# Life Time of Trilayer Actuators Based on Polypyrrole

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Artificial muscles based on polypyrrole films doped with $ClO_4^-$ had demonstrated movements up to 180 degrees in $LiClO_4$ aqueous solution which are controlled through the applied electrical current. Movements of this type are achieved with currents from 10 mA. The current density and its polarity control the rate and the movement´s direction of the artificial muscle[1, 2]. Besides, bilayer and trilayer devices based on this polymer ($PPy(ClO_4^-)$) had shown be able to work as sensors of temperature and electrolyte concentration, among others[3].

In order to exploit the interesting properties of this polymer as artificial muscle and to develop devices able to carry out more complex movements, it is necessary to evaluate its life time under different conditions. A trilayer ($PPy(ClO_4^-)$/adhesive layer/($PPy(ClO_4^-)$) (2 cm long, 1.5 cm wide, 6 mg and 13 μm thickness each PPy film) was subjected to a constant current density to move it in consecutive angles of 180 degrees in 1M $LiClO_4$ aqueous solution. The actuation of the trilayer was interrupted when a crack across each film was formed; this crack was placed on the air-solution interface. This crack blocked the electrical energy between the potentiostate and the trilayer. However, the integrity of the films was maintained since the movements were continued when the electrical contacts were replaced below crack. The movement´s characteristics of the trilayer are maintained when the electrical contacts are relocated.

The evaluated trilayers showed an average life time of 112 cycles of 180 degrees. Approximately, from the 70-cycle the electrical potential through the trilayer began to increase with the cycles number. However, the electrical charge and the movement rate related to all cycles were constant. The life time of the trilayer is limited by the fatigue of the PPy films which is showed as a crack placed on the area with higher strains that is where the trilayer is bent. To decrease the strains in the PPy films, the way to improve the adhesion between the adhesive layer and the films was studied. The evaluation of different adhesive types between the two PPy films showed an increase in the life time of the trilayer up to 477 cycles. The life time of these trilayers is also limited by the formation of a crack in the interface air-solution. Also, the actuation properties of the trilayer are maintained when the electrical contacts are relocated.

[1] T. F. Otero, E. Angulo, J. Rodríguez, and C. Santamaría, *J.Electroanal.Chem.* 369 (1992) Electrochemomechanical properties from a bilayer: polypyrrole/non-conducting and flexible material, artificial muscle.
[2] T. F. Otero and M. T. Cortés, *Chem.Commun.* 284 (2004) Artificial muscle: movement and position control.
[3] T. F. Otero and M. T. Cortés, *Sensor and Actuators B* 152 (2003) A sensing muscle.