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Review

New applications of poly(arylene ether)s in organic light-emitting diodes

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ABSTRACT

Compared with conventional π-conjugated polymers, poly(arylene ether)s (PAEs) may take advantages of excellent thermal properties, well-defined effective conjugated length and no catalyst contamination. Recently, their applications have been extended from engineering plastics to optoelectronic materials. In this review, various kinds of functional PAEs used as fluorescent polymers, host polymers and phosphorescent polymers in organic light-emitting diodes (OLEDs) are outlined, and their molecular design, synthesis and device performance are overviewed.

1. Introduction

Poly(arylene ether)s (PAEs) have emerged as high-performance engineering plastics since the first successful preparation with high molecular weight by R. N. Johnson et al. in 1967 [1–3]. Due to existence of the rigid and thermally stable arylene units, flexible and heat resistant oxygen ether, and/or extra polar bonds (e.g. –(C=O)–, –(O=S=O)–) [4], these amorphous or semi-crystalline engineering plastics possess excellent properties, such as high thermal and oxidative stability, good mechanical strength, superior electrical insulating ability and high glass transition temperatures. Up to now, there has been a great family of PAE products including poly(arylether ketone), poly(aryl ether sulfone), poly(arylene ether nitrile) and so on, which have been widely used in electronic and electrical products, aerospace industry and mechanical manufacturing fields [5].

It should be noted that, the application of PAEs has been recently extended from engineering plastics to optoelectronic functional materials. Apart from high thermal and morphological stability, PAEs possess well-defined conjugated moieties and localized excited state between two saturated oxygen atoms [6]. Therefore, their optical properties can be modulated easily and reliably to realize wide bandgap blue emission. In addition, unlike conventional π-conjugated polymers (π-CPs) that are synthesized through cross-coupling reactions catalyzed by transition metal catalyst, PAEs can be synthesized from difluorinate and dihydroxy monomers by means of classical polycondensation conditions with base in polar solvents (Fig. 1). Simple work-up of washing by water and precipitating in poor solvents can readily produce the desired polymer with high purity for use in optoelectronic devices without any residual catalyst contamination, which is always an annoying problem for metal-catalyzed conjugated polymers [7].

In this review, we will demonstrate the new application of PAEs in organic light-emitting diodes (OLEDs). Various kinds of functional PAEs including fluorescent polymers, host polymers and phosphorescent polymers are outlined, and their molecular design, synthesis and device performance are overviewed.

2. PAE-based fluorescent polymers

In contrast to traditional fluorescent π-CPs, PAE-based fluorescent polymers can be considered as incorporating small-molecular fluorescent emitters with well-defined structure into a polymeric skeleton through insulated oxygen atoms. As the fluorescent emitters take advantages of structural uniformity and regularity, the PAEs possess well-defined optical properties. In this sense, PAEs should be able to take advantages of both polymeric and small-molecular materials. That is, the optical properties of the polymers are mainly determined by the small-molecular emitters,

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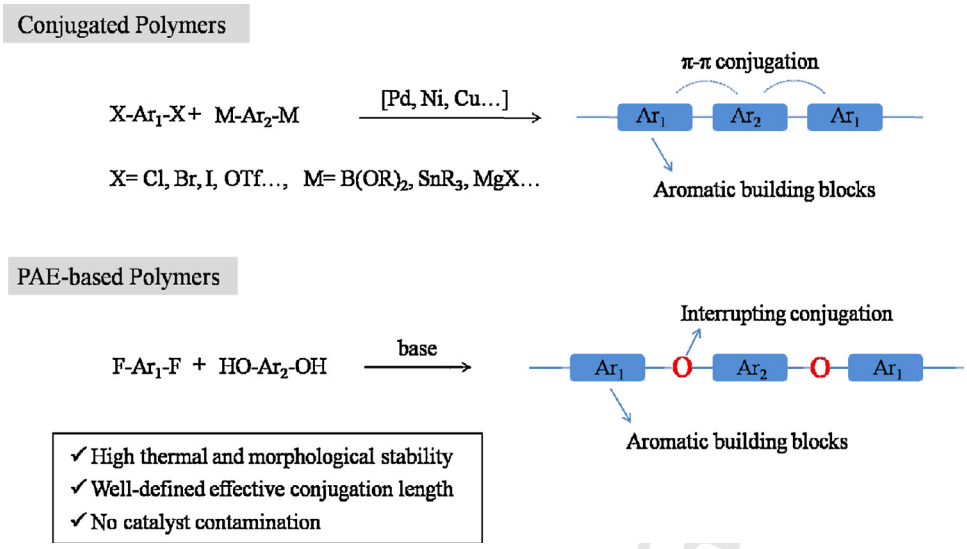

Fig. 1. Comparison between π-conjugated polymers and PAEs.

and their thermal properties and morphology in the solid state can be modulated through designing appropriate polymer structure. Although a series of condensation light-emitting polymers (such as polyesters [8,9], polyamides [10–12], and polyurethanes [13]) have been reported with small-molecular fluorescent emitters as building blocks for the polymer main chain, only the PAEs show good electroluminescent properties comparable or even higher than those of fully π-CPs, probably due to their relatively high photoluminescence efficiency and weak charge trapping effect [14,15].

2.1. PAEs with fluorescent main chain

PPV-based PAEs: The early studies of the light-emitting PAEs are concentrated on poly(phenylenevinylene) (PPV) derivatives. In 1993, F. E. Earasz et al. [6] reported a polyaryl alkyl ether (P1, Fig. 2) by combining phenylenevinylene oligomers with flexible-chain aliphatic oligomeric segments in the main chain. A differential scanning calorimeter (DSC) trace of the copolymer displays a glass transition at 341 °C. No melting or other thermal transition in the measured temperature range of 303–490 °C was observed. The

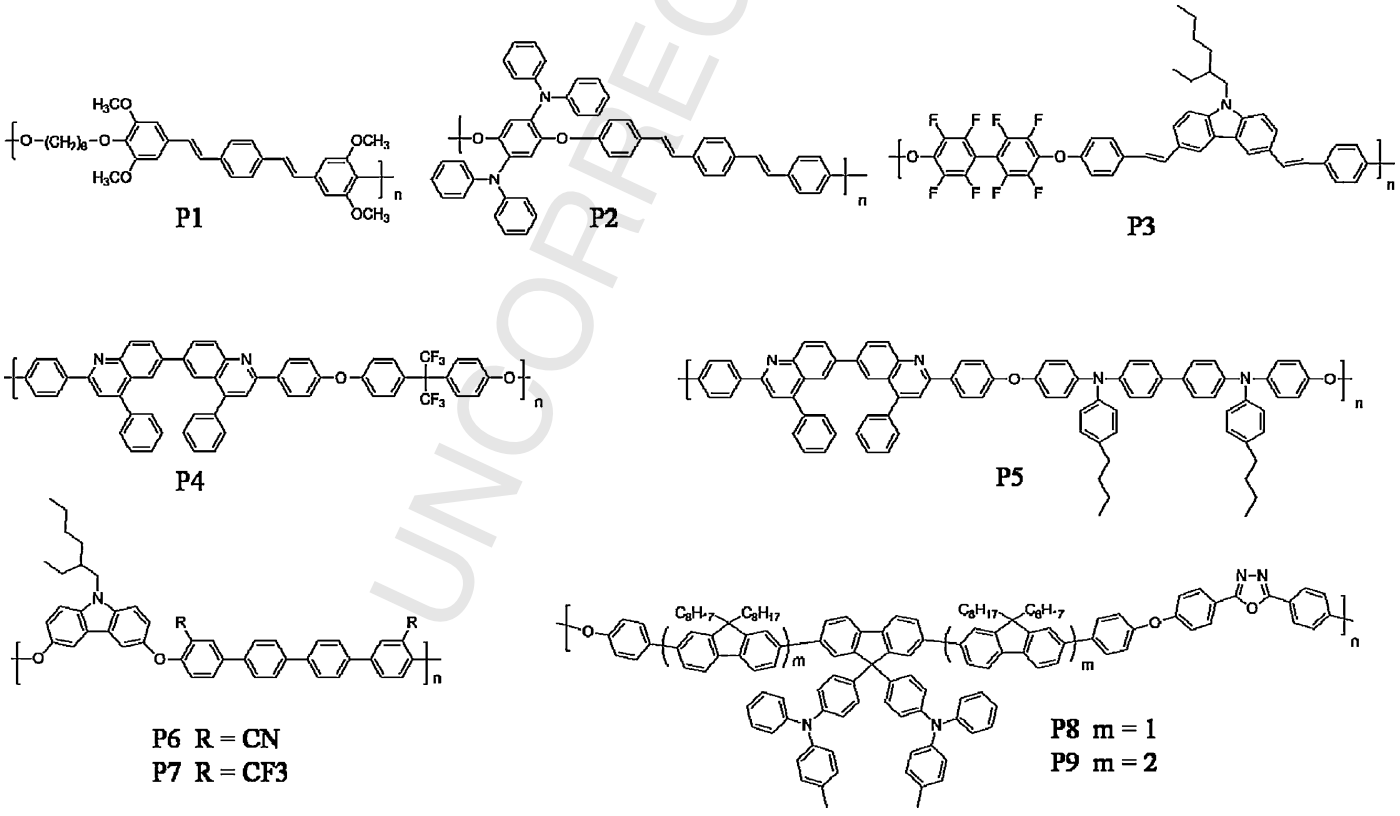

Fig. 2. Chemical structures of PAEs with fluorescent main chain.

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