MAR13-2012-003469

Abstract for an Invited Paper
for the MAR13 Meeting of
the American Physical Society

Highly efficient organic light-emitting diodes by delayed fluorescence

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Although typical organic molecules only contain carbon (C), hydrogen (H), nitrogen (N) and oxygen (O) atoms, the unique bonding of C involving sp3, sp2 and sp hybrid orbitals enables generation of very complicated molecular architectures that have extensive functions in a wide variety of organisms and industrial products. In the last two decades, the allure of the unlimited freedom of design of organic molecules has shifted a significant proportion of electronics research from inorganic into organic materials. In particular, great advances have been achieved in organic light-emitting diodes (OLEDs). First-generation OLEDs containing fluorescent molecules have progressed to second-generation ones using phosphorescent molecules, which is an attractive design for practical electronics. Herein, new organic electroluminescent (EL) molecules lacking precious metals are presented. The energy gap between the singlet (S1) and triplet (T1) excited states is minimized by strategic design, promoting highly efficient spin up-conversion from T1 to S1 states while maintaining a high radiative decay rate of >106/s, leading to a high fluorescence efficiency of >90%. Using these unique molecules, a very high external EL efficiency of >19% is realised, which is comparable to those of high-efficiency phosphorescence-based OLEDs. These molecules harvest both singlet and triplet excitons for light emission through fluorescence decay channels. We call this new luminescence concept “hyperfluorescence.”