

Spectroscopic Studies of Current Quenching in Organic LEDs

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Many organic light-emitting diodes (OLEDs) are hampered by decreasing efficiency and a blue shift in their emission with increasing current density. We present studies of this phenomenon in model devices based on DCJTB, a red dye, dilutely doped into Alq₃. Our experiments consist primarily of charge modulated absorption and photoluminescence quenching spectroscopy during device operation. By studying a series of devices with varying doping concentrations, we have gained insight into the current quenching mechanism and the attendant spectral behavior.

We find that the steady state photoluminescence spectrum red shifts substantially with DCJTB doping concentration while there is almost no effect on the corresponding excitation spectra. This underscores the importance of energy transfer amongst the dye molecules and suggests that previous attribution of the red shift to solid-state solvatochromism is incorrect. Charge modulation spectroscopy enables us to measure the spectrum and densities of DCJTB cations in the device under forward bias. We can correlate cation density with the magnitude of current quenching by simultaneous measurements of photoluminescence quenching. Based on these measurements, we conclude that the reason for the quenching is resonant Förster transfer from excited DCJTB molecules to nonemissive DCJTB cations. This explanation is consistent with both the density dependence of the quenching and the concomitant spectral blue shift with increasing current.

In the course of these experiments, we have also observed that retraction of charge from DCJTB sites is slow. We show that the kinetics of charge extraction from the DCJTB sites are thermally activated and field dependent though it is difficult to specifically associate the energy barrier with the HOMO offset between DCJTB and the Alq₃ host matrix. Surprisingly, we find the extraction kinetics to be well described by a biexponential fit and provide circumstantial evidence that the two rates are associated with distinct doping sites that have different barriers to extraction. It is tempting to associate these two types sites with DCJTB monomers and dimers but further work needs to be done to support that interpretation.

This work was done in collaboration with Millard Wyman, Alfred P. Marchetti, Terri Haskins, Arabinda Chowdhury (Department of Chemistry, University of Rochester, Rochester, NY 14627) and Ralph H. Young, Denis Y. Kondakov, Eastman Kodak Company, Rochester, New York 14650-2110.