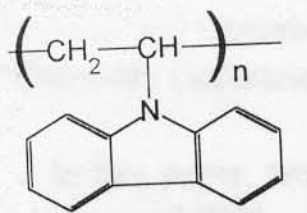


**Strong Electroluminescence from Molecularly Doped Polymers:** C.C. WU, J.C. Sturm, R.A. Register, and \*M.E. Thompson, Advanced Technology Center for Photonic and Optoelectronic Materials, Princeton University, Princeton, NJ 08544, \*Chemistry Department, University of Southern California, Los Angeles, CA 90089

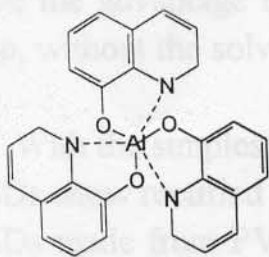
In this paper, we report LEDs made from a new family of molecularly doped polymers (MDP), in which the hole-transporting matrix polymer poly(9-vinylcarbazole) (PVK) is doped with the electron-transporting molecule tris(8-hydroxy quinolate) aluminum (Alq) and different fluorescent dyes. These devices have the advantage that they can be fabricated in a single spin-coating deposition step, without the solvent problems of separate carrier transport and emissive layers.

With the simplest ITO/ spin-coated single-layer MDP/Mg:Ag structure, all these LEDs show rectified I-V characteristics and emit light only under forward bias. The LEDs made from PVK/Alq emit green light from the Alq doped into the polymer, but the efficiency is low, at most about 0.1%. Further doping PVK/Alq with a tiny amount of organic dye, usually less than 1 wt% in total, transforms the luminescence spectra to that of the organic dye and dramatically raises the quantum efficiency. By tailoring the ratio between PVK, Alq and organic dye, we have been able to achieve relatively high external quantum efficiencies, for example, 0.7% for orange-red and 0.5% for green, measuring only the light emission through the back of the glass substrate. A typical composition by weight is 100:40:X (PVK:Alq:dye,  $0.1 < X < 1$ ). The organic dyes used include Nile red (orange-red) and coumarin 6 (green). Practical brightnesses can be obtained at reasonable operating voltages, for example, 100 cd/m<sup>2</sup> at about 12V and brightness ~4000 cd/m<sup>2</sup> at about 20V. Initial non-optimized reliability tests of devices not sealed in hermetic packages indicate that these devices can be continuously operated well over 100 hours before the brightness drops to one half of its initial value.

The organic dye molecules doped into the PVK/Alq are thought to function as efficient emission centers. Comparing the energy levels of PVK, Alq and organic dyes suggests at least two possible mechanisms for the emission from these centers, i.e. the carrier trapping model and the energy transfer model. In the first case, they trap both holes and electrons and form excitons on themselves. In the latter case, they trap excitons formed on Alq. In any case, these dilutely dispersed dyes have a lower nonradiative rate of exciton recombination than the PVK/Alq matrix, and therefore lead to a much higher luminescence efficiency.



PVK



Alq

Fig. 1 Chemical structure of PVK and Alq

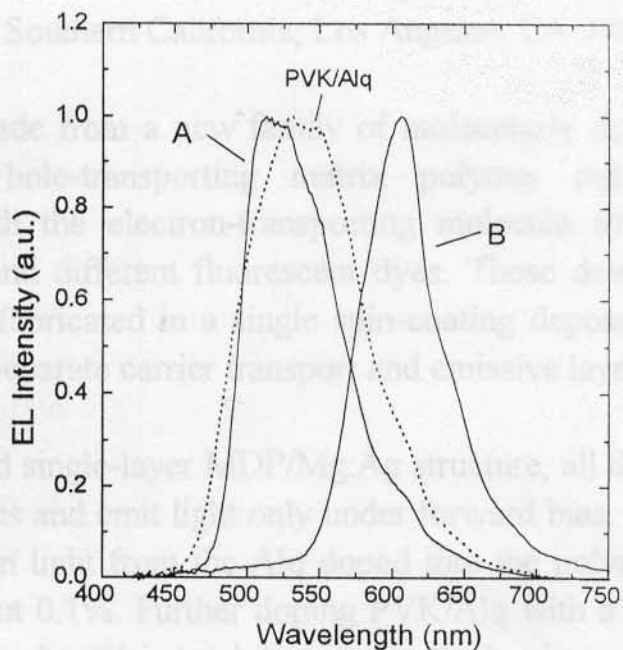


Fig. 2 Electroluminescence spectra of PVK/Alq, PVK/Alq doped with a green dye (coumarin 6, A) and PVK/Alq doped with an orange-red dye (nile red, B).

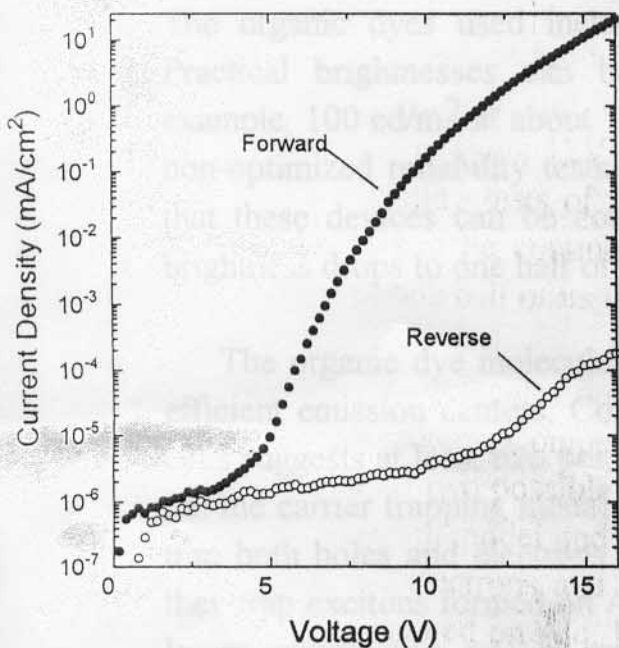


Fig. 3 Typical I-V characteristics

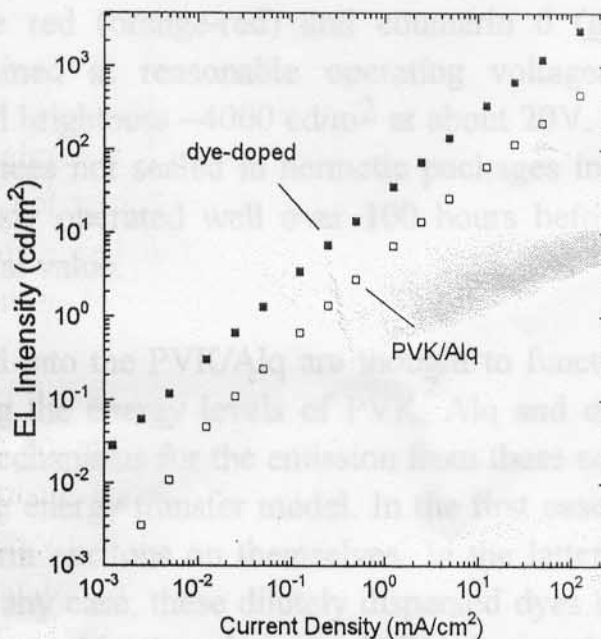


Fig. 4 Light intensity vs. dc drive current for PVK/Alq and dye-doped PVK/Alq