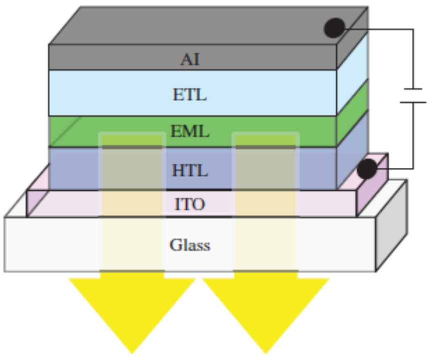
General components of an OLED and materials used:



MATERIALS USED IN AN OLED:

1. **Substrate**

The substrate is used to support the OLED. The substrate most commonly used may be a plastic, foil or even glass. The material should be transparent.

2. **Anode**

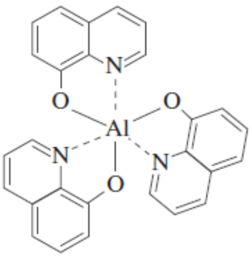
The anode component usually used is indium tin oxide ITO. This material is transparent to visible light and is sufficiently conducting and has a high work function which promotes injection of holes into the HOMO level of the organic layer.

3. **Cathode**

Usually metals like barium, calcium and aluminium are used as a cathode because they have low work functions which help in injecting electrons into the LUMO level of the different layers.

4. **Emissive layer:**

The light emitting material may be small organic molecules or polymers(Polymer light emitting diodes, PLED).

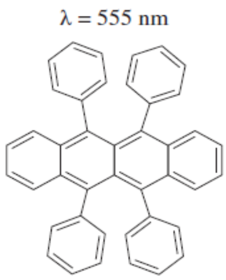


(a) Metal Chelates

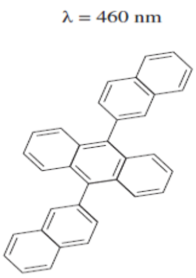
- The metal chelate structure consists of a metal atom surrounded by ligands. They were the first category of materials to be utilized in OLEDs, beginning with tris(8-hydroxyquinolinato)aluminum (Alq3), shown in the figure, which shows a green electroluminescence
- Metal chelates typically have an electron mobility much greater than their hole mobility, making them suitable for use as an ETL in OLED.

(b) Polycyclic Aromatic Hydrocarbon Oligomers (PAH):

Eg., Derivatives of naphthalene, anthracene, tetracene



tetracene derivative



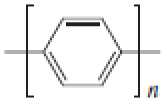
anthracene derivative

PAHs are particularly useful because of their high hole mobility for the fabrication of efficient OLEDs if combined with an electron conducting molecule such as a metal chelate.

(c) Conjugated Polymers

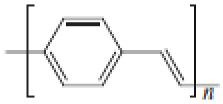
(*p*-phenylene vinylene) PPV , poly-p-Phenylene, polyfluorene, polythiophene derivatives

(A) $\lambda = 401$ nm



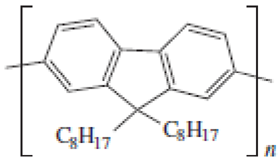
Poly-p-phenylene

(B) $\lambda = 550$ nm



PPV

(C) $\lambda = 425$ nm

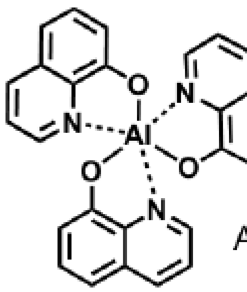


Polyfluorene

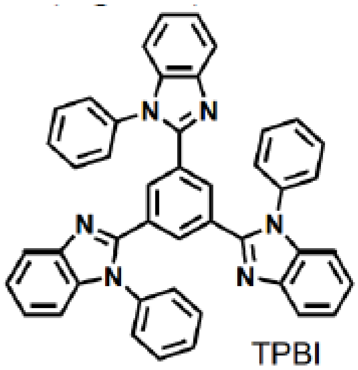
5. Electron and Hole transport layers:

Organic semiconductors (molecules with a conjugated electron system) show a higher mobility for one type of charge carriers (holes or electrons). This might be due to impurities or structural defects in the molecular layer. Thus, the materials for ETL and HTL are selected according to their intrinsic mobility preferences (as to be a hole or an electron transporter).

For example

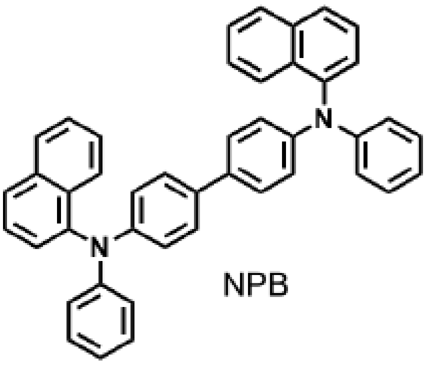


Alq_3



TPBI

are used as electron transport layers.



NPB

Is used as hole transport layer

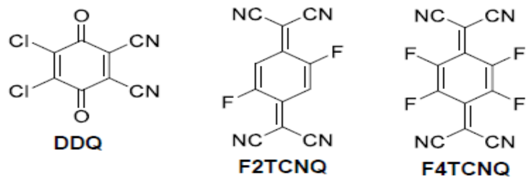
Doping of ETL and HTL layers: Charge transfer complexes

One of the methods to improve the charge carrier mobilities of the ETL and HTL is doping with molecules that act as acceptors or donors with respect to the ETL and HTL materials, to form molecular adducts called charge transfer complexes.

Charge transfer complexes are formed by partial transfer of an electron from the donor molecule of low ionisation potential to an acceptor molecule of high electron affinity.

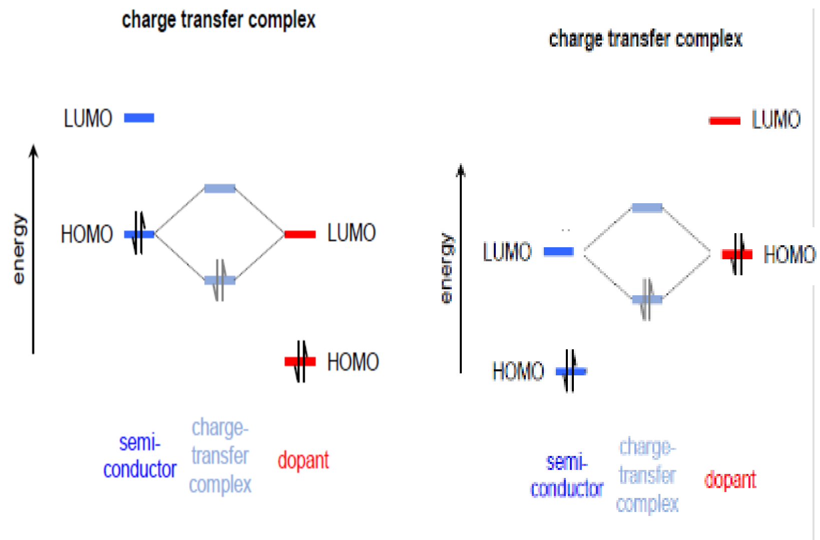
$$D + A \dashrightarrow D^{\delta+} A^{\delta-}$$

(Note: when strong oxidising and reducing agents are used complete charge transfer occurs, leading to the formation of radical ions)



Tetracyano-quinodimethane(TCNQ) derivatives and dicyano-dichloro-quinone (DDQ) are examples for strong acceptor molecules and they form charge transfer complexes with organic semiconductors and improve their hole transport properties.

Partial charge transfer to form a charge transfer complex occurs through the interaction between molecular orbitals of the semiconductor and dopant as shown below.



Semiconductor- Donor
Dopant – Acceptor
p-type doping

Semiconductor- Acceptor
Dopant -Donor
n-type doping

If complete charge transfer occurs ion-pairs are formed. The energy diagram for the process is shown below.