Polymers under Multiple Constraints

Polymer- & Soft-Matter-Seminar

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“Triblock Copolymers – Using Nanophase Separation to Achieve Low Modulus, Elastic Deformation and Good Mobility in Polymer Semiconductors”

Tuesday,
June 21, 2022

at: **4.15pm**

VDP 4 1.27,
Von-Danckelmann-Platz 4
06120 Halle

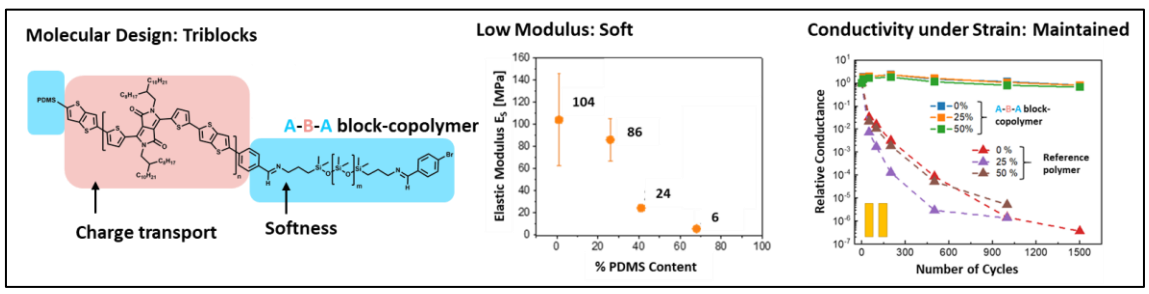

Fig. 1: *left* – molecular design of the triblock co-polymers; *middle* – the modulus can be tuned by the PDMS content; *right* – conductivity is maintained for 1500 stretching cycles up to 50% strain.

Polymer electronics are competitive for applications such as wearable sensors which require high mechanical functionality (e.g., elasticity), but only moderate electronic functionality (e.g., charge carrier mobility). Still, the elastic modulus of polymer semiconductors (PSCs) (0.1 - 1 GPa for typical PSCs) is orders of magnitudes away from human skin (0.1 - 10 MPa). Different pathways were explored to achieve low-modulus PSCs, e.g. non conjugated spacers [1], backbone regio-regularity [2], or sidechains modifications [3], to name a few, but lowering the modulus is generally associated with a decrease in mobility.

One can draw on an old concept in polymer engineering to approach the problem: Block copolymers separate on the nanoscale, and the two phases retain their respective properties (Tg, etc). This approach was successfully used to realize elongability (plastic deformation) in PSCs [4].

We synthesized triblock co-polymers (TBCs) by covalently end-capping the PSC poly-diketo-pyrrolopyrrole-thienothiophene (PDPP-TT), with two elastomeric polydimethyl-siloxanes (PDMS) chains [5]. The resulting TBCs are soft and durable: the TBC with the highest PDMS content has a low modulus (6 MPa) in the range of mammalian skin and achieves a mobility of 0.1 $cm^2V^{-1}s^{-1}$, in the range of the pure PDPP-TT (0.7 $cm^2V^{-1}s^{-1}$). In a doped state, the TBC maintains electronic functionality over more than 1500 cycles at 50% strain. Also, the TBC can be shear-coated at high speeds (up to 10 s cm-1) to yield smooth films with increased thickness (up to 600 nm) without degradation of the electrical performance [6]. Using physisorptiononto the active channel, OFET-based biosensors were fabricated which detect both SARS-CoV-2 antigens as well as anti-SARS-CoV-2 antibodies in less than 20 minutes. The device demonstrates a high sensitivity of about 19%/dec and limit of detection (LOD) 0.36 fg/mL for anti-SARS-Cov-2 antibodies, and at the same time, a sensitivity of 32%/dec and LOD of 76.61 pg/mL for the virus antigen detection [7].

References:

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[2] Kim, Kim, Lee, Yu, Kim, Song, Shin, Oh, Jeon, Kim, Kim: *Macromolecules* 48 (2015), 4339.
[3] Savagatrup, Makaram, Burke, Lipomi: *Adv Funct Mater* 24 (2014), 1169.
[4] Müller, Goffri, Breiby, Andreasen, Chanzy, Janssen, Nielsen, Radano, Sirringhaus, Smith, Stingelin-Stutzmann: *Adv. Funct. Mater.* 17 (2007), 2674.
[5] Ditte, Perez, Chae, Hambsch, Al-Hussein, Komber, Formanek, Mannsfeld, Fery, Kiriy, Lissel: *Adv. Mat.* (2021), 2005416
[6] Ditte, Perez, Hambsch, Kiriy, Mannsfeld, Voit, Krukskaya, Lissel: *Polymers* 13 (2021), 1435
[7] Ditte, Nguyen Le, Ditzer, Sandoval Bojorquez, Chae, Bachmann, Baraban, Lissel: *ACS Biomater. Sci. Eng.* (2021), doi.org/10.1021/acsbiomaterials.1c00727