the volume changes in the conducting polymer phase in bilayers. Preparation of the artificial muscle was done by electrochemically polymerizing a pyrrole film on a 25 μm thick polyimide film (size 20 x 5 mm) which was coated with 250 Å gold layer to get electrical contacts. Polymerization of pyrrole was done in an aqueous solution containing 0.05 M pyrrole and 0.05 M sodium dodecylbenzenesulfonate (SDBS). Force measurements were done using a microbalance simultaneously with cyclic voltammetry in an aqueous electrolyte of 0.1 M $NaClO_4$. To examine the effect of the film thickness and the polymerization current density on the force, films were prepared with different current densities and with various thicknesses. PPy films were electrochemically deposited on the quartz crystal microbalance electrode to understand the mass change during oxidation and reduction of these films.

The force measurement results showed that the films made with higher current densities have larger forces than the films made with lower current densities. They also clearly demonstrated that with the increment of the PPy film thickness, the resultant force showed an increasing trend. When the force measurements are compared with cyclic voltammetry, it is possible to conclude that the force changes are associated only with main peaks of the cyclic voltammogram. The other interesting feature is that most of the force changes occur in a narrow potential window, which is an advantage in the applications. The results obtained with quartz crystal microbalance showed that during oxidation and reduction 10-20 water molecules co-intercalated to PPy/DBS film with each cation move in and out.