INV13

Controlling volume and mechanical properties of polythiophenes via electrochemical doping

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1. Introduction

The properties of organic mixed ionic-electronic conductors such as conductivity, volume and even mechanical properties can be tuned via electrochemical doping. These dynamic processes rely on exchange of ions with the surrounding electrolyte combined with injection or extraction of electronic carriers through the addressing electrode. Polythiophenes with glycol side chains are single component OMIECs where the glycolated chains facilitate the ion transport. We demonstrated that a polythiophene with tri-ethylene glycol side chains reversibly expands by 300% upon electrochemical addressing, relative to its previous contracted state, while the first irreversible actuation can achieve values of 10000%, outperforming any other conjugated polymers [1]. Here I will present our findings on how the molecular structure impacts the volume change based on a study with series a of polythiophenes that differ in the length and/or in the distribution of the ethylene glycol side chains [2]. Furthermore, I will discuss the effect of the electrolyte and molecular design not only on the volume change but also on the mechanical properties of the polymer. Molecular Dynamics also provide insight on the mechanisms involved at the nanoscale correlating the volume changes with ion and water molecule intercalation to the polymer matrix as well as conformational changes of the polymer chains. Finally, I will preset our results on applying these materials for dynamic microfiltration [3] and drug delivery.

2. Figures

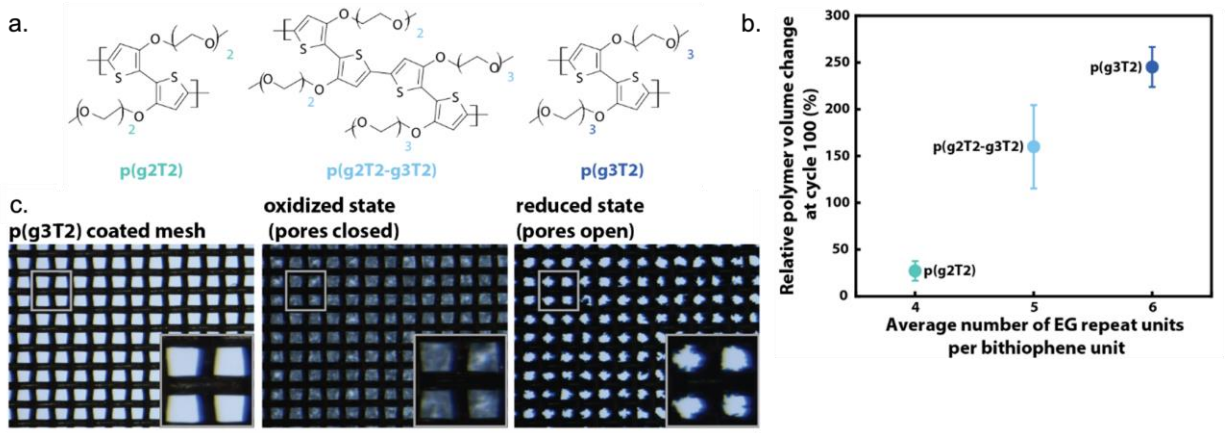

Figure 1: a. Chemical structure of a series of polythiophenes with ethylene glycol side chains. b. Relative volume increase at the 100th electrochemical cycle of the polythiophenes under study. c. Filter with tuneable porosity at the microscale based on a metallic mesh coated with p(g3T2).

3. References

[1] "Reversible electronic solid-gel switching of a conjugated polymer" J. Gladisch†, E. Stavrinidou†*, S. Ghosh, A. Giovannitti, M. Moser, I. Zozoulenko, Iain McCulloch and M. Berggren* Advanced Science, 1901144 (2019)
[2] "Controlling Electrochemically Induced Volume Changes in Conjugated Polymers by Chemical Design: from Theory to Devices" M. Moser*, J. Gladisch, S. Ghosh. T. C. Hidalgo, J. F. Ponder Jr., R. Sheelamanthula, Q. Thiburce, N. Gasparini, A. Wadsworth, A. Salleo, S. Inal, M. Berggren, I. Zozoulenko*, E. Stavrinidou* and I. McCulloch Advanced Functional Materials, 2100723 (2021)
[3] "An Electroactive Filter with Tunable Porosity Based on Glycolated Polythiophene" J. Gladisch, V. K. Oikonomou, M. Moser, S. Griggs, I. McCulloch, M. Berggren, and E. Stavrinidou*, Small Science, 2022 (2022)