Conductivity of electrochemical synthesized polyfurane/perchlorate doped films

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In the first experimental study of conductivity of polyfurane, Tourillon and Garnier[1] established that doped PFu reached a conductivity value between 10 - 80 $S\cdot cm^{-1}$ at room temperature. However, Oshawa et al[2]. did not reproduce these conductivity values, they found lower values ($\sigma = 10^{-5}$ $S\cdot cm^{-1}$). They established that the conductivity depended on the water content. Some years later, Zotti et al[3] synthesized polyfurane films doped with BF_4^- with a conductivity value of 10^{-3} $S\cdot cm^{-1}$.. Demirboga et al.[4] found that the conductivity of PFu doped films was depended on the temperature. But not so much work it has been done until now.

The aim of this work is to study the influence of the temperature and humidity on the conductivity of the polyfurane perchlorate doped films, PFu/ClO_4, in order to clarify this discrepancy of values.

Polyfurane films doped with perchlorate anions, PFu/ClO_4, were potentiostatically generated onto platinum electrodes at η_p = 2.55 V (Ag/Ag^+) during 600s. Details of the electrochemical synthesized are described elsehere[5].

The conductivity measurements were made by complex admittance spectroscopy using a 4284-A Hewelett Packard, controlled by a computer connected to the analyzer by a IEEE interphase. All measurements were carried out over the platinum electrode, no film was taken out to avoid the contact problems provoked by the roughness of the material.

The analysis of the conductivity at different temperatures (from –57 to 149ºC) in a constant nitrogen flux revealed the PFu/ClO_4 films were few conductors. Its conductivity values changed from 10^{-7} to 10^{-9} $S\cdot cm^{-1}$ depending on the temperature. From room temperature to 80ºC the conductivity belonged constant, but at higher temperatures (from T > 80ºC until 150ºC) its increased strongly. The conductivity is proportional to $T^{-1/4}$ in the temperature range what suggest a hopping conductivity mechanism. Similar results were found in polypyrrole[6], poly(N-methylpyrrole)[7] and poly(N-alkylanyline)[8].

PFu/ClO_4 films presented an increase of three orders of magnitude when the conductivity was measured at air instead of in a flux of nitrogen. However, after bubbling nitrogen during three minutes the conductivity stabilized, no important changes were found. This behaviour of the conductivity could be related with the morphology of PFu/ClO_4 films. They presented a nodular interlinked laminar structure with holes among layers. The different layers were connected among them by a perpendicular growth to the substrate. When films are measured at nitrogen flux, the electronic conductivity is the only one that appeared, being so small due to the structure of PFu films. When the conductivity were measured at the air, it increased due to the humidity that exists in the film. This indicates that exits an ionic conductivity besides of the electronic one. This fact was previously established by T. Oshawa[2] which indicated the possibility of used poyfuran as humidity sensor.

REFERENCES

1. G. Tourillon, F. Garnier, J. Electroanal. Chem., 135 (1982) 173.
2. Oshawa, K. Kaneto, K. Yoshino, Jpn. J. Appl. Phys. 23 (1984) L663.
3. G. Zotti, G. Schiavon, N. Comisso, A. Berlin, G. Pagani, Synth.Met., 36 (1990) 337.
4. B. Demirboga, E. Middle, J. Phys. and Chem. of solids, 61 (2000) 907.
5. I. Carrillo, C. Barba, M.J. González-Tejera and I. Hernández-Fuentes, Macromolecules, 29 (1996) 5585.
6. L. Zuppiroli, M.N. Bussac, S. Pachen, O. Chauvet, L. Forro, Phys. Rev., 50 (1994) 5196.
7. A. Lian, S. Besner, L.H. Dao, Synth. Met, 74 (1995) 21.
8. R. Sigh, A.K. Narula, R.P. Tando, A. Mansingh, S. Cahandra, J. Appl. Phys., 79 (1996) 1476.