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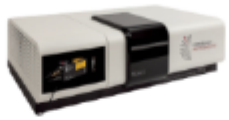
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Electroluminescence and Photoluminescence Spectroscopy of a Phosphorescent Organic Light Emitting Diode (PhOLED)

Investigation of emission properties of a PhOLED. The spectrum and chromaticity coordinates of the emission and the triplet lifetime are determined using time-resolved spectroscopy.

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APPLICATION NOTE
Electroluminescence and Photoluminescence Spectroscopy of a Phosphorescent Organic Light Emitting Diode (PhOLED)
 AN_P57_21 January 2019, Stuart Thomson

Introduction
 Our daily experience with organic (carbon based) materials such as polyethylene shopping bags and polyvinyl chloride insulation on cables suggests that they should be electrical insulators and this is indeed true for the majority of organic materials. However, there exists a small subset of organic materials with a particular electronic structure that are semiconducting in nature and can be used to make optoelectronic devices such as light emitting diodes.

The first organic light emitting diode with practical efficiency and brightness was demonstrated by Tang and Van Slyke working at Eastman Kodak in 1987. In the ensuing 30 years, OLEDs have been extensively optimized and today OLEDs are found in high end smartphone and television displays due to their superior display performance compared to LCDs. A schematic of a typical OLED structure is shown in Figure 1a. Electrons and holes are injected into the organic electron and hole transport layers, recombine in the central doped emission layer and the energy is then transferred via resonant transfer to a dopant molecule. The choice of dopant molecule controls the colour of the OLED emission and is typically a small molecule with high photoluminescence quantum yield.

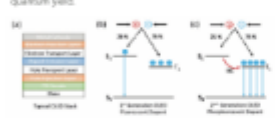


Figure 1: Schematic of all layers in a typical bottom emitting OLED and mechanism of emission in (a) fluorescent doped OLEDs and (b) phosphorescent doped OLEDs.

In first generation OLEDs the dopant molecule was purely organic and the light was emitted through fluorescence. However, due to spin statistics 75% of the excitons generated when electrons and holes recombine in the OLED are in the non-emissive triplet state (T) and the maximum efficiency of the OLED is therefore fundamentally limited to 25% (Figure 1b). The solution to this problem is to move away from pure organic molecules towards organic molecules that incorporate heavy metals such as Iridium. The use of heavy metals increases the spin-orbit coupling between the exciton spin angular momentum and the orbital angular momentum and the triplet state becomes emissive (Figure 1c) which is called a phosphorescent OLED or PhOLED.

The red and green OLEDs used in modern smartphone and television displays are high efficiency second generation PhOLEDs but a stable high efficiency blue phosphorescent dopant emitter has yet to be found and further research will be required to achieve this goal. Development and characterization of new OLED materials and structures requires both photoluminescence spectroscopy of the individual components and electrochromance characterization of the completed device. In this application note the dual functionality of the FS5 Spectrofluorimeter for OLED characterisation is demonstrated through the investigation of the emission properties of a PhOLED doped with the Iridium based emitter HMDQ(Irac) using steady state and time-resolved electrochromance and photoluminescence spectroscopy.

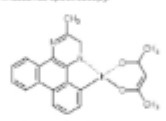


Figure 3: Chemical structure of the phosphorescent emitter HMDQ(Irac)

Materials & Methods
 A phosphorescent OLED was fabricated via vacuum sublimation using HMDQ(Irac) as the dopant and encapsulated with a glass coverlip and optical epoxy

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