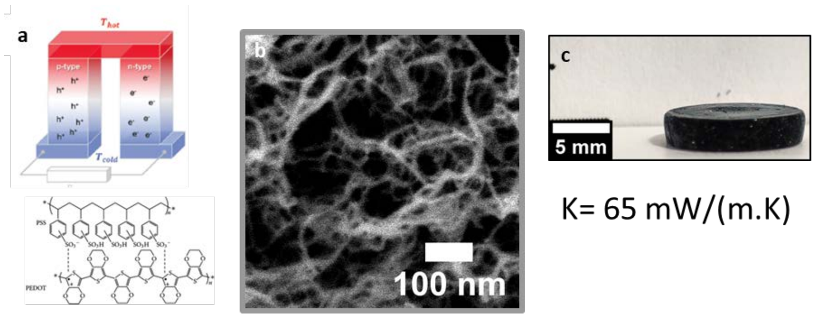
Conducting porous polymer for thermoelectric applications

PHD SUPERVISOR: Dr HDR Laure Biniek
INSTITUT CHARLES SADRON – STRASBOURG
WEBPAGE
TEL: 03.88.41.41.78 ; E-MAIL: laure.biniek@ics-cnrs.unistra.fr

Context: What if body heat could power wearable devices, medical monitors and watches with ultralight, cheap and flexible thermoelectric devices? In principle, this could be achieved with conducting polymers which are capable to convert temperature differences to voltage bias via the Seebeck effect. Thermoelectric efficiency is evaluated by its figure of merit expressed by $ZT = S^2\sigma T/\kappa$ (T: absolute temperature, S: Seebeck coefficient, σ: electrical conductivity, κ thermal conductivity). Most of the research in litterature focusses on increasing σ, although it is equally important to minimize *κ*.[1] Inspired by the aerogels, that are very efficient thermal insulators because of their porosity, we aim at introducing the same porosity into conducting polymeric materials to minimize *κ*. As we have recently demonstrated it, a mesoporous PEDOT:PSS aerogel exhibits thermal conductivity four times lower than the dense film counterpart while maintaining sufficient electrical conductivity (see figure).[2]

Description. This project aims at developing new porous conducting polymers, based on thiophene derivatives, more thermoelectrically efficient. A special attention will be dedicated in improving the Seebeck coefficient ; blends of semi-conducting polymers with complementary density-of-states or with high dielectric constant will be investigated.[3] The porous materials will be prepared by gelation of the polymers in a solvent followed by drying. The mechanism of the gelation is essential to control the formation of a strong 3D network which will conduct the electrical charges. It will be studied by a combination of cryo-electron microscopy (cryo-TEM and cryo-SEM), X-Ray scattering and rheology experiments. The geometry and the size of the pores will be controlled by the nature of the solvent and the drying techniques (ice-templating, freeze-drying or supercritical drying). Thermoelectric performances will be measured as a function of the porous structure, polymer blend ratio and doping mechanism. Ultimately, we plan to gain insights into the structure–properties relationship to better design this new class of functional materials for energy applications.



a) Schematic of a thermoelectric generator; Chemical structure of conducting PEDOT :PSS polymer. b) SEM image of the inner porous structure of the PEDOT :PSS aerogel. c) Aerogel image.

References: [1]. Weinbach et al. J. Mater. Chem. C, 2021,9, 10173-10192 ; [2] Weinbach et al., Frontiers in Electronic : Thermoelectric material, 2022, accepted [3] Zuo, G., et al., Adv. Electron. Mater. 2019, 5, 1800821.

Possible starting date: October 2022

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