Conducting IPNs based electrochemical actuators:

from polymer chemistry to devices

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The synthesis of electronic conducting interpenetrating polymer networks is proposed as an alternative to multilayer architectures for the design of electroactive devices [1]. The electronic conducting polymer (ECP) poly(3,4-ethylenedioxythiophene) (PEDOT) as Electroactive Polymer (EAP) was symmetrically distributed in a solid polymer electrolyte (SPE) matrix based on poly(ethylene oxide) (PEO) and Nitrile Buradiene Rubber (NBR) which was subsequently swollen with ionic liquid [2]. Therefore conducting IPN properties are determined mainly by three material characteristics, the CP content in the device, the SPE ionic conductivity and the mechanical properties of the IPN material. Material improvements are one of the key enabler for further progress in electro-mechanical or electro-optical performances.

In this lecture we present the synthesis of conducting IPN devices based on high molecular weight NBR, PEO derivative and PEDOT. Conducting IPNs were prepared by oxidative chemical polymerization of EDOT into the PEO/NBR IPN. This procedure allows an inhomogeneous distribution of PEDOT across the sample thickness, i.e. the concentration decreases from the outside towards the center, leading to a very poor connectivity of PEDOT inside the bulk of the SPE. After swelling with an ionic liquid and applying an alternative low voltage between the two sides of the film, this device can work as an actuator or an electroemissive device according to the ECP content [1]. Such a device possesses some advantages compared with a multilayered device: easier elaboration, perfect adherence between layers, high ECP/SPE interface and no delamination.

Conducting IPN behaves as an actuator when the PEDOT content (i.e. the electroactive polymer) is higher than 7w%, typically between 10 to 30wt%. Actuators with a thickness ranging from 250 to 10 µm were obtained [3]. Actuation performances under electrical stimulus have been characterized in open air in a two electrode configuration. Conducting IPN actuators exhibit a maximum strain value of 1% with an output-force of 30 mN. Moreover, mechanical sensor behavior of this EAP material has been studied. Voltage response has been observed when a mechanical stimulus is applied. The sensor was able to measure strain up to an applied deformation frequency of 10Hz [4]. As expected, when the actuator thickness is decreased the actuation frequency increases. Ultrathin actuators can operate at high frequency (above 100Hz) while producing a large displacement at the mechanical resonance [5]. Actuation results of micro and macro-actuators will be presented as well as the integration of these materials into two biomimetics perception prototypes [6]

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