

Professor Andrew Paul Monkman,

Head of the Organic Electroactive Materials Research Group,
Department of Physics, University of Durham
Birthdate 6th September 1963

**Education :**

1982-1985 B.Sc. (1st) in Physics from Queen Mary College, University of London
1985-1989 Ph.D. "Characterisation of the Conducting Polymer Polyaniline", also from Queen Mary College, University of London.

Appointments :

1988–1997 Lecturer, Applied Physics, University of Durham
1997-2002 Promoted to a Readership, University of Durham
2002- Promoted to a Personal Chair, University of Durham
2004-2012 Director, Photonic Materials Centre, University of Durham

Fellowships

STINT Fellowship (held University of Linköping), Swedish Government 1998
Leverhulme Fellow 2002-2003
Fellow of the Institute of Physics
Charter Physicist
Samsung Global Research Outreach Award 2013
Mercator Fellow, University of Düsseldorf, 2019-2024

Areas of Research

Professor Andrew Monkman obtained his degree and PhD at the University of London with Professor David Bloor. He joined Durham University in 1988 and was appointed to a personal Chair in 2002. Professor Monkman runs the OEM research group focussing on the study of the optical properties of organic semiconductors, with special focus on organic solid state lighting. The research group has a sophisticated array of spectroscopic techniques ranging from 15 fs time resolution time resolved laser measurements to the ability to study the weakest phosphorescent processes. Many dedicated spectroscopic techniques have been developed for the study of triplet exciton dynamics, triplet annihilation processes and thermally activated delayed fluorescence, in organic materials. The group has developed these optical measurements to enable the studies of OLED devices as well as materials and thus provide a deeper understanding of how OLEDs produce light. The group also has excellent clean room facilities to fabricate both polymer and small molecule encapsulated devices.

The group currently focus on triplet harvesting using the TADF mechanism. We have developed the photophysical characterisation of this mechanism and are developing new methods to further understand the details of reverse intersystem crossing and the excited state involved in the triplet harvesting. We have identified three distinct regimes of TADF and shown that the original ideas of the TADF mechanism are incorrect. This is helping us design much more efficient TADF materials and TADF devices. Our broad range of optical measurement techniques is vital to helping us understand this complex mechanism.

The simple little Thermally Activated Delayed Fluorescence molecule that breaks all the rules!

The development of highly efficient organic emitters is fundamental to enhancing the commercial reach of Organic Light Emitting Diodes (OLEDs). Thermally Activated Delayed Fluorescence (TADF) emitters have caused great excitement in the OLED world as metal-free systems for harvesting triplet states by reverse intersystem crossing (rISC). TADF molecules with a donor-acceptor (D-A) structure and C-N bridge have been particularly successful, giving both small singlet triplet gaps, strong SOC by vibronic coupling and high photoluminescence quantum yields. However, D-A systems with C-C bridging are much less common, *spiro* bridged TADF molecules have received far less attention. Spiro-linked TADF materials present interesting fundamental photophysical properties, as their rigid and orthogonally connected D-A system contrasts strongly to more flexible C-N bridged systems

Here we describe the excited states of a TADF spiro-anthracenone derivative, 10-phenyl-10*H*,10'*H*-spiro[acridine-9,9'-anthracen]-10'-one (ACRSA). It emits bluish-greenish TADF and has demonstrated an device external quantum efficiency (EQE) of 16.5%. We investigated its complex excited state dynamics in both solution and solid state, using time-resolved photoluminescence and DF spectroscopy. The photophysics of the molecule is excitation dependent, Kasha's law is total broken as we find three emissive states, both local and charge transfer, two of which are formally one photon forbidden. Depending on which excited state is pumped we find different decay channels and DF and phosphorescence efficiencies. In solid state, CT emission dominates but host 'polarity' has little effect, however host packing has a major influence. We also show that the spiro bridge prevents dihedral angle inhomogeneity which has a marked effect on the photophysics, as does guest aggregation.

We have then used ACRSA to investigate different TADF triplet sensitizers with the hyperfluorescence emitter v-DABNA, to obtain maximum efficiency, limit parasitic spectral broadening and v-DABNA excimer formation. We discover the key optical properties for the TADF triplet up-conversion sensitizers required for optimal energy transfer to the v-DABNA, retaining very high FRET efficiency at low v-DABNA concentrations and small singlet energy gap between the sensitizer and v-DABNA. Three different sensitizers were studied, DMAC TRZ, a very efficient TADF material and two rather poor TADF materials, ACRSA and AZB-TRZ.

For ACRSA we achieve a 3 fold increase in EQE, >28% from the hyperfluorescent devices compared to the pure ACRSA devices, which is higher than the DMAC-TRZ hyperfluorescent devices. From our results we find that the most important photophysical parameters for sensitization are different to those for optimal TADF, so the best TADF molecules are not the best for sensitization.