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Preparation and Applications of Conducting Polymer Gels

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We have witnessed tremendous advances in the development of organic conductive molecular and polymeric materials and this field continues to be of great scientific and commercial interest. The electric conduction in organic solids has been one of the most fascinating topics for synthetic chemists and solid-state physics. Conductive polymers possess a highly delocalized π-electron system, whereas charge-transfer salts are composed of π-molecules. The superiority of organic conductive materials over their counterpart inorganic materials resides in their tremendous architectural flexibility, inexpensiveness and ease of processing and fabrication. Recently examined applications of conjugated polymers include organic light-emitting diodes (OLEDs), chemical sensors, photovoltaic cells, field-effect transistors, and so on [1-3].

The acetylenic triple bonds have rich π-electrons, which can be polymerized to yield the linear conjugated polymer systems. Polyacetylene (PA), the simplest conjugated polymer, consists of a backbone of carbon atoms, each bonded to one hydrogen atomand connected together by alternating single and double bonds. It can be made free-standing thin film by using Shirakawa catalysts [$Ti(OC_4H_9)_4$-$Al(C_2H_5)_3$]. However, the drawbacks are that this material is thermally unstable and insoluble, making it unsuitable for general use [4].

More processable conjugated polymers can be prepared by the linear polymerization of substituted acetylenic monomers and by the cyclopolymerization of nonconjugated diynes [5-7]. Nitrogen-containing polymers have received unabated attention in the design and synthesis of multifunctional polymers [5]. Unlike other π-conjugated polymers, they contain nitrogen heteroatom either in the main chains or in the side chains that provide facile quaternarization reaction and protonation of the nitrogen sites [5]. In recent years, we reported the studies on the synthesis and characterization of new conjugated cyclopolymer by the cyclopolymerization of dipropargylamine derivative.

Electroluminescence (EL) devices have been studied due to their practical application as full-color flat panel displays [8]. The EL phenomenon from organic molecules was first observed for anthracene in 1965. However, the qualities of the devices such as efficiency and lifetime were significantly lower than those obtained from inorganic molecules. Ever since the first report was published on a high performance bilayer light-emitting display (LED) by Tang and Vanslyke, significant effort has been put forth in realizing the potential of commercial available polymer LEDs. Advantages of conjugated polymer-based LED over small molecule-based LED are low-cost, large-area, flexibility and easy design of the molecular structure for EL polymers. Among the π -conjugated polymers, it was reported that poly(*p*-phenylenevinylene) (PPV), polythiophene (PTh), poly(9,9-dialkylfluorene) (PF), and their derivatives have been widely used as the most powerful

candidate materials for the application of polymer LEDs. Various polymerization methods for the synthesis of emitting polymers have been developed such as Wittig reaction, Heck reaction, Suzuki reaction, Ni(0)-mediated Yamamoto coupling reaction, and Gilch polymerization. Among them, Gilch polymerization offers a number of important advantages for the introduction of vinylene units along the polymer backbone with high molecular weight and low polydispersity, and allows for easy purification.

The concept of self-doping in conjugated polymers was introduced by Wudl et al [9]. In self-n-doped polymers, cationic sites acts as dopant and are incorporated into the polymer. The cyclopolymerization of dipropargyl monomers carrying an ionic nature is a facile synthesis method for self-doped conjugated ionic polymers. A number of dipropargyl quaternary ammonium salts were polymerized to yield the unusual conjugated polymeric materials. The potential counterions are ionically bound to the polymer. Dihexyldipropargylammonium salts were first polymerized by $MoCl_5$-$EtAlCl_2$ catalyst systems to give the corresponding conjugated polymers in high yields. A similar water-soluble conjugated polymer from the polymer reaction of poly(N-hexyldipropargylamine) and methyl trifluoromethanesulfonate was reported at the same time. The precursor polymer, poly(dipropargylhexylamine), was obtained in a good yield via a ring-forming polymerization of the corresponding monomer using a Schrock catalyst. Treatment of this polymer with methyl trifluoromethanesulfonate in methylene chloride affords the poly(dipropargyl-N-hexyl-N-methylammonium triflate) in 92 % yield. In recent years, we reported a facile synthetic method of new self-dopable ionic conjugated polymer, poly(2-ethynylpyridinium-N-benzoylsulfonate), by the activation polymerization of 2-ethynylpyridine with the ring-opening of 2-sulfobenzoic acid cyclic anhydride.

Recent advances in the area of acetylene-terminated polyimides (Thermid materials) include modifications of these materials through a semi-interpenetrating polymer network approch and the development of phenylethynyl end-capped polyimides. Besides their potential application in aerospace structures, these Thermid materials are being evaluated for a variety of electrical/electronic applications.

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