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Tuning the pore morphology of conducting polymer gels to develop bulk and lightweight thermoelectric materials

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Abstract

Thermoelectricity effect depends on the temperature difference between two conducting materials which results in electrical voltage. It has important applications such as converting waste heat into energy. Conducting polymers, in thin films, have shown great potential as thermoelectric materials. However, controlling the temperature difference is rather difficult when nanometer-thick films are utilized. Here, we attempt to solve this issue by developing these materials in the form of porous bulk gels which have good thermal insulating property [1], [2]. Hence, combining these properties which are offered by a π-conjugated polymer with 3D porous architecture can be an alternate strategy to develop bulk lightweight thermoelectric generator.

In this study, three different conductive porous architectures based on poly(3,4-ethylenedioxythiophene): poly(styrenesulfonate) (PEDOT: PSS) were designed and characterized by a multiscale and correlative approach using microscopy (TEM/SEM/Cryo-SEM) and spectroscopy techniques. First, PEDOT: PSS gels were prepared by acid treatment [3] of the colloidal dispersion that leads to formation of nanofibers and their entanglement into a 3D network as shown in Figure 1 (A). Next, the solvent in the gels were extracted in different environments such as supercritical, sublimation and ambient conditions to yield porous structures in the form of aero-/cryo-/xero-gels [Figure 1(B-D)]. Overall, aerogels conserve the native structure of the wet gels, while cryogel form honeycomb like structure and its orientation/direction can be further tuned by ice-templating routes. Finally xerogels- leads to collapse of the entire network due to uncontrolled capillary tension between the walls. We demonstrated that the pore structure and size can thus be tailored from 30 to 300 µm, influencing thermoelectric properties. Here, we aim at discussing the limits and/or the key parameters of the drying techniques to control the porous structure and their impact on the TE properties of the PEDOT: PSS dried gels.

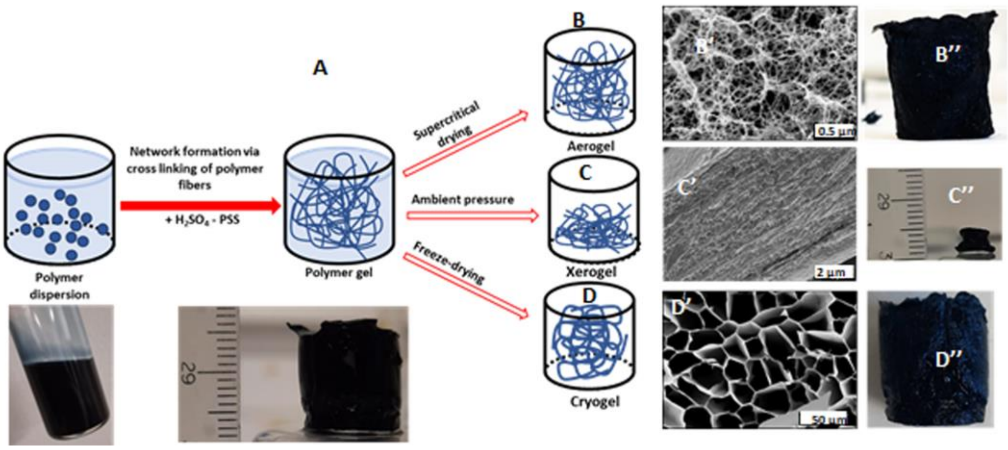

Figure 1: Schematic of polymer gels formation and the variety of porous structures obtained upon drying (B'C'D': SEM images)

References

1) N. Hüsing, U. Schubert, Angew. Chemie - Int. Ed. 2007, 37, 22.
2) M. Noroozi et al, ACS Appl. Energy Mater. 2019, 2, 5319.
3) B. Yao, H. Wang, Q. Zhou, M. Wu, M. Zhang, C. Li, G. Shi, Adv. Mater. 2017, 29, 1700974.