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Charge Density Dependent Hole Mobility and Density of States Throughout the Entire Finite Potential Window of Conductivity in Ionic Liquid Gated Poly(3-hexylthiophene) BRYAN D. PAULSEN, C. DANIEL FRISBIE, Department of Chemical Engineering & Materials Science, University of Minnesota — Ionic liquids, used in place of traditional gate dielectric materials, allow for the accumulation of very high 2D and 3D charge densities ($>10^{14}$ #/cm^2 and $>10^{21}$ #/cm^3 respectively) at low voltage (<5 V). Here we study the electrochemical gating of the benchmark semiconducting polymer poly(3-hexylthiophene) (P3HT) with the ionic liquid 1-ethyl-3-methylimidazolium tris(pentafluoroethyl)trifluorophosphate ([EMI][FAP]). The electrochemical stability of [EMI][FAP] allowed the reproducible accumulation of 2 x 10^{21} hole/cm^3, or one hole (and stabilizing anion dopant) per every two thiophene rings. A finite potential/charge density window of high electrical conductivity was observed with hole mobility reaching a maximum of 0.86 cm^2/V s at 0.12 holes per thiophene ring. Displacement current measurements, collected versus a calibrated reference electrode, allowed the mapping of the highly structured and extremely broad density of states of the P3HT/[EMI][FAP] doped composite. Variable temperature and charge density hole transport measurements revealed hole transport to be thermally activated and non-monotonic, displaying a activation energy minimum of ∼20 meV in the region of maximum conductivity and hole mobility. To show the generality of this result, the study was extended to an additional four ionic liquids and three semiconducting polymers.

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