



DOWNLOAD FREE WHITE PAPERS & APPLICATION NOTES

Identifying Thermally Activated Delayed Fluorescence (TADF)

OLEDs have become one of the most popular display types for high-end televisions and smartphones due to their superior contrast ratios and lower power consumptions than conventional LCD displays. A new generation of OLED utilising thermally activated delayed fluorescence (TADF) is currently under intense research and development. In this application note, the need for a new generation of OLEDs is discussed, the physics behind TADF OLEDs introduced, the characterisation of a new TADF emitter using a spectrofluorometer presented.

DOWNLOAD NOW

APPLICATION NOTE
Identifying Thermally Activated Delayed Fluorescence (TADF) using an F55 Spectrofluorometer
 AN_P56, 2 May 2019, Stuart Thomson

Introduction
 Thermally activated delayed fluorescence (TADF), also known as E-type delayed fluorescence, was first observed in 1934 by Francis Perrin.¹ In 2012 it received a resurgence in attention, and exposure to a wider audience, when Professor Takaya Adachi and colleagues at Kyoto University used the TADF mechanism to harvest triplet excitons in organic light emitting diodes (OLED) and create a new type of high-efficiency OLED that does not require the use of heavy metals.² TADF has since become one of the most popular approaches to harvest triplet excitons in OLEDs, and new TADF emitters with good stability and attractive colour coordinates are being intensely researched in both academia and industry.

The Triplet Exciton Problem
 OLEDs are one of the most popular display types for televisions and smartphones, offering higher contrast ratios and lower power consumption than conventional LCD displays. In an OLED, layers of organic (carbon-based) semiconductors are sandwiched between two electrodes and electrons and holes are injected into the organic semiconductor under an applied bias. Upon encountering, the electrons and holes form Coulombically bound electron-hole pairs called excitons which can then recombine to generate light. Due to spin statistics, 25% of the excitons formed will be in the singlet state (S) and 75% in the triplet state (T). In the first OLED designs, which used fluorescent molecular emitters, only the S state was emissive, with the T₁ → S₀ radiative transition being forbidden due to conservation of spin angular momentum. These 1st generation OLEDs were therefore limited to a maximum internal quantum efficiency (IQE) of 25%.

3rd Generation TADF OLEDs
 These shortcomings led to the development of heavy metal free 3rd generation OLEDs which operate using the TADF mechanism. In a TADF emitter, the S₁ and T₁ states are designed to be close in energy and strongly coupled, which enables excitons generated in the T₁ state to undergo a thermally assisted reverse intersystem crossing (RISC) to the S₁ state where they can then radiatively decay to the S₀, resulting in delayed fluorescence emission (Figure 1). Using TADF, IQEs of 100% can be achieved without the need for heavy metals.

New TADF emitters with high quantum yields, good stability and desirable colour coordinates need to be developed. During the development of new emitters, the emission properties must be fully characterised and the information then used to refine subsequent molecular designs. In this application note, the capability of the F55 Spectrofluorometer for providing a complete characterisation of TADF emitters is demonstrated by investigating the recently published emitter CDBA³ and confirming the presence of TADF emission.

Materials & Methods
 CDBA was dissolved in toluene at a concentration of 2 x 10⁻⁴ M. The solution was then degassed using freeze-pump-thaw and the cuvette bubbled with nitrogen to prevent the ingress of oxygen. Absorption and photoluminescence measurements were performed using the F55 Spectrofluorometer equipped with a PMT400 detector, multichannel scaling (MCS) lifetime electronics, a 100 W Xenon lamp, a 5 W monochromated Xe flashlamp and a 375 nm passenced pulsed diode laser (PL-375). Room temperature measurements were made using the SC-25 Thermoelectric Cuvette Holder Module, while cryogenic measurements utilised the SC-30 Liquid Nitrogen Dewar Module. To measure the PLQY, the SC-30 Integrating Sphere Module was used.

Figure 1 The operating mechanisms behind 1st, 2nd and 3rd generation OLEDs.
 To overcome this limitation, heavy metals, such as platinum and iridium, were incorporated into the molecular emitters to make 2nd generation phosphorescent OLEDs. The presence of heavy metals in the molecule increases the strength of the spin-orbit coupling between the spin angular momentum and the orbital angular momentum and the T₁ → S₀ radiative transition becomes allowed. This approach enables IQEs of 100% to be achieved; however, the use of heavy metals has several significant drawbacks. The metals are rare and expensive and are therefore impractical for high production volumes. In addition, phosphorescent OLEDs suffer from poor stability, particularly in the blue, and to date, no stable deep blue phosphorescent emitter has been found.

Figure 2 Chemical structure of the CDBA TADF emitter.
Figure 3 F55 Spectrofluorometer.

Sponsored by



More White Papers from this Sponsor

- Electroluminescence and Photoluminescence Spectroscopy of a Phosphorescent Organic Light Emitting Diode (PhOLED)
- Photophysical Characterisation of Perovskite Quantum Dots
- Charge Carrier Recombination Dynamics of Semiconductor Photocatalyst



Visit Photonics Media to download other white papers and learn more about the latest developments in lasers, imaging, optics, biophotonics, machine vision, spectroscopy, microscopy, photovoltaics and more.

www.photonics.com/WhitePapers.aspx

We respect your time and privacy. You are receiving this email because you are a Photonics Media subscriber, and/or a member of our website, Photonics.com. You may use the links below to manage your subscriptions or contact us.

Questions: info@photonics.com

[Unsubscribe](#) | [Subscribe](#) | [Subscriptions](#) | [Privacy Policy](#) | [Terms and Conditions of Use](#)

Photonics Media, 100 West St., PO Box 4949, Pittsfield, MA 01202-4949

© 1996 - 2019 Laurin Publishing. All rights reserved. Photonics.com is Registered with the U.S. Patent & Trademark Office. Reproduction in whole or in part without permission is prohibited.