POLARONIC FERROMAGNETISM IN POLY(3-HEXYLTHIOPHENE) AT ROOM TEMPERATURE
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The discovery of conducting polymers in the 1970s was one of the greatest revolutions in materials science, as it led to a new generation of electronic and optical devices[1,2]. These systems are low dimensionally materials, and therefore presents a linear pi-conjugated backbone and are subject to Peierls distortion[3]. Consequently, electron-phonon interactions and electron-electron correlation could result in the localization of pi-electron along the conjugated backbone and in the case of nondegenerate ground state, this leads to polaron formation[4] which is characterized by a charge ±(e) and a spin 1/2. The interaction between two polarons, under certain conditions, results in a diamagnetic bipolaron with charge ±(2e) and spin 0 or 1 [5]. Recently, Vandeleene et al [6] have also reported ferromagnetic phase in poly(3-alkylthiophene) in their neutral state and the influence of the substituent (alkyl, alkoxy, thioalkyl), and the regioregularity on the magnetic properties. They observed the appearance of ferromagnetic phase at low temperature and superparamagnetic behavior at room temperature. Considering the exposed above, in this work we extend our investigation to a different polythiophene derivative, poly(3-hexylthiophene), and performed a systematic study of the magnetic properties up to 300 K in pressed pellets samples partially doped with ClO4-. The samples were electrochemically synthesized at 298 K using a constant potential of 1.60 V (referred to a quasi-reference silver electrode) and 0.2 M 3-hexylthiophene in acetonitrile with 0.1 M LiClO4 as supporting electrolyte. Magnetization measurements show that the samples exhibit complex magnetic behavior showing diamagnetism, paramagnetism, and ferromagnetism, where interchain interaction plays the most significant role in the collective interaction of magnetic moments, depending on the preparation conditions. The critical temperature obtained from curve spontaneous magnetization, around 617 K, which means that the interaction between the magnetic moments is strong. In conclusion, it has been demonstrated that when the samples are partially reduced, it leads to a concentration of polarons that allows the emergence of the ferromagnetic interaction. [1] Burroughes, J.H., et al. Nature, 1990. 347(6293): p. 539-541. [2] Forrest, S.R. Nature, 2004. 428(6986): p. 911-918. [3] Peierls, R.E., Quantum Theory of Solids. 1955: Oxford University. [4] Kim, Y.H., et al. Physical Review B, 1988. 38(8): p. 5490-5495. [5] Horowitz, G., A. Yassar, and H.J. Vonbardeleben, Synthetic Metals, 1994. 62(3): p. 245-252 [6] S. Vandeleene et al. Macromolecules, 44, 4911, 2011.