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APPLICATION NOTE

Fluorescence, Delayed Fluorescence and Phosphorescence Spectra of a TADF Emitter measured using the FLS1000 with a VPL Laser and Gated PMT Detector

AN_P40; June 2019; Stuart Thomson

Introduction

Materials exhibiting thermally activated delayed fluorescence (TADF) have attracted widespread research attention as a new generation of high-efficiency emitters for use in Organic Light Emitting Diodes (OLEDs). In a TADF OLED, triplet excitons are converted to singlet excitons through a thermally assisted reverse intersystem crossing which enables internal quantum efficiencies of 100% to be achieved.[1]

In TADF research the spectra of the fluorescence and phosphorescence components of the emission must be measured in order to assign the origin of the component and calculate the energy splitting between the molecular levels. In this application note, the FLS1000 Photoluminescence Spectrometer equipped with a gated PMT detector and a VPL pulsed diode laser is used to measure the prompt fluorescence, delayed fluorescence and phosphorescence spectra of the TADF emitter CzDBA.[2] The VPL series of pulsed diode lasers are a new range of variable pulse length lasers designed by Edinburgh Instruments that are optimised for measuring longer-lived emission such as upconversion, delayed fluorescence and phosphorescence.

Materials & Methods

CzDBA was dissolved in anhydrous toluene at a concentration of 2 x 10⁻⁵ M and loaded into a 10 ml quartz cuvette. Spectra were measured using the FLS1000 Photoluminescence Spectrometer equipped with a gated PMT-900 detector, single photon counting multichannel scaling (MCS) lifetime electronics, a 375 nm variable pulse length diode laser (VPL-375) and a 77 K – 500 K liquid nitrogen cryostat (Oxford Instruments OptistatDN2).

Figure 1 FLS1000 Photoluminescence Spectrometer equipped with an Oxford Instruments liquid nitrogen cryostat for the measurement of low-temperature phosphorescence spectra.

Results & Discussion

Fluorescence and Delayed Fluorescence Spectra measured using TRES at 300 K

At room temperature, photoexcitation of a TADF emitter results in prompt fluorescence emission on nanosecond timescale and delayed fluorescence emission on a microsecond timescale. The prompt and delayed fluorescence decay of CzDBA was measured using single photon counting multichannel scaling (MCS) with a variable pulse length diode laser (VPL-375) as the excitation source (Figure 2).

MCS is a complementary time-resolved technique to the more widely known time-correlated single photon counting (TCSPC) and is the method of choice for measuring delayed fluorescence. In MCS the detection window is split into time intervals and all photons that arrive within a specified time interval are counted, the photons in the next interval are then counted and so on until the entire time range has been covered. This multiple stop mode detection enables higher detection count rates to be used than in TCSPC which reduces the acquisition time of longer decays.

The pulse length of the VPL laser can be adjusted from 100 ns to 1000 µs which allows the pulse length to be optimised to the type of emission being measured. For the decay shown in Figure 2, the pulse length of the VPL was set to 100 ns which is sufficient to deliver sufficient power to the sample without obscuring the delayed fluorescence.

Figure 2 Fluorescence decay of CzDBA solution at 300 K measured using MCS.

Measuring the Phosphorescence Spectrum of a TADF Emitter

In this application note the measurement of the low temperature phosphorescence spectrum of a TADF emitter using a gated PMT is demonstrated.

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