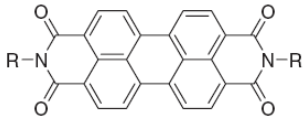
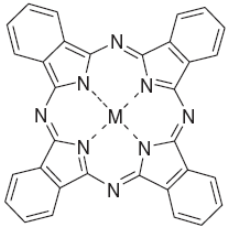
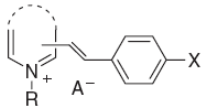
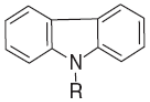
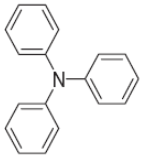
TABLE 5.1
Summary of Major Classes of Organic Small Molecules

Classes	Property	Application Fields	Parent or Basic Structures
Perylene bisimides	n-Type semiconductor	Solar cell OLED OFET	
Phthalocyanines	p-Type semiconductor	OLED Solar cell NLO	 M = 2H or Metal
Porphyrins	p-Type semiconductor	Solar cell OLED NLO	 M = 2H or Metal
Cyanines	\	Solar cell NLO	
Carbazoles and triphenylamine derivatives	Hole transport	OLED Hole transport	 Carbazoles  Triphenylamine

Introduction to Organic Electronic and Optoelectronic Materials and Devices (Eds. Sun & Dalton) CRC Press, 2008. ISBN-10: 0849392845

TABLE 5.1 (continued)
Summary of Major Classes of Organic Small Molecules

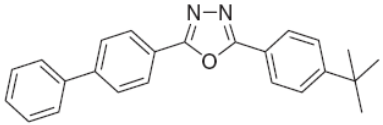
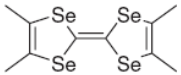
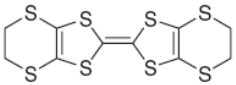
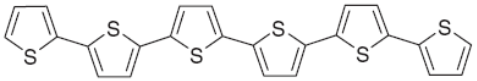
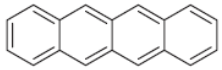
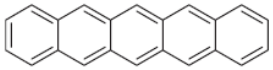
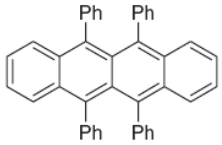
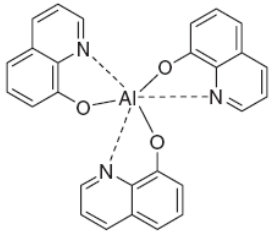
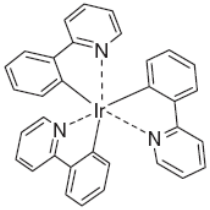
Classes	Property	Application Fields	Parent or Basic Structures
Oxadiazoles	Electron transport	OLED Electron transport	 PBD
Tetrathiafulvalenes	Electron donor	Synthetic metal Solar cell	 TMTSF  ET
Thiophene oligomers	Electron donor	OFET Solar cell	
Polycyclic aromatic hydrocarbons	p-Type semiconductor	OFET OLED	 Tetracene  Pentacene  Rubrene
Complexes		OLED Solar cell	 AlQ_3  $Ir(ppy)_3$

TABLE 5.2

Comparison of Electronic Absorption Data of Macrocyclic Copper(II) Complexes

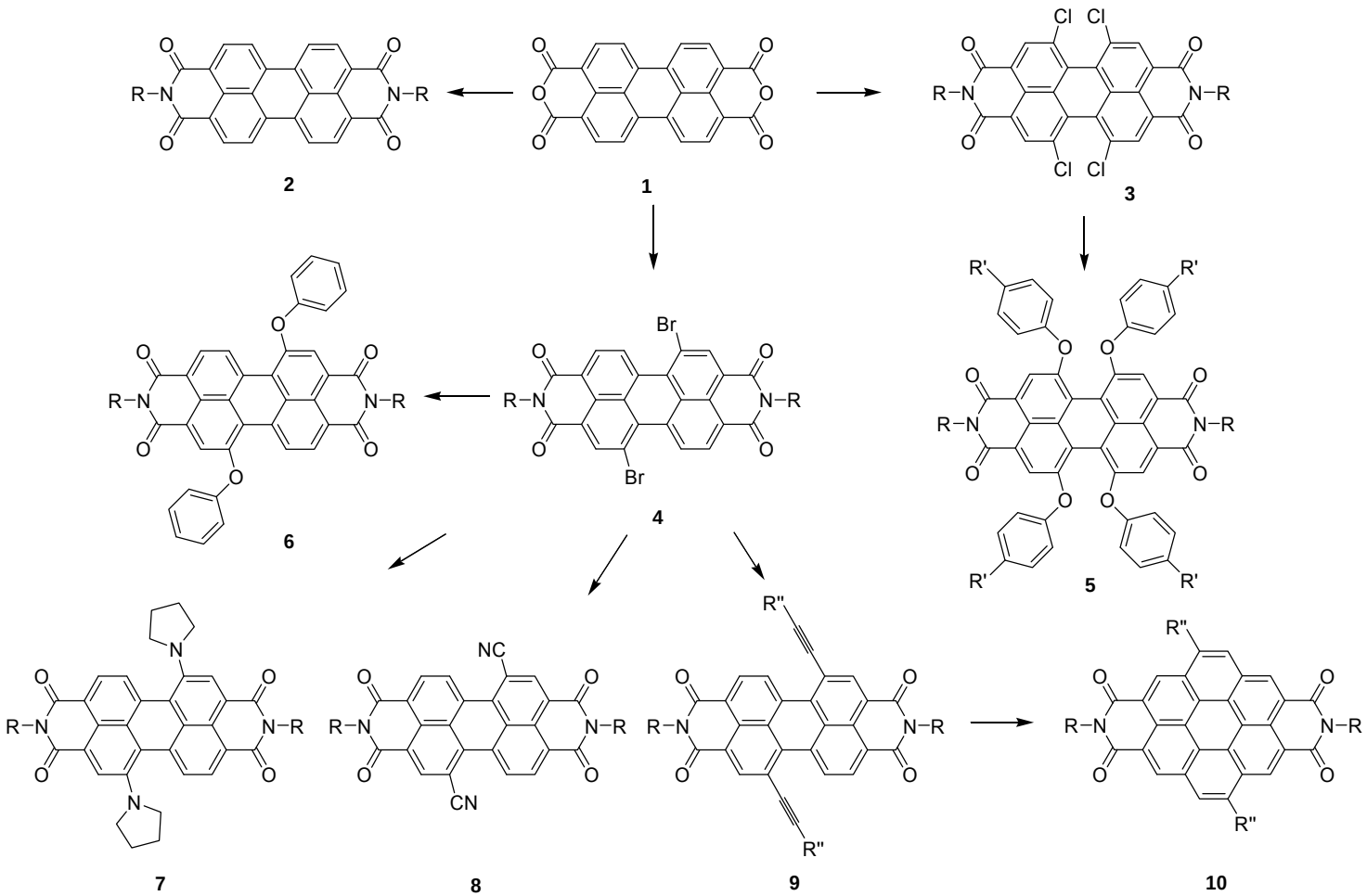
Copper(II) Complexes	Naphthalocyanine	Phthalocyanine	Porphyrin	Tetrazaporphyrin
Q band λ_{max} (logε)	765 (5.23)	678 (5.34)	540 (2.04)	578 (4.98)
B band λ_{max} (logε)	—	350 (4.76)	417 (44.7)	334 (4.57)

Source: From Chen, Z.M., Xia, Z., and Wu, Y.Q., Prog. Chem., 16, 820, 2004. With permission.

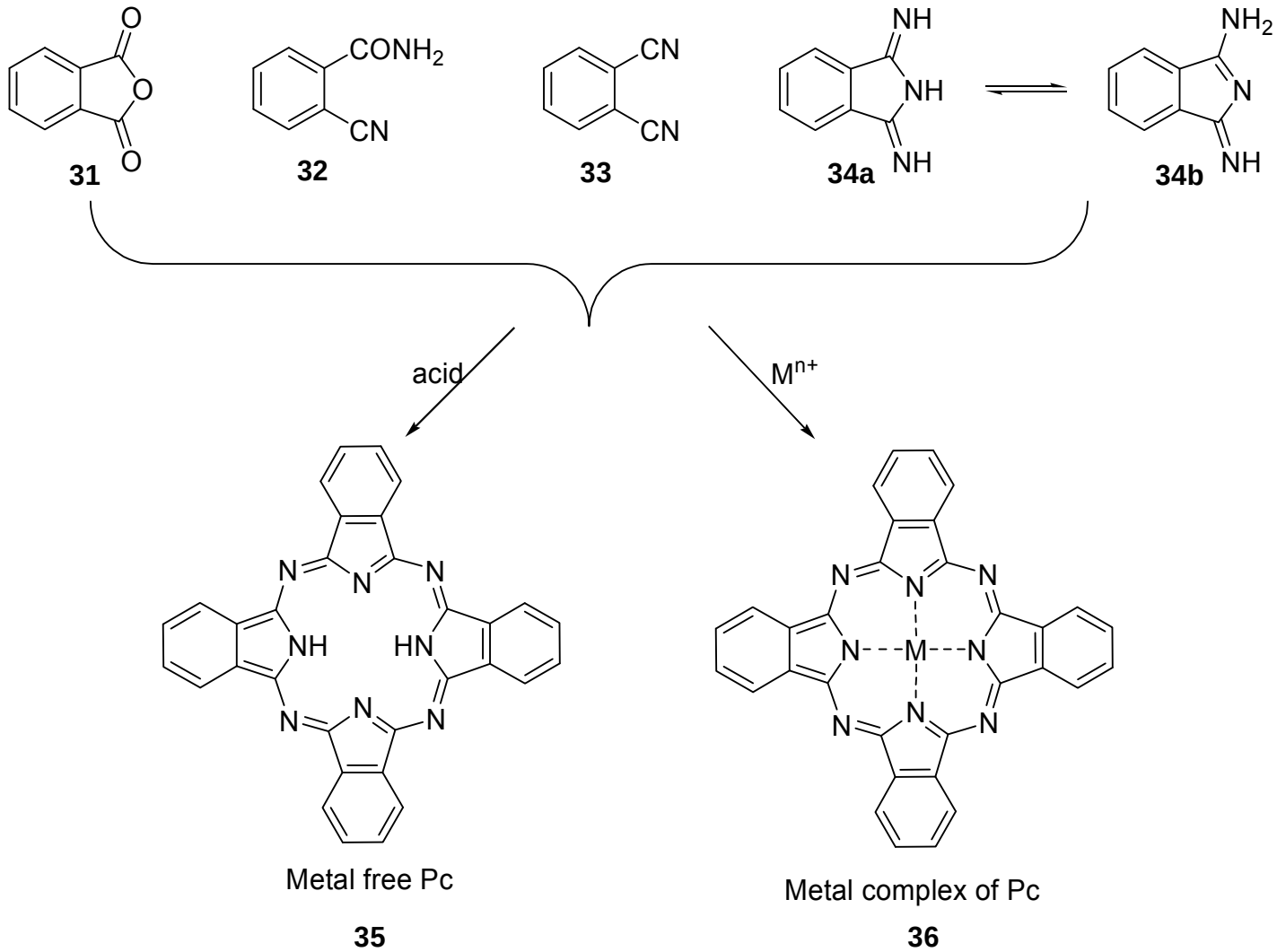
TABLE 5.3
Physical Properties of Typical Hole-Transporting Materials Derived from Carbazole and Triphenylamine Unit

	PPD	ISB	IDB	α-NPD	TPD	BCB	NCB	TNB
T_g (°C)	152	115	110	95	65	110	109	85
Electron affinity (eV)	—	2.06	1.95	2.60	2.30	2.13	2.56	2.60
Ionization potential (eV)	—	5.46	5.30	5.70	5.50	5.53	5.78	5.58

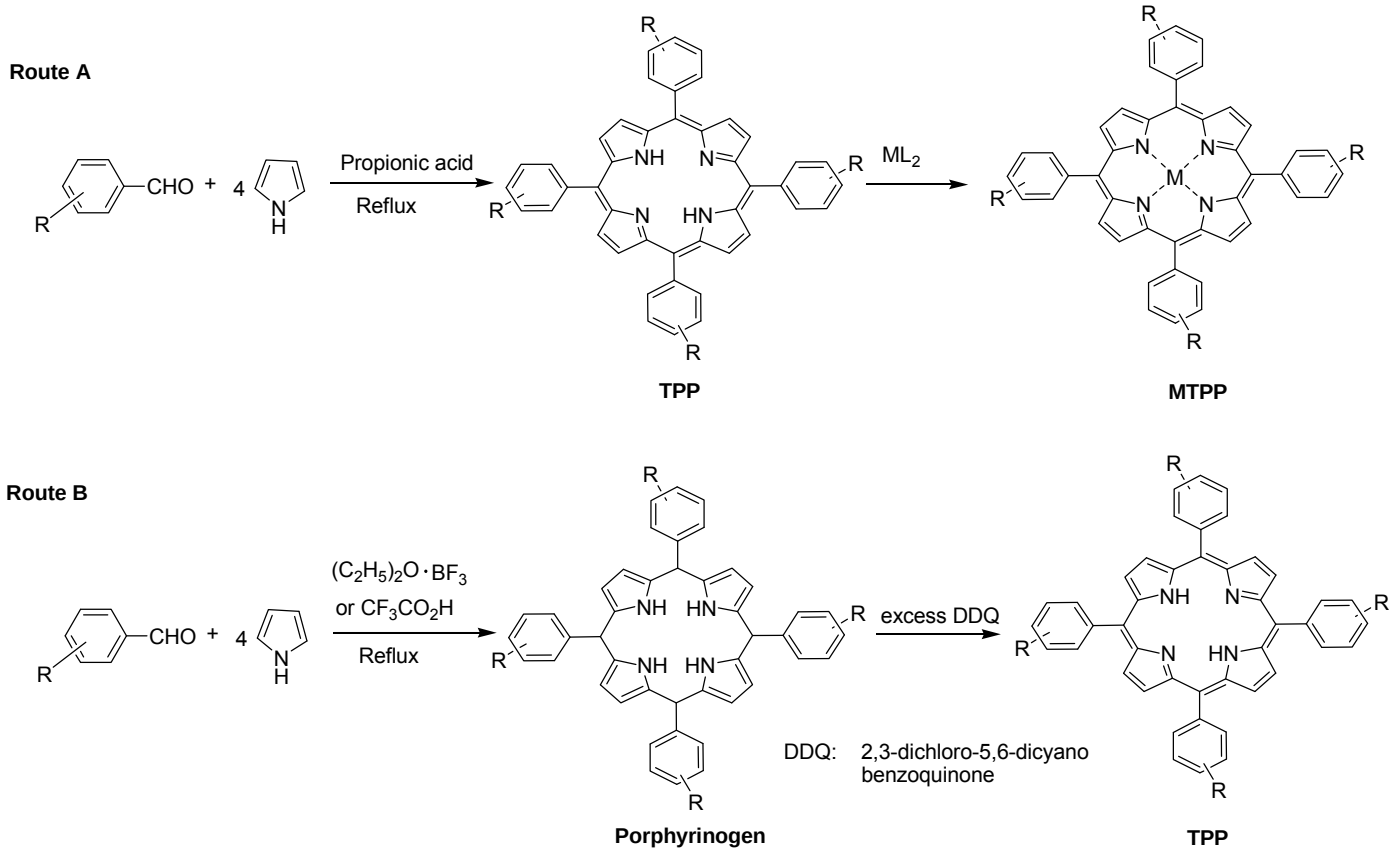
Source: From O'Brien, D.F. et al., *Adv. Mater.*, 10, 1108, 1998. With permission



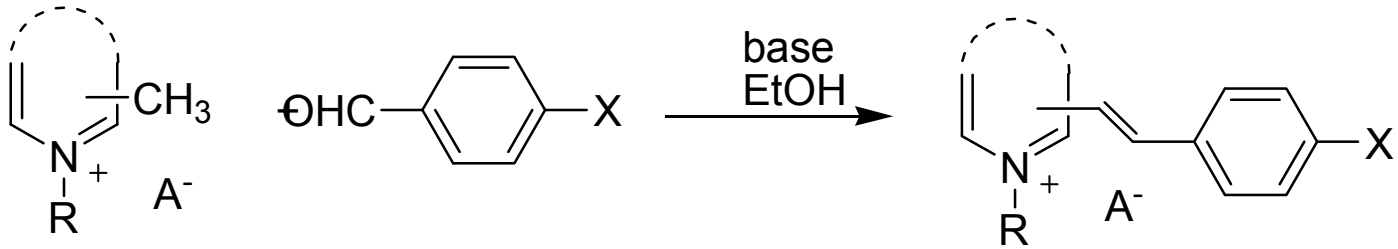
SCHEME 5.1 Synthetic routes to perylene bisimide derivatives



SCHEME 5.2 Synthetic routes of phthalocyanine and metal phthalocyanine.

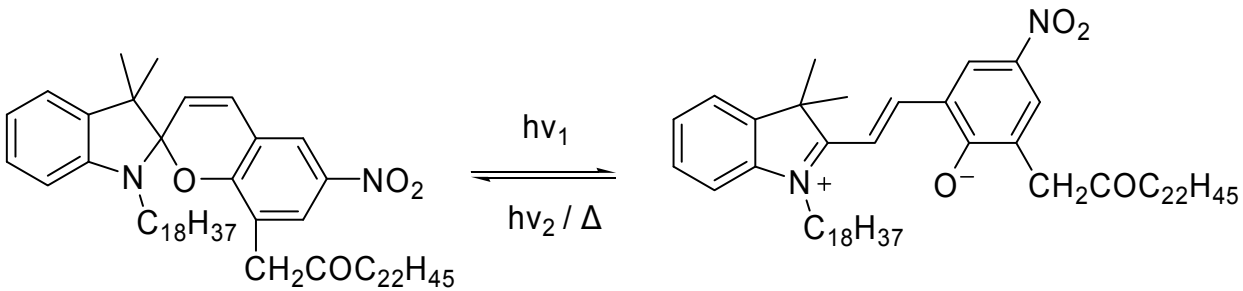


SCHEME 5.3 Synthetic routes for aryl-substituted meso-porphyrin: (A) Adler–Longo's method; (B) Lindsey's method.

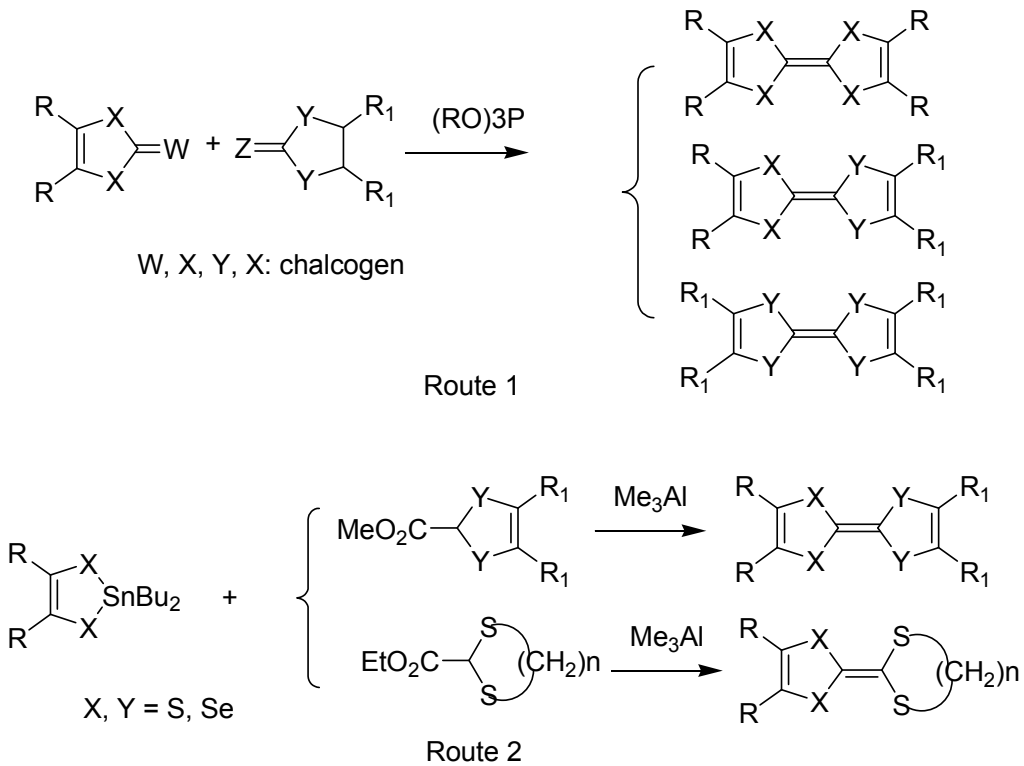


R = alkyl group; X = NMe_2, OMe, OH, H
A = Br, I

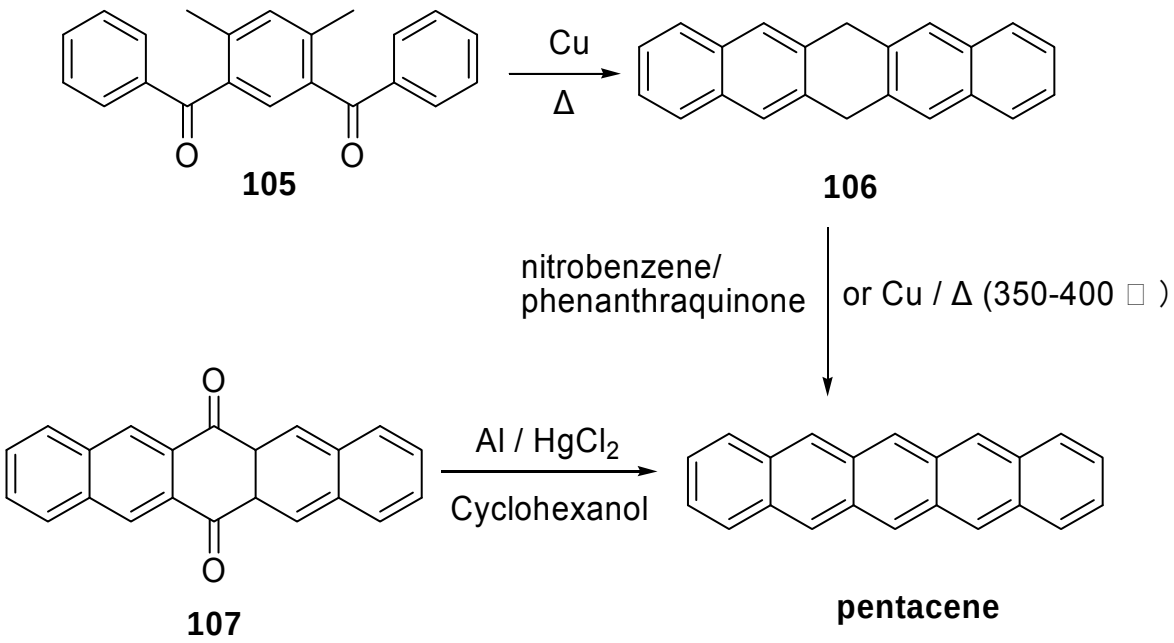
SCHEME 5.4 General method for the synthesis of cyanines



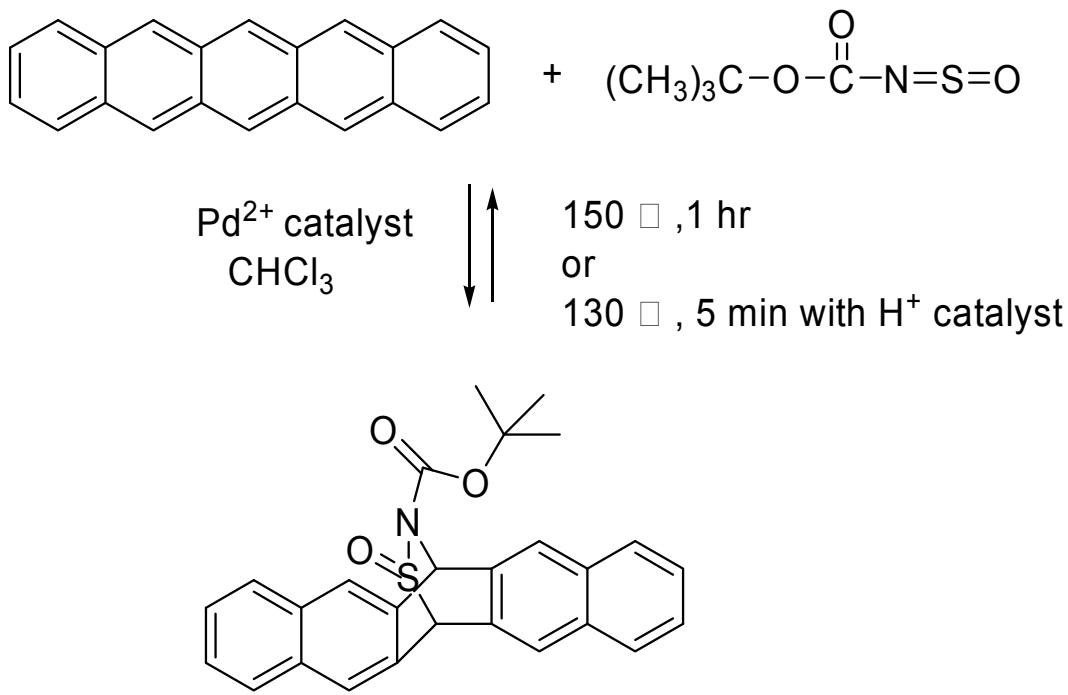
SCHEME 5.5 Photochromic conversion of a spiropyran with NLO effect



SCHEME 5.6 Synthetic routes for TTFs



SCHEME 5.7 Synthetic routes for pentacene



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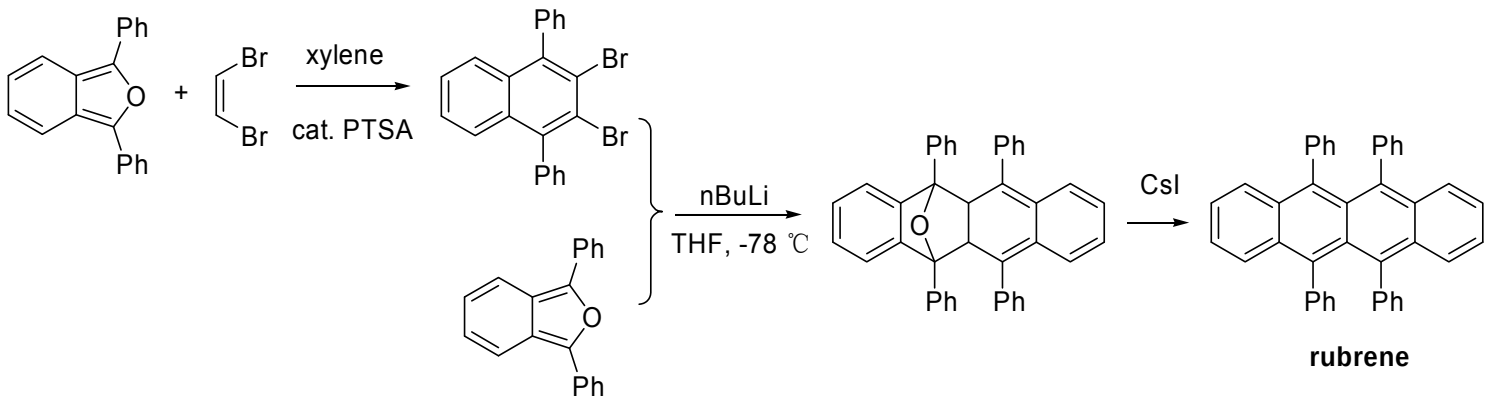
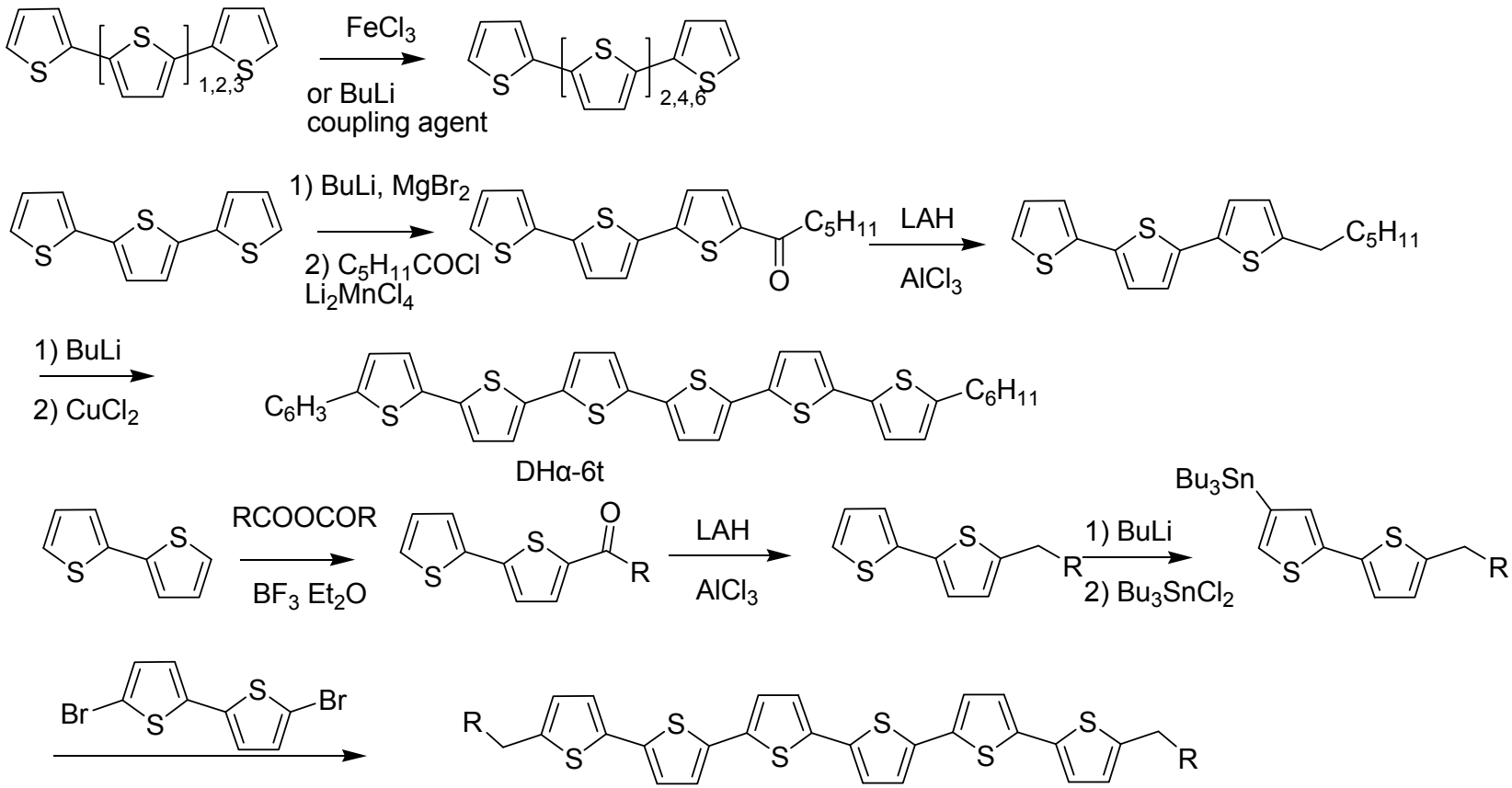
SCHEME 5.8 Conversion between pentene and its precusor



SCHEME 5.9 Synthetic route of rubene described by Doge



SCHEME 5.10 Synthetic routes of thiophene oligomers

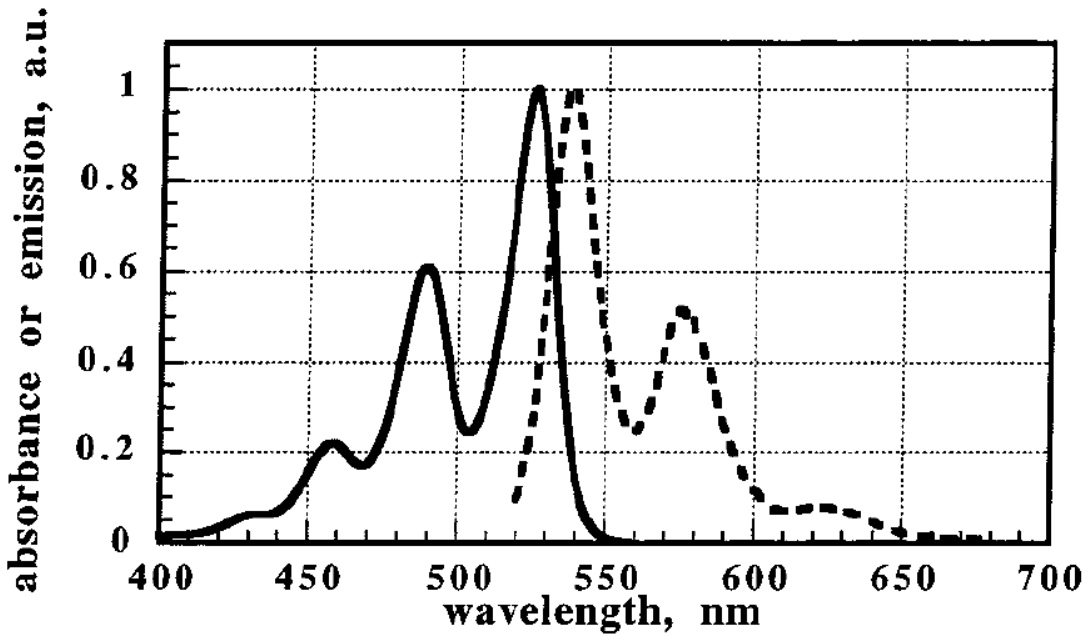


Figure 5.1 Normalized absorption (solid) and emission spectra (dash) of perylene bisimide 11 excited at 489 nm.

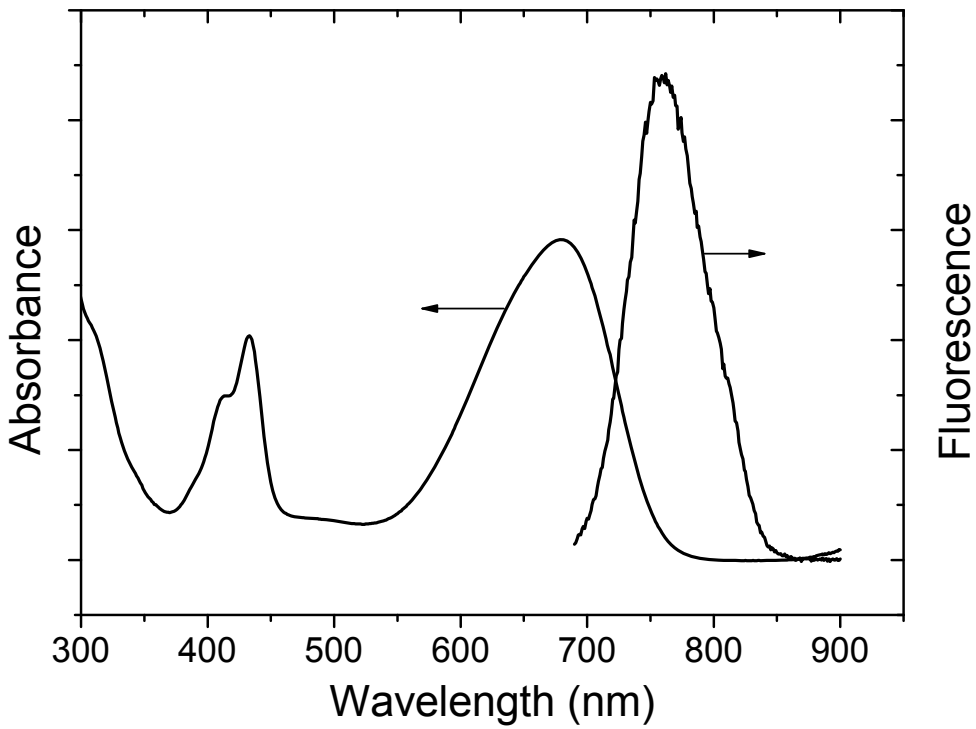


Figure 5.2 Absorption and fluorescence spectra of **12** excited at 645 nm in CH_2Cl_2 solution (10^{-5} M).

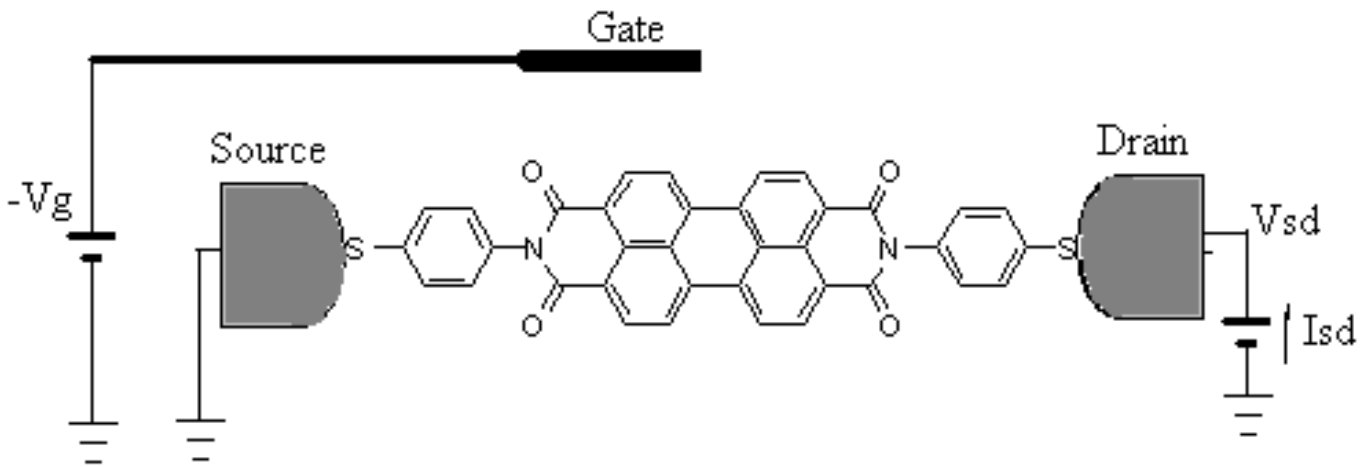


Figure 5.3 Schematic diagram of a single molecule transistor with an electrochemical gate based on perylene bisimide.

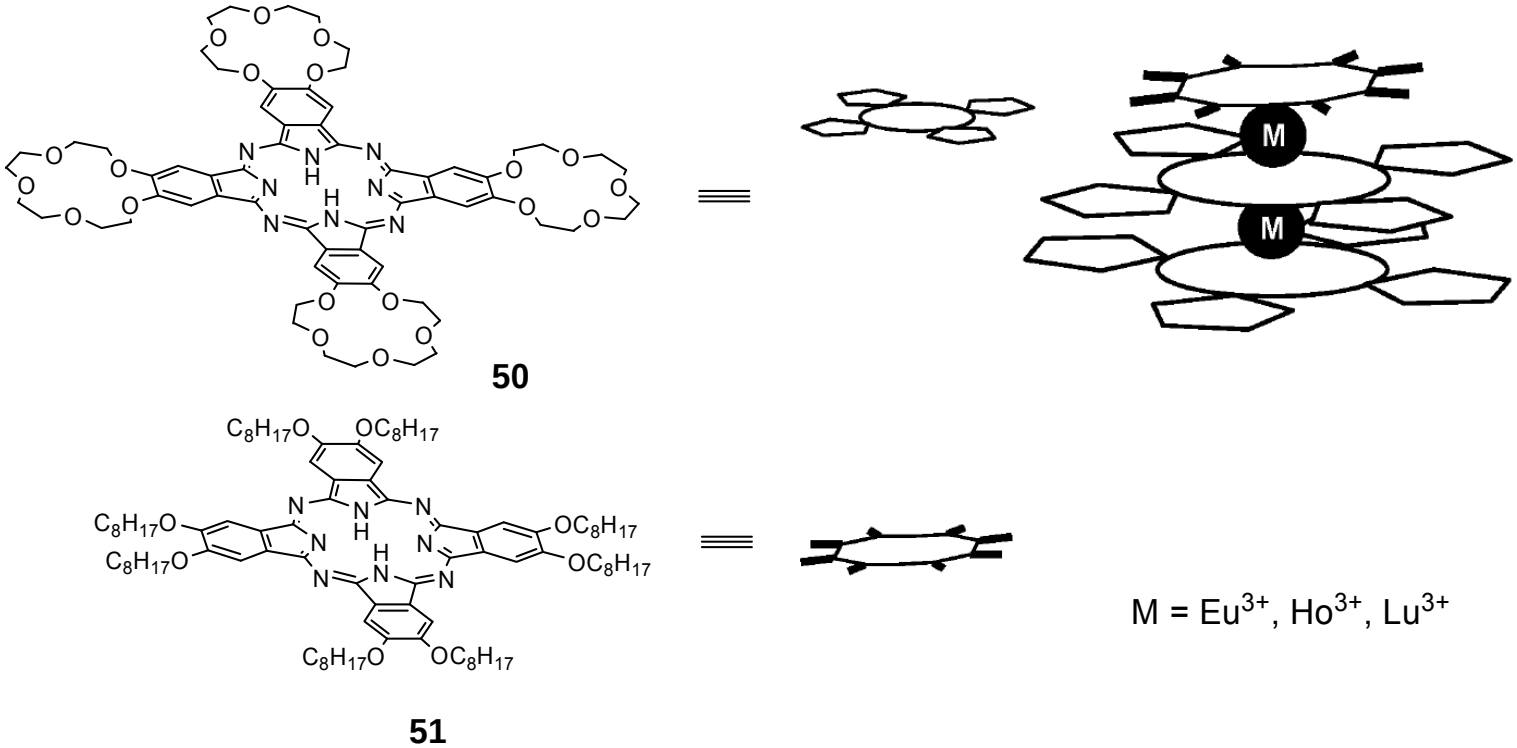


Figure 5.4 Schematic molecular structures of the triple-decker compounds.

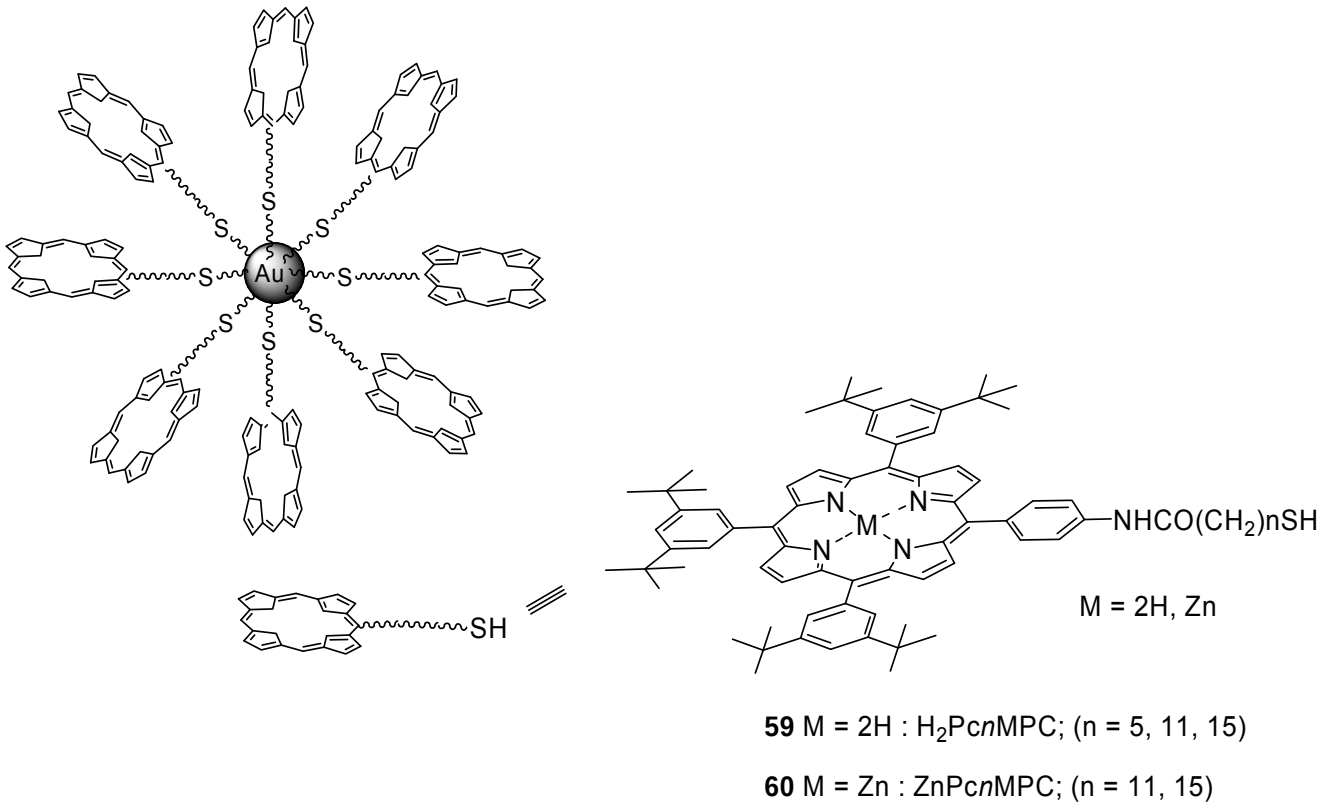


Figure 5.5 Schematic diagram of self-organization of porphyrins **59** and **60** by clusterization with gold nanoparticle.

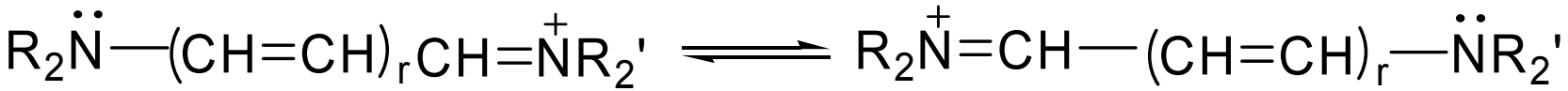


Figure 5.6 General structure of cyanine compounds.

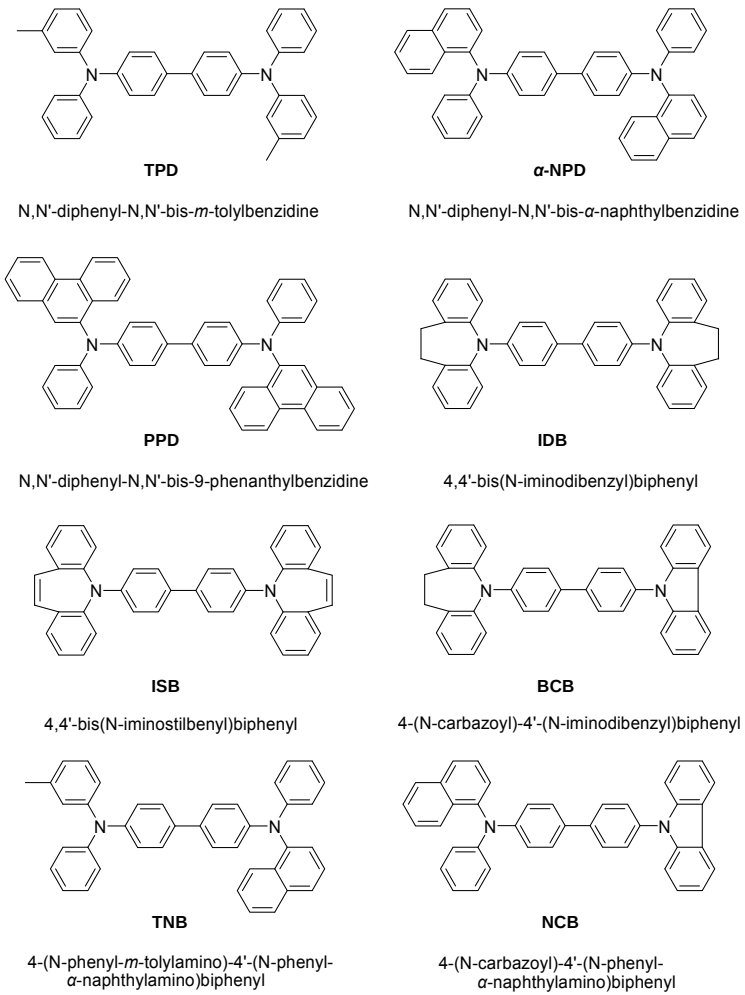


Figure 5.7 Several typical hole-transporting materials with high T_g, derived from the same biphenyl backbone as **TPD** and α **-NPD**, but utilize different amine substituents.