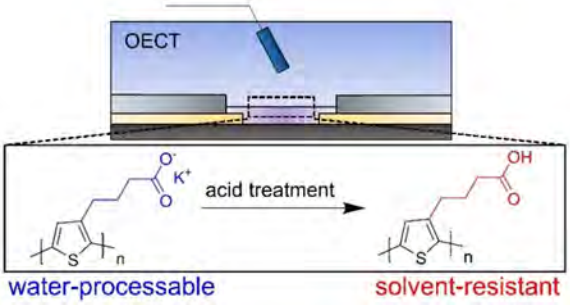
Carboxylic-acid functionalization yields solvent-resistant electrochemical transistors

Brian Khau[1], *bkhau3@gatech.edu, Lisa Savagian*[2], *Michel de Keersmaecker*[3], *Miguel Gonzalez*[1], *Elsa Reichmanis*[1,3,2]. (1) Chemical and Biomolecular Engineering, Georgia Institute of Technology, Atlanta, Georgia, United States (2) Materials Science & Engineering, Georgia Institute of Technology, Atlanta, Georgia, United States (3) Chemistry, Georgia Institute of Technology, Atlanta, Georgia, United States

Organic electrochemical transistors (OECTs) are promising contemporary sensing platforms for high-fidelity transduction of (bio)chemical signals into electrical observables. In an OECT, such signals simultaneously dope an organic semiconducting polymer channel and induce ion injection, changing the bulk conductivity and output current response. Such devices exhibit multiple advantages that make them apt for bioelectronics applications, namely working voltages < 1 V, direct interfacing with biologically relevant electrolytes for *in vivo* usage, and printable fabrication for inherently wearable form factors. However, a prominent barrier to OECT applications is the lack of understanding of structure-property relations, as there are very few high-performing semiconducting polymer families that are electrochemically active in aqueous media. Many state-of-the-art polymers come with processability drawbacks; aqueous-processable polymers such as poly(3,4-ethylenedioxythiophene):poly(styrenesulfonate) (PEDOT:PSS) require insulating cross-linkers to protect against dissolution in aqueous electrolyte, while glycolated polymers frequently display marginal solubility in both organic and aqueous solvents.

We show that the carboxylic acid-functionalized conjugated polymer poly [3-(4-carboxypropyl)thiophene] (P3CPT) can be processed from a water-soluble precursor, yet requires no additives to yield solvent-resistant OECTs which exhibit electroactivity in aqueous and organic electrolytes. Devices fabricated with P3CPT exhibit unipolar p-channel operation in accumulation mode, with maximum transconductance of 26 ± 2 mS on interdigitated electrodes and competitive volumetric capacitance (C^*) of 150 ± 18 F-cm^{-3}, which rank amongst the highest for conjugated polymers with ionic sidechain moieties. This work paves the way for future use of carboxylic acid functionalization to modify existing p- and n-channel backbones to yield highly competitive and processable OECT active materials.



Water-soluble precursors can be spray cast on transistor substrates and acidified to yield solvent-resistant materials with substantial electroactivity in aqueous and organic media.