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μSR study of electron radical dynamics in regio-regular polythiophene

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Abstract. We have carried out longitudinal field (LF) muon-spin-relaxation (μSR) measurements in polythiophene based polymers of Poly(3-hexylthiophene-2,5-diyl) with regio-regular structure to elucidate the intra- and inter-chain hopping mechanisms. The LF dependent muon-spin depolarization rate indicates the occurrence of dimensional crossover from 1 dimensional intra-chain spin diffusion to 3 dimensional inter-chain spin diffusion at 25 K.

1. Introduction

The studies of conducting polymers have been attracting much attention due to many new possibilities for wide ranging and growing applications in many fields such as those for the development of devices combining unique optical, electrical, and mechanical properties [1, 2]. One of the materials being intensively studied is the polythiophene (PT) based polymers. Polythiophene is produced by polymerization of thiophenes, a sulfur heterocycle. Compared with other systems of conducting polymers, the polythiophene forms an important class for reason of its certain practical advantages. For instance, it is easily synthesized and doped with various dopant, it is chemically, thermally and environmentally stable in air and humid environment both in doped and undoped states [3]. It is also easily grafted with side changes for property modifications [4]. As such, it has potential applications for field-effect transistors [1], solar cells, batteries and light-emitting diodes [2].

One of the most notable properties of these materials is their electrical conductivity resulted from the delocalization of π-electrons in the conjugated chain backbone induced via doping. This property is related with the charge carrier transport and its mobility along (intra) and perpendicular (inter) to the polymer chain [5, 6, 7].

So far, the macroscopic electronic transport measurements of PT based polymers have been reported to exhibit strong dependence of the conductivity on their structures. For instance, the conductivity of the polymer depends on its regio-regularity (regio-random or regio-regular). A regio-random copolymer of 3-methylthiophene for example, possesses a conductivity of 50 S/cm, while a more regio-regular copolymer configurations has a higher conductivity of 140 S/cm [8].