Bis[3-(trifluoromethyl)phenyl]thiophene-based High Refractive Index Polymers: Synthesis, Characterization, and Properties

Abstract

Development of opto-electronic devices is one of the key points of focus in modern day research for new functional materials. High refractive index (RI) organic materials have important applications, such as, image sensors in Complementary-Metal-Oxide-Semiconductors (CMOS), anti-reflective coatings and as encapsulants in light emitting diodes (LED)s. Considering their immense applications, four different polymer series with high RI were prepared. To ensure that the polymers exhibit high refractive indices, polymers with high sulfur content were prepared, with Bis[3-(trifluoromethyl)phenyl]thiophene moiety as an integral part of the repeat unit structure.

The first series of polymers involved novel sulfur containing high refractive index linear and branched poly(arylene thioether)s and linear poly(arylene ether)s, which were synthesized via nucleophilic substitution reactions. They were followed by the preparation of the second series of polymers which involved polyimides. Three types of polyimides were synthesized also via nucleophilic substitution reactions. For that two new sulphur containing aromatic amino monomers were also developed, one bi-functional and one tri-functional. Increase in sulfur and aromatic content in the polymer backbone successfully resulted in the increase of their refractive index. The third series of polymers involved sulfur containing polytriazoles, which were synthesized via Cu(I) assisted click polymerization reactions. A novel bifunctional azide was synthesized by the conversion of a previously synthesized amine by our group, to an azide using trimethylsilylazide in a polar aprotic solvent. Use of the trifunctional azide in optimised conditions resulted in increased solubility of an otherwise insoluble linear polytriazole. Another series of polymer/TiO_2 hybrid materials were also synthesized, in which the TiO_2 nanoparticles were synthesized in-situ from their precursors. The pristine polyimide in this series was previously synthesized and reported and the different characteristics of the hybrid materials were investigated. The refractive index of the hybrid materials was found to increase with the increase of nanoparticle weight percent in the polymer matrix. In each case the sulfur and aromatic content influence the refractive index of the polymers. The highest RI of 1.76 at 589 nm, was observed in case of the polyimides, among the pristine polymers with poly(arylene thioether)s and poly(arylene ether)s showing the best processability. The polymer with the highest filler loading exhibited the highest RI among all the polymers investigated. The tuneable optical properties and good dynamic stability of the polyimides make them preferable candidates in opto-electronic application.

Keywords: Sulfur containing polymers, High refractive index, Polycondensation, Thermal imidization, Click polymerization, Optical applications