Blue Emitting Pt and Pd Complexes for Displays and Lighting Applications

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Phosphorescent Materials

Max theoretical quantum efficiency

<table>
<thead>
<tr>
<th></th>
<th>Fluorescent</th>
<th>Phosphorescent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal</td>
<td>25%</td>
<td>100%</td>
</tr>
<tr>
<td>External</td>
<td>5%</td>
<td>20%</td>
</tr>
</tbody>
</table>

Heavy metal complexes, introduced by Forrest and Thompson since 1998.

Harvested both by fluorescent and phosphorescent dyes

Harvested only by phosphorescent dyes

Quantum statistics of excitons

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>triplet</td>
<td>$s =</td>
</tr>
<tr>
<td>singlet</td>
<td>$s = \frac{1}{\sqrt{2}}(</td>
</tr>
</tbody>
</table>

Excitons

- Symmetric states
- Asymmetric states

Singlet 25% Triplet 75%
How to harvest 100% electro-generated excitons?

**PHOLED:**

**TADF:**
2) Hashimoto *et al.*, JACS (2011)

**MADF:**
Li *et al.*, PCT/US13/66793

**DF/PH Emitter**
Maintaining a $\Phi$ of close to 1 and a $\tau$ of close to 1 $\mu$s.
Blue triplet emitter design

1. Add electron withdrawing groups to lower HOMO
2. Replace pyridine with azole groups to raise LUMO
3. Break conjugation with 6-membered chelating rings

- FLrpic
- Irpmi
- Pt-4
- PtON1
- PtON2
- PtNON

(1) Blue emitters with green triplet energy
(2) Ppy-based blue emitters
Tetradentate Pt Complexes

<table>
<thead>
<tr>
<th>Complex</th>
<th>$\lambda_{\text{max}}$ (nm)</th>
<th>$\Phi$ (%)</th>
<th>$\tau$ (μs)</th>
<th>$k_r$ ($\times 10^4$ s$^{-1}$)</th>
<th>$k_{nr}$ ($\times 10^4$ s$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PtON7</td>
<td>452</td>
<td>89</td>
<td>4.1</td>
<td>21</td>
<td>2.6</td>
</tr>
<tr>
<td>PtOO7</td>
<td>442</td>
<td>58</td>
<td>2.5</td>
<td>23</td>
<td>17</td>
</tr>
<tr>
<td>Pt-16$^{[9b]}$</td>
<td>450</td>
<td>32</td>
<td>5.1</td>
<td>6.3</td>
<td>13.3</td>
</tr>
<tr>
<td>Pt(Mepmic)$^{[9a]}$</td>
<td>419</td>
<td>20</td>
<td>25</td>
<td>0.8</td>
<td>3.2</td>
</tr>
<tr>
<td>Ir(cnpmic)$^{[7b]}$</td>
<td>425 (sh), 450</td>
<td>78</td>
<td>19.5</td>
<td>4</td>
<td>1.1</td>
</tr>
<tr>
<td>Ir(dbfmi)$^{[7a]}$</td>
<td>445</td>
<td>70$^a$</td>
<td>19.6</td>
<td>3.6</td>
<td>1.5</td>
</tr>
<tr>
<td>PtON1</td>
<td>449</td>
<td>85</td>
<td>4.5</td>
<td>19</td>
<td>3.3</td>
</tr>
</tbody>
</table>

First Blue Emitter with 6-membered Chelate Rings

Estimated LT70 of 1337 hr @1000 nits, reported most stable blue emitters with triplet energy of over 2.8 eV.

Why MADF materials?

Magic of MADF?

77 K → RT

Limit set by carbazole host

S0  ISC  S1  ISC  T1

phosphorescence

Thermal Activated Delayed Fluorescence (TADF)

Metal Assisted Delayed Fluorescence (MADF)

PL Intensity (a.u.)

Wavelength (nm)

Limit set by carbazole host
Take-home message

- New emitter design can play a key role of blue OLED development.