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Nanoporous Carbide-Derived Carbon Material-Based Linear Actuators

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Devices using electroactive polymer-supported carbon material can be exploited as alternatives to conventional electromechanical actuators in applications where electromechanical actuators have some serious deficiencies. One of the numerous examples is precise microactuators. In this paper, we show for first time the dilatometric effect in nanocomposite material actuators containing carbide-derived carbon (CDC) and polytetrafluoroetylene polymer (PTFE). Transducers based on high surface area carbide-derived carbon electrode materials are suitable for short range displacement applications, because of the proportional actuation response to the charge inserted, and high Coulombic efficiency due to the EDL capacitance. The material is capable of developing stresses in the range of tens of N cm^{-2}. The area of an actuator can be dozens of cm^2, which means that forces above 100 N are achievable. The actuation mechanism is based on the interactions between the high-surface carbon and the ions of the electrolyte. Electrochemical evaluations of the four different actuators with linear (longitudinal) action response are described. The actuator electrodes were made from two types of nanoporous TiC-derived carbons with surface area (S_A) of 1150 m^2 g^{-1} and 1470 m^2 g^{-1}, respectively. Two kinds of electrolytes were used in actuators: 1.0 M tetraethylammonium tetrafluoroborate ($TEABF_4$) solution in propylene carbonate and pure ionic liquid 1-ethyl-3-methylimidazolium trifluoromethanesulfonate (EMITf). It was found that CDC based actuators exhibit a linear movement of about 1% in the voltage range of 0.8 V to 3.0 V at DC. The actuators with EMITf electrolyte hadabout 70% larger movement compared to the specimen with $TEABF_4$ electrolyte.

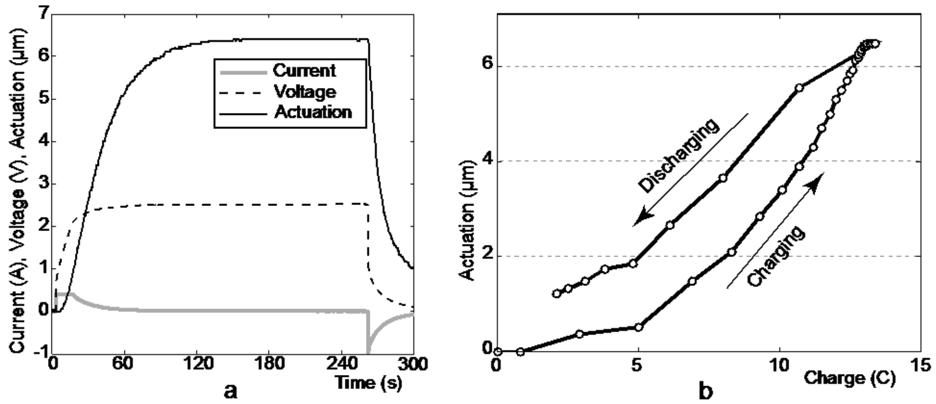

Fig.1. Voltage and current characteristics of linear actuator (I = 1000 mA, V = 2.5 V). Actuation, voltage and current vs. time (a) and actuation vs. charge (b).

Keywords: porous carbon; ionic liquid; carbide-derived carbon; electroactive polymer (EAP) actuator