4. Future Work

Future work should focus on highly efficient white phosphorescent polymeric light-emitting diodes. The first idea was simple. With these achievements we have obtained, could we just put blue-emitting and red-emitting materials into the blend, thus making a hodgepodge-like blend with 6 materials, to get white PLED with high efficiency? The advantage of this is that we may get it work by just producing one emitting layer.

For the first trial we blended the following 6 materials with the ratio $PVK : PBD : TPD : Ir(mppy)_3 : DPVBi : DCJTB = 61 : 24 : 9 : 6 : 4800 : 24$. Notice that DPVBi is a blue-emitting small molecule while DCJTB is a red-emitting small molecule. The blending ratio among them was chosen to maintain the ratio among the four-ingredient blend, and, initially, to make the ratio of blue:red:green (i.e., DPVBi:DCJTB:Ir(mppy)$_3$) to be 200:1:1. However, we understand that the green emitter approximately more efficiently emits 4 times greater than the other two emitters. Thus we reduced the green emitter, Ir(mppy)$_3$, to a quarter. Therefore blue:red:green, (i.e., DPVBi:DCJTB:Ir(mppy)$_3$) was set to 200:1:0.25. Figure 4.1 shows the EA-IPs of the materials and insets show the two new emitters.

Figure 4.2 shows the spectra of the device. Although the CIE coordinate of it was about (0.39,0.39)[1], it hardly put out light. Luminance of the device was just about 20 cd/m^2 while yield was lower than 0.01 cd/A.

There were two major points that made the device inefficient. Firstly, almost every material in the blend was a small molecule (only 1% of PVK was a polymer). Therefore the film was bad. Secondly, blending more emitters may break the electron-hole balance in the original 4-material system. Therefore, to get high-efficiency devices, it is probably more plausible to separate the red emitter and blue emitter to different layers.

Next we try to separate DCJTB from the blend and adulterate it into TFB. The blend of TFB and DCJTB is then spin-coated at the first layer and serves as the hole-transporting material as well. Experiments showed that the first TFB:DCJTB layer could not be baked at 180°C. If we did so, the DCJTB somehow would be damaged and there would be no red-emitting

[1] The pure white has CIE coordinate of (0.33,0.33).

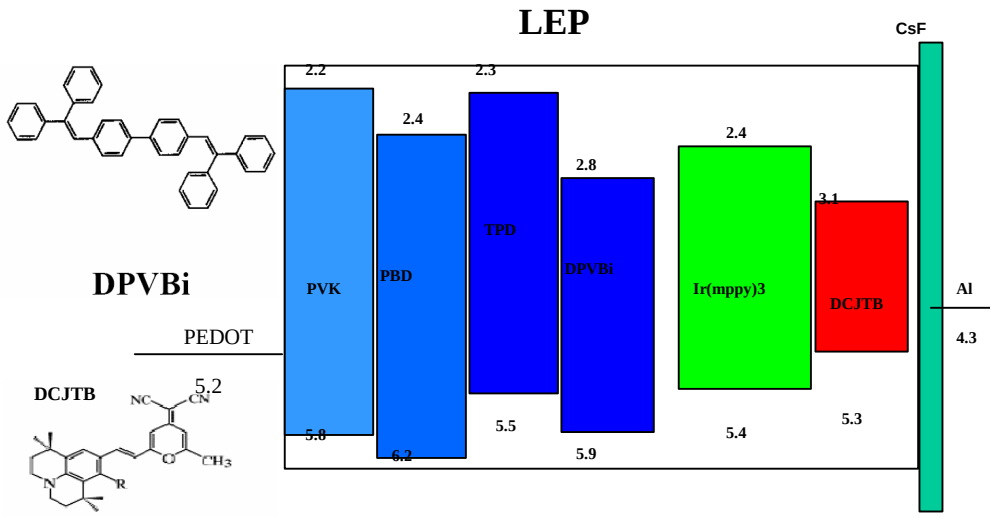

Figure 4.1: EA-IPs of the 6-ingredient blend.

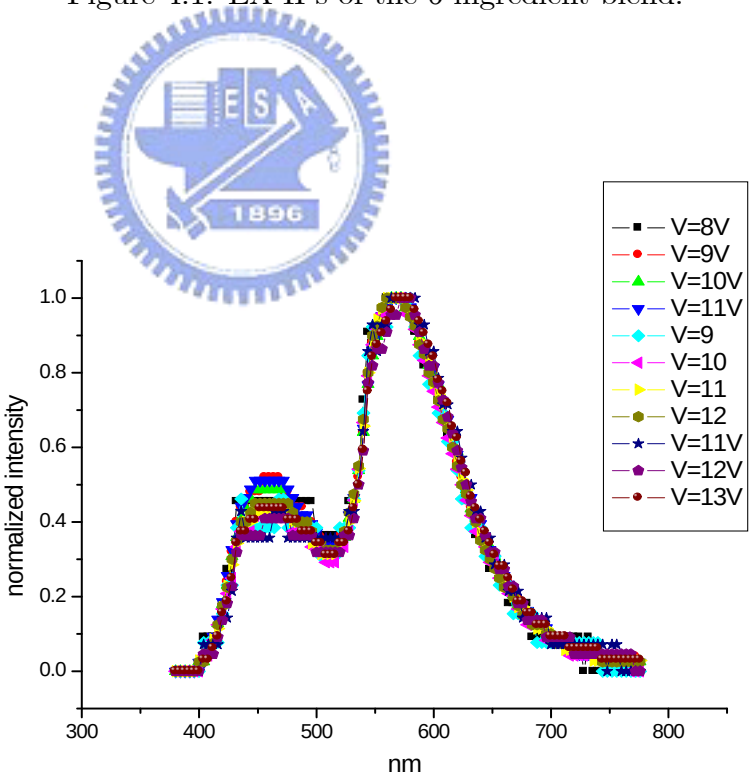

Figure 4.2: Spectra of 6-material blend. The device hardly put out light.

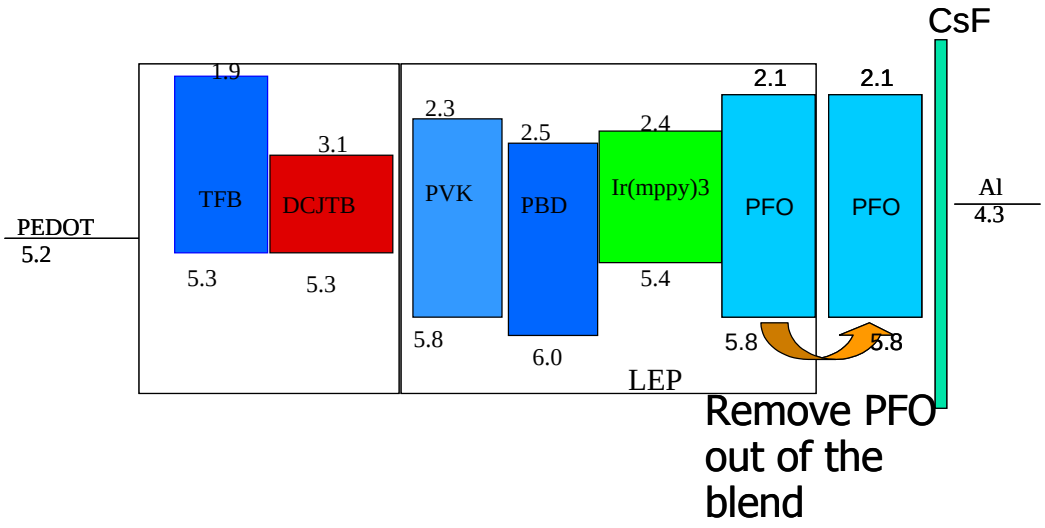

Figure 4.3: The EA-IPs of the multilayer white device.

peak at the spectra. However, if we bake the blend at 120°C, DCJTB works well for putting out red light. We also once tried to replace the blue DPVBi small molecule with PFO. Nevertheless, the hodgepodge blend with DPVBi being replaced by PFO could not perform well on yield and lumnance even if it was really close enough to white. We therefore believe that it would be a better idea to remove PFO out of the blend. The EA-IPs of materials are in Figure 4.3. We dumped TPD this time because we knew that for the bi-layer case yield would be better without TPD in the LEP. Performance and spectra of devices are in Figure 4.4 and Figure 4.5, respectively.

We see from Figure 4.5 that some excitons are formed on DCJTB and relax to photons with peak 588 nm. One may argue that the peak is generated by energy transfer from green (from $Ir(mppy)_3$). However, it may not be true because almost every exciton recombined on $Ir(mppy)_3$ is triplet. Even if it transfers from triplet states of $Ir(mppy)_3$ to those of DCJTB, the triplet exciton in DCJTB should not relax to the ground state because DCJTB is not a heavy metal complex. Therefore red photons should mostly come from direct recombination of holes and electrons on DCJTB.

We can observe that the device symbolic of ■ in Figure 4.4 has yield of about 14 cd/A. It also has a peak at 588 nm. However, luminance of it is as low as 1,000 cd/m^2. We impute this to inappropriate baking temperature

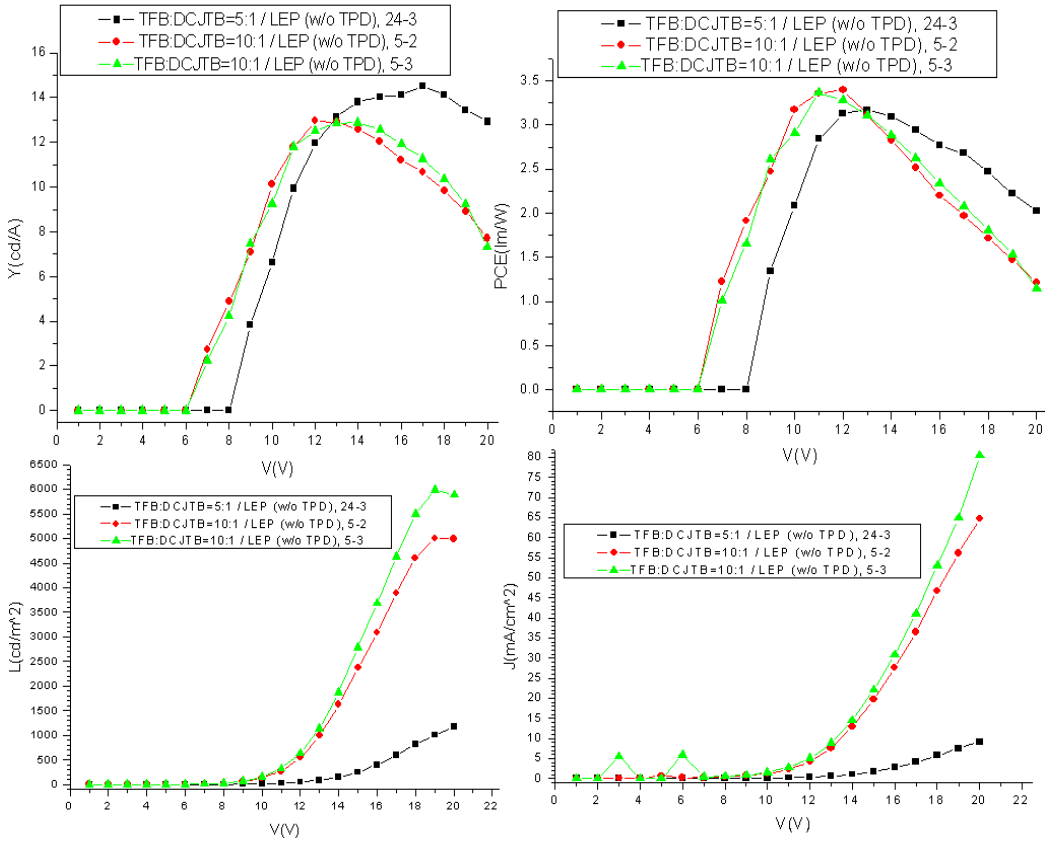

Figure 4.4: Performance of devices on the basis of LEP to convert to red-emitting with high efficiency.

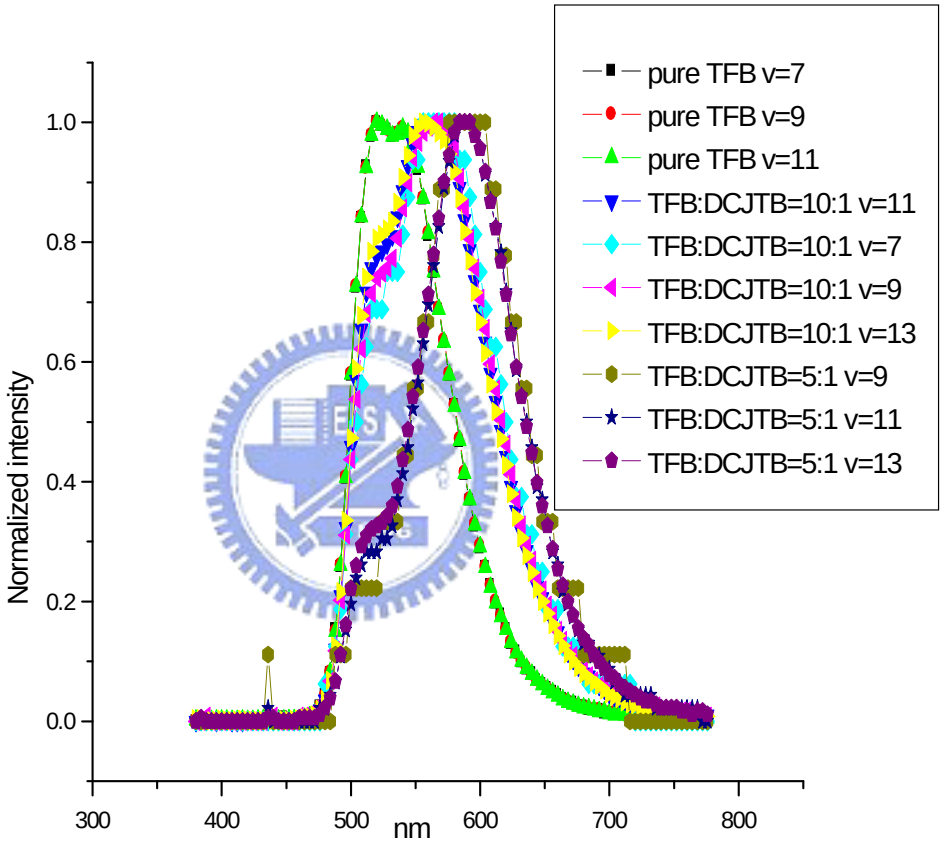

Figure 4.5: Spectra of devices on the basis of LEP to convert to red-emitting with high efficiency.

of the TFB:DCJTB blend. We guess that there is a more suitable baking temperature between 120°C and 180°C.

Up to now we have demonstrated the possibility of converting green to green-red. In the mean time we could still maintain the characteristic of high efficiency. In the future there is only one step left behind to achieve white. We may spin-coat PFO at the third layer. Furthermore, we may replace DCJTB with red Iridium. I hope my junior co-work will take charge of this and he will produce world-record white PLED very soon.