Investigating Solution Based Testing of OLED Emitter Molecules

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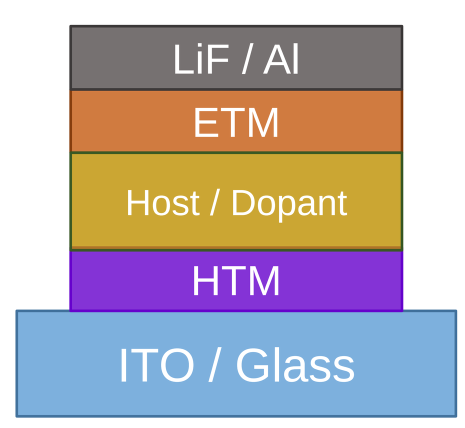
Motivation

- Organic Light-Emitting Devices (OLEDs) allow the fabrication of thin, light and efficient displays as well as efficient, tunable lighting.
- Blue-colored OLEDs present the biggest challenge to the industry due to their short lifetimes and poor efficiencies relative to other OLEDs.
- A major goal for OLED technology is to find new blue emitter molecules that allow for improved device stability. This requires a method for testing new molecules.
- Conventional testing is based on making prototype OLED devices with the new emitter molecule. This method has two large issues:
  1. Making a prototype device is relatively time consuming and expensive.
  2. The resulting device performance is dependent on more than just the emitter molecule.

Typical OLED architecture, consisting of hole-transport material (HTM), host with an emissive dopant, and an electron-transport material (ETM).



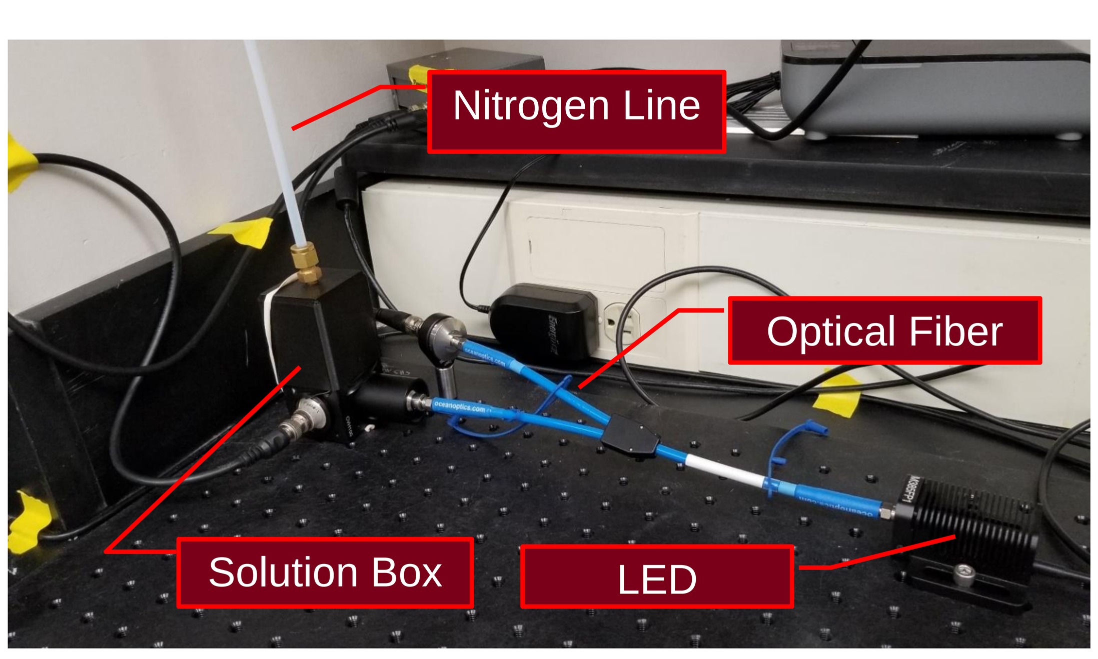
Solution Photoluminescence (PL)

The below method of Solution PL testing can overcome the issues listed above.

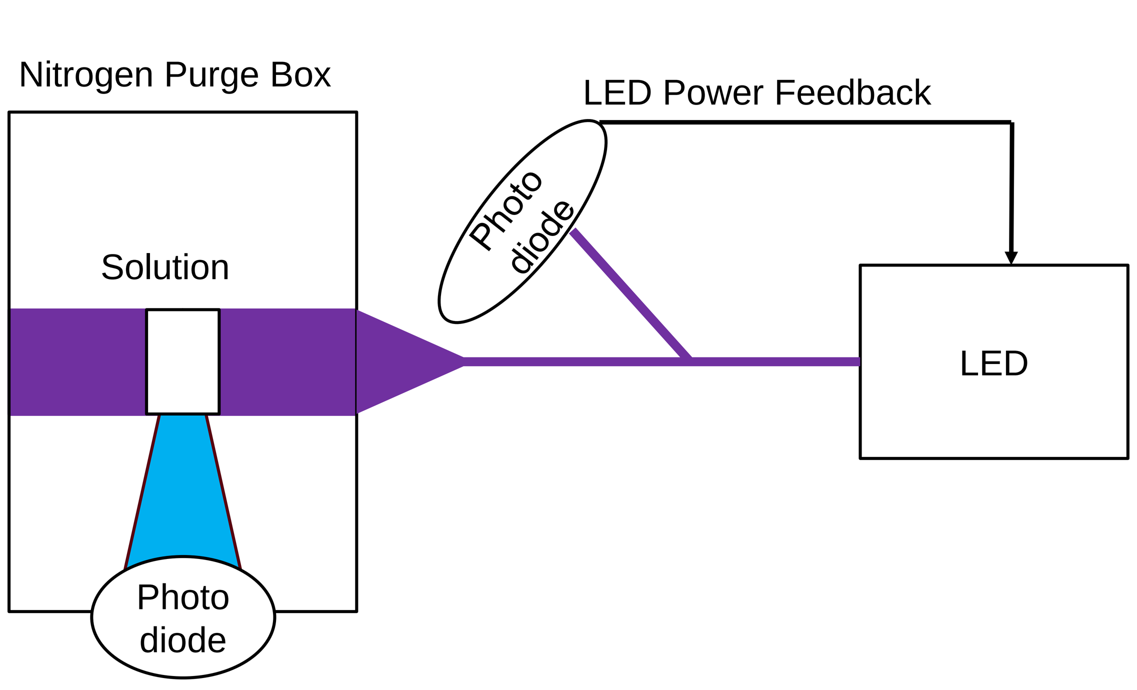
1. The emitter molecule is dissolved in a suitable solvent.
2. The solution is loaded into a cuvette, and placed in the testing apparatus.
3. Ultra-violet light from an LED shines on the solution, exciting the emitter molecules and causing them to emit light. The intensity of emitted light is measured.
4. As the experiment progresses, the molecules optically degrade, resulting in a decrease in emission intensity.
5. The timescale of this degradation can be compared to that of known emitter molecules.

This is a cheaper, faster, and easier way to screen potential emitter molecules than fabricating complete OLEDs.

Experimental Design



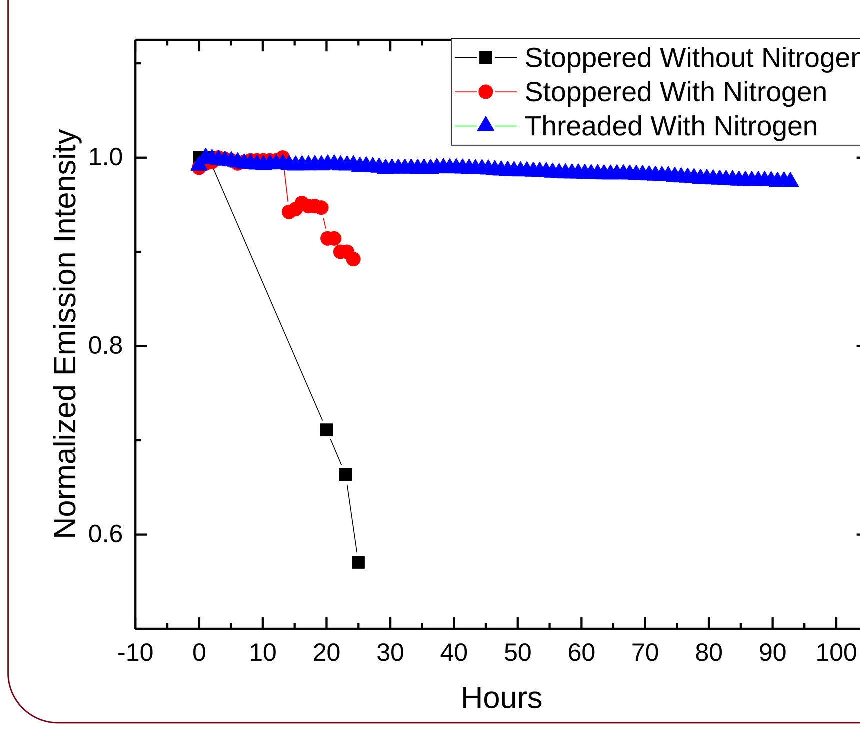
- The blue split optical fiber routes the LED's light to the solution box, and to a photodiode for power feedback.
- The gas line pumps nitrogen gas into the black solution box.
- A second photodiode is mounted on the box perpendicular to the incident LED light to measure the solution's emission.

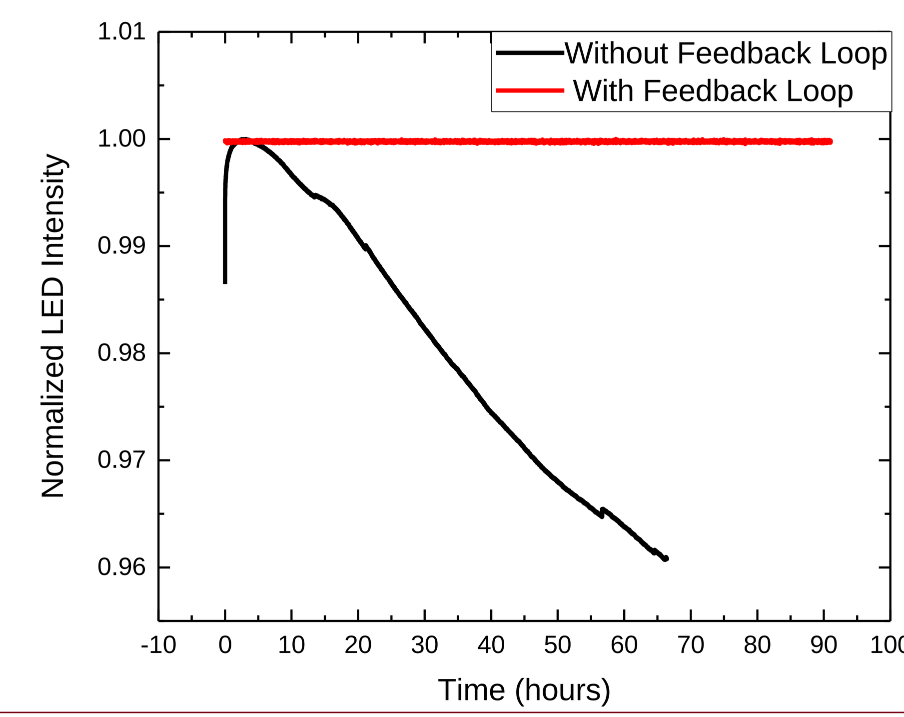


Development

Two main issues were present in the initial setup: oxygen contamination and unstable LED intensity

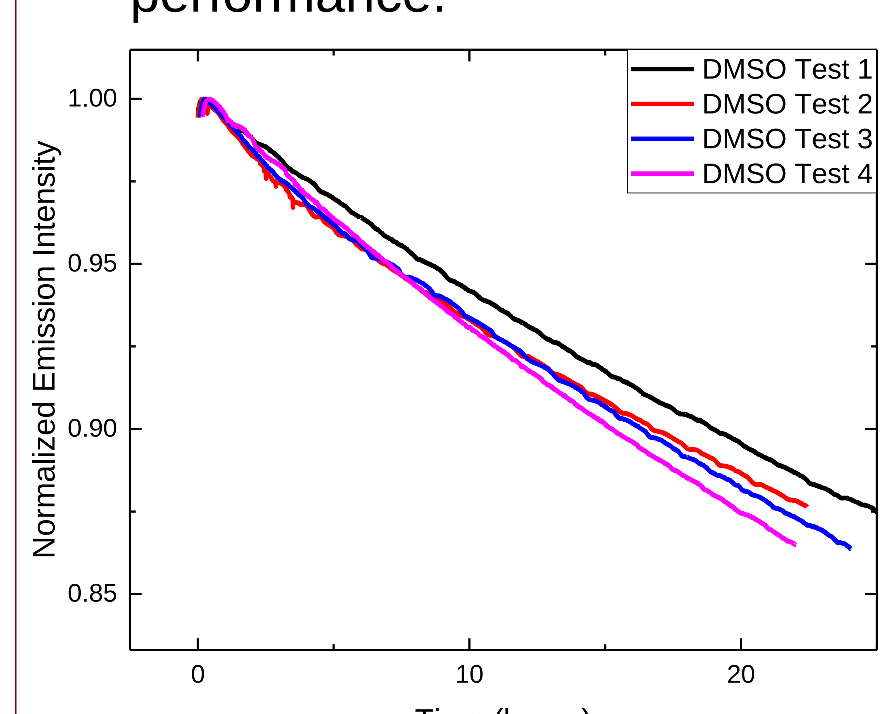
- Oxygen contamination was solved by switching from a stoppered cuvette to a threaded cuvette, and using nitrogen gas to create an inert atmosphere around the cuvette.
- LED intensity was stabilized with a feedback loop that continuously adjusts the LED's current supply.

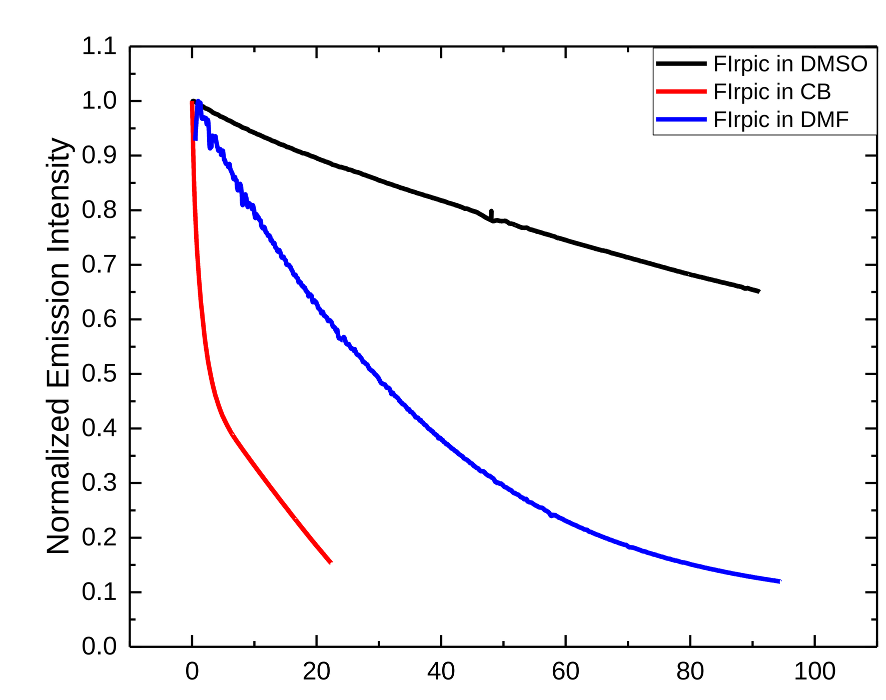


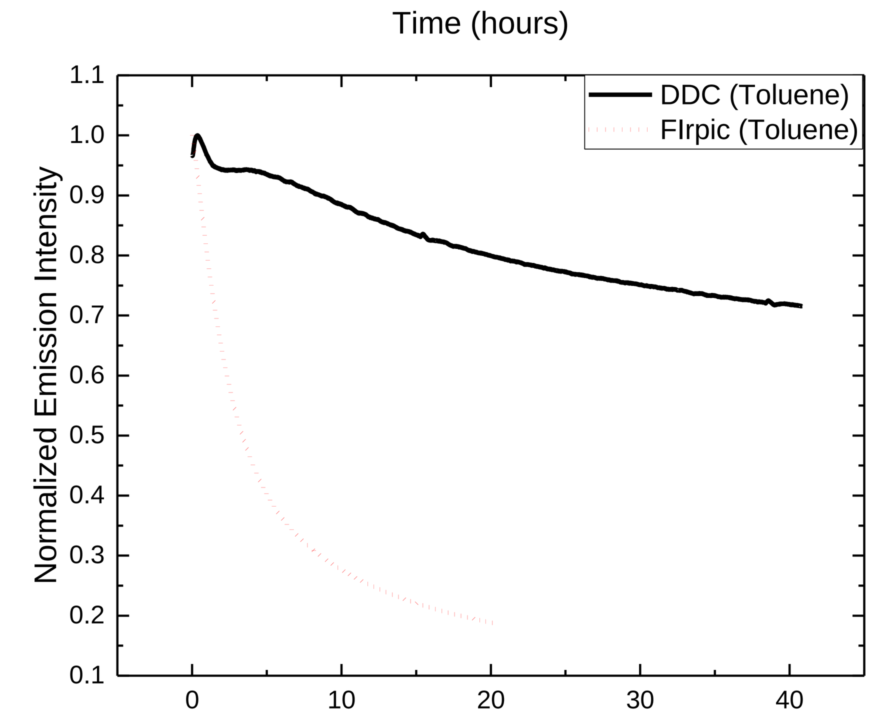


Results

- The left graph below demonstrates the reproducibility of this method. These four tests were done on a 20 µM solution of FIrpic (a blue emitter) dissolved in dimethyl sulfoxide (DMSO), and show consistent, low noise results.
- The graph on the right shows the results from the same emitter in two additional solvents: dimethylformamide (DMF) and chlorobenzene (CB). These varying results show a solvent dependence, meaning that the solvent used must be considered when comparing emitter performance.







This graph demonstrates the power of solution based testing. DDCzTRz (DDC) is a blue emitter known to have higher stability than FIrpic in OLED devices. With toluene as the solvent, DDC showed a much longer lifetime than FIrpic, a result visible within the first few hours of testing.

Conclusions/Future Work

Now that the setup is functional, the next steps are:

- Test several other known emitters. Data from these molecules can be used to confirm if there is a correlation between emitter performance in solution and in OLEDs.
- If this correlation is observed, the setup can be used to quickly test the potential of newly developed emitter molecules.
- Investigate the observed solvent dependence with other emitters.