Conducting Ipn Based Actuators. From Ipn Characterizations To Actuators

Cédric Plesse[a], Guillaume Palaprat[a], Jonathan Juger[a], Johan Citerin[b], Frédéric Vidal[a], Abderrhamane Kheddar[b], Dominique Teyssié[a], Claude Chevrot[a]

[a] Laboratoire de Physicochimie des Polymères et des Interfaces, EA 2528, Université de Cergy-Pontoise, 5 mail Gay-Lussac, Neuville sur Oise, 95031 Cergy-Pontoise cedex, France
[b] Laboratoire Systèmes Complexes, CNRS-UEVE, Université d'Evry, CE 1433 Courcouronnes, 40 rue du Pelvoux, 91020 Evry Cedex, France
e-mail: frederic.vidal@u-cergy.fr

Interpenetrating polymer networks (IPNs) have been developed for many years leading to materials with controlled properties [1]. When an electronic conducting polymer (ECP) is incorporated in an IPN, this one becomes a conducting IPN (CIPN) and can reveal interesting stimulus responsive behavior under application of a low electrical voltage [2].
CIPNs actuators were designed in order to solve the interface and adhesion problems which have been reported in the design of classical conducting polymer based actuators. The synthetic pathway ensures a gradual dispersion of the ECP through the thickness of the material. The system is thus similar to a layered one with the advantage that the intimate combination of the three polymers needs no adhesive interface. The last step in making the conducting IPN into an actuator is to ensure the ionic conductivity by incorporation of an ionic salt [3].
Poly(ethylene oxide) (PEO) based IPNs could represent an interesting medium as solid polymer electrolytes (SPEs). For instance in a PEO/PB IPN, the PEO partner acts as the SPE in the presence of salt whereas the polybutadiene network ensures convenient mechanical properties as the damping properties. In this work the cross-linked PEO is formed through a radical copolymerization of poly(ethylene glycol) methacrylate (PEGM) and poly(ethylene glycol) dimethacrylate (PEGDM) while the cross-linked PB results of a polyaddition on isocyanate groups of Desmodur N3300 from alcohol groups of a hydroxytelechelic polybutadiene.
The highest ionic conductivity through the SPE-IPN matrix is necessary in order to ensure the best actuation of CIPN actuators. The ionic conductivity measurements will be presented for ionic liquid swollen PEO/PB IPNs. The chosen ionic liquid is 1-ethyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide (EMImTFSI). Various PEO/PB IPNs have been synthesized by careful tuning of the proportion of each polymer partner, the cross-linking density of the PEO network and the degree of interpenetration. Thus, the ionic conductivity has been measured at various temperature for a series of EMImTFSI swollen (PEO/PB) SPE-IPN matrixes. CIPN actuators have been optimized using the best SPE-IPN.
However attractive can be a bending actuator, probably more interesting would be to realize a polymer actuator endowed with a linear actuating ability in air and exhibiting displacement amplitude and/or output force as high as possible because it would suit more applications including robotic and biomedical fields. Two ways have been investigated:

- The first one, starting from an IPN film, is to design actuators displaying a bistable mechanism. This new actuator has shown a linear deformation under low voltage [4].
- The second one is to design the CIPN actuators as a fibre. The actuation characteristics will be detailed during the presentation.

References:

[1] Sperling LH, Klempner D, Utracki LA, editors. Interpenetrating Polymer Networks, 1994 American Chemical Society, Washington:
[2] F. Vidal, J-F. Popp, C. Chevrot, D. Teyssié, Proceedings of SPIE, The International Society for Optical Engineering in electroactive polymer actuators and devices. **2002**, 95, 4695
[3[F. Vidal, C. Plesse, D. Teyssié, C. Chevrot, *Synthetic Metals*, **2004**,142, 287.
[4] F. Vidal, C. Plesse, G. Palaprat, A. Kheddar, J. Citerin, D. Teyssié Cl. Chevrot, *Synthetic Metals*, **2006**,156, 1299.