



HAL
open science

Impedance spectroscopy of hybrid peptidic homopolymers/platinum nanoparticles assemblies

Louis Merle, G Manai, Adeline Pham, Sébastien Lecommandoux, P Demont, Colin Bonduelle, Simon Tricard, Adnen Mlayah, Jérémie Grisolia

► To cite this version:

Louis Merle, G Manai, Adeline Pham, Sébastien Lecommandoux, P Demont, et al.. Impedance spectroscopy of hybrid peptidic homopolymers/platinum nanoparticles assemblies. EMRS 2021, Sep 2021, Strabsourg, France. hal-04811884

HAL Id: hal-04811884

<https://hal.science/hal-04811884v1>

Submitted on 29 Nov 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution - NonCommercial - ShareAlike 4.0 International License

Impedance spectroscopy of hybrid peptidic homopolymers/platinum nanoparticles assemblies

Submitted to symposium S : Organized nanostructures and nano-objects: fabrication, characterization and applications V of the E-MRS 2021 Fall Meeting, which will be held at in a virtual format from September 20 to 23, 2021..

L. Merle, G. Manai, A. Pham, S. Lecommandoux, P. Demont, C. Bonduelle, S. Tricard, A. Mlayah, J. Grisolia

Affiliations :

LPCNO, Université de Toulouse, INSA, CNRS, UPS, 135 Avenue de Rangueil, Toulouse 31077, France;

Laboratoire de Chimie des Polymères Organiques, Université de Bordeaux, CNRS, Bordeaux, INP, Pessac, France;

CIRIMAT, Université Toulouse - Paul Sabatier, 118 Route de Narbonne 31062 Toulouse; Laboratoire de Chimie des Polymères Organiques, Université de Bordeaux, CNRS, Bordeaux, INP, Pessac, France;

CEMES, Université de Toulouse, CEMES-CNRS, 29 rue Jeanne Marvig, Toulouse 31055, France;

Abstract :

Hybrid materials combining metallic nanoparticles (NPs) and polymers has stimulated a large effort to make new optical, electronic and magnetic [1, 3] properties emerging. Such composite nanomaterials have the potential of improving the functionality of devices ranging from information storage to microelectronic sensors [4,5]. In this context, hybrid nanomaterials combining platinum (Pt) nanoparticles (NPs) and poly(α -benzyl-L-glutamate) (PBLG) in alpha helix conformation were investigated by in situ alternative-current impedance spectroscopy as a function of temperature, applied DC bias voltages and PBLG polymerization degree.

TEM images of the hybrid materials show a lamellar structure, made possible by Pt, whose organization depends on the degree of polymerization. The corresponding Nyquist's plots generated from the impedance spectroscopy data show that for each degree of polymerization, a perfect semi-circle typical of an equivalent electrical circuit consisting of parallel resistance R and capacitance C plus a series resistance R_s is observed. The R and C values are obtained using a fitting procedure. This procedure allows determining the relaxation time constant, which is interpreted as the characteristic time of a dipolar relaxation process. Variations of τ with temperature are well described by Arrhenius's law which allows to extract the activation energy of the relaxation process. We found that the activation energy is around 0.1 eV whatever the DP of the PBLG. It is comparable to the stretching vibration energy of the CN bond in PBLG, which is in favor of a conduction process involving polaronic coupling and hopping.

The evolution of the activation energy with applied DC Bias voltage and the polymerization degree reveals a piezo-electric effect induced by the presence of the Pt NPs. This piezo-electric effect is not present in the pure PBLG reference sample and is due to the orientation of the dipoles carried by the α helix and to the lamellar structure of the hybrid Pt-PBLG nanomaterial.

We will discuss the obtained results and show that impedance spectroscopy under applied DC bias is able to address the physics of dipole relaxation and charge carrier dynamics in polymer/nanoparticle nanostructured hybrid materials.

References:

1. Kao, J., Thorcelsson, K., Bai, P., Rancatore, B. J. & Xu, T. Toward functional nanocomposites: taking the best of nanoparticles, polymers, and small molecules. *Chem. Soc. Rev.* 42, 2654-2678 (2013).
2. Mei, S., Staub, M. & Li, C. Y. Directed nanoparticle assembly through polymer crystallization. *Chem. Eur. J.* 26, 349-361 (2020).
3. Yi, C., Yang, Y., Liu, B., He, J. & Nie, Z. Polymer-guided assembly of inorganic nanoparticles. *Chem. Soc. Rev.* 49, 465-508 (2020).
4. Huynh, W. U., Dittmer, J. J. & Alivisatos, A. P. Hybrid nanorod-polymer solar cells. *Science* 295, 2425-2427 (2002).
5. Balazs, A. C., Emrick, T. & Russell, T. P. Nanoparticle polymer composites: where two small worlds meet. *Science* 314, 1107-1110 (2006).