Technology Offer

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Molecular Triangles as Building Block for Blue Emitters in OLEDs

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Background

Organic light-emitting diodes (OLEDs) have received extraordinary attention for their merits such as low-cost, light weight, flexibility, thin panel thickness, wide viewing angle, and low power consumption. OLEDs can be divided into two types according to the materials used. One is the polymeric OLED (PLED), which is generally fabricated by deposition from solution. Due to the ease and low cost of device fabrication via solution processing – which is done at room temperature allowing fabrication on flexible organic substrates –, the PLED displays attract much attention. The solution processability of the polymers enables production of full colour PLED pixels by printing techniques such as inkjet printing, screen printing, dye diffusion, and laser-induced thermal transfer or by patterning with the photo-lithographic process. These printing methods of PLED are more promising for large-size, high-resolution displays than the shadow mask technique, which is the patterning method for small molecule OLEDs.

In PLEDs the three primary colours (red, green, and blue) for full colour displays have been demonstrated, however only green and red PLEDs presently meet the requirements for commercial applications. For blue PLEDs, various kinds of conjugated polymers have been proposed. However, they are not yet sufficient for practical displays due to their short lifetime, low efficiency, and insufficient colour purity.

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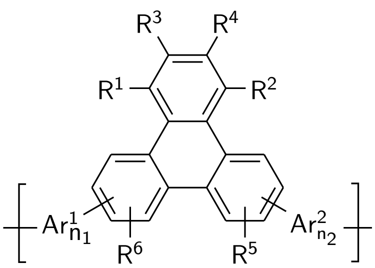
Starting form triphenylene triangles, synthesis of polymers according to Scheme 1 as well as macrocyclic dyes (see Scheme 2) was accomplished.

PLEDs comprising the triangle polymer as emitting layers can show significant advantages in colour purity, device efficiency and/or operational lifetime. In addition, the polymers can have good solubility characteristics and relatively high glass transition temperatures, which facilitate their fabrication into coatings and thin films that are thermally and mechanically stable and relatively free of defects. If the polymers contain end groups which are capable of being cross-linked, the crosslinking of such groups after the films or coating is formed increases the

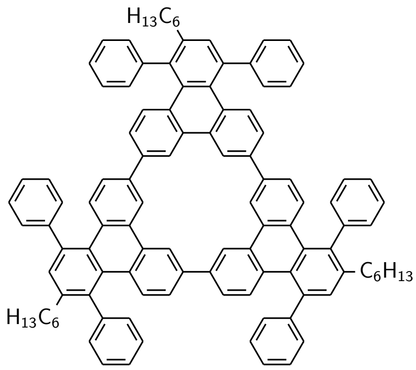


Scheme 1: Backbone of the blue emitting polymer containing the molecular triphenylene triangle; Ar and Ar' – aryl substituents, R – H or organic substituents, n_1 and n_2 are 0, 1 or 2.

solvent resistance thereof, which is beneficial in applications wherein one or more solvent-based layers of material are deposited thereon.

In triphenylene homo- and co-polymers with a variety of surrounding alkyl and aryl substituents π–π stacking is prevented, because of the twisted phenyl rings around the triphenylene core, resulting in almost identical photo-luminescence spectra in both solutions and films. All polymers exhibit narrow emission in the range of 430–450 nm, where the human eye is most sensitive for the blue range. The best performance in terms of turn-on voltage and luminescence efficiency is obtained by blending with a hole-transporting material. Furthermore, the polymer films may be used as protective coatings for electronic devices and as fluorescent coatings. The thickness of the coating or film is dependent upon the ultimate use, generally, in the range from 0.01 to 200 μm.

Starting from the triangular monomer of the polymer, a macrocyclic dye (see Scheme 2) was developed showing similar luminescence properties: It exhibits an intense blue emission (200 cd/m^2 at 6.5 V, $\lambda_{max} = 460$ nm) that is located close to the ideal value for blue-emitting OLEDs. The macrocyclic dye was tested successfully as an active component in the emissive layer of an OLED and showed promising performance both regarding emissive properties and device stability. Due to non-planar conformation, the maximum emission wavelength of the dye shifts only slightly from solution to solid state.



Scheme 2: Example of a macrocyclic, blue emitting dye consisting of array of triphenylene triangles.

The experiments carried out on the triphenylene macrocycles demonstrated the great potential of this new class of blue emitters for solution-processed, small-molecule OLED applications.

Advantages

- emission at wavelength of 430–450 nm
- high colour purity and efficiency
- long operational lifetime
- solution processable

Patent Information

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US7968872, KR101422055B1, JP5568303B2, CN101495433B granted
EP2046705B1 granted, nationalized in DE, ES, FR, GB, IT, NL
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