



Nobel Prize in Chemistry

2010

Mary P. Watson
Assistant Professor
Department of Chemistry & Biochemistry
October 29, 2010

The 2010 Nobel Laureates

Richard F. Heck



Photo: University of Delaware, USA

University of Delaware
Willis F. Harrington Professor
Emeritus

Ei-ichi Negishi



Photo: Purdue University, USA

Purdue University

Akira Suzuki



Photo: Hokkaido University, Japan

Hokkaido University

“for palladium-catalyzed cross couplings in organic synthesis”

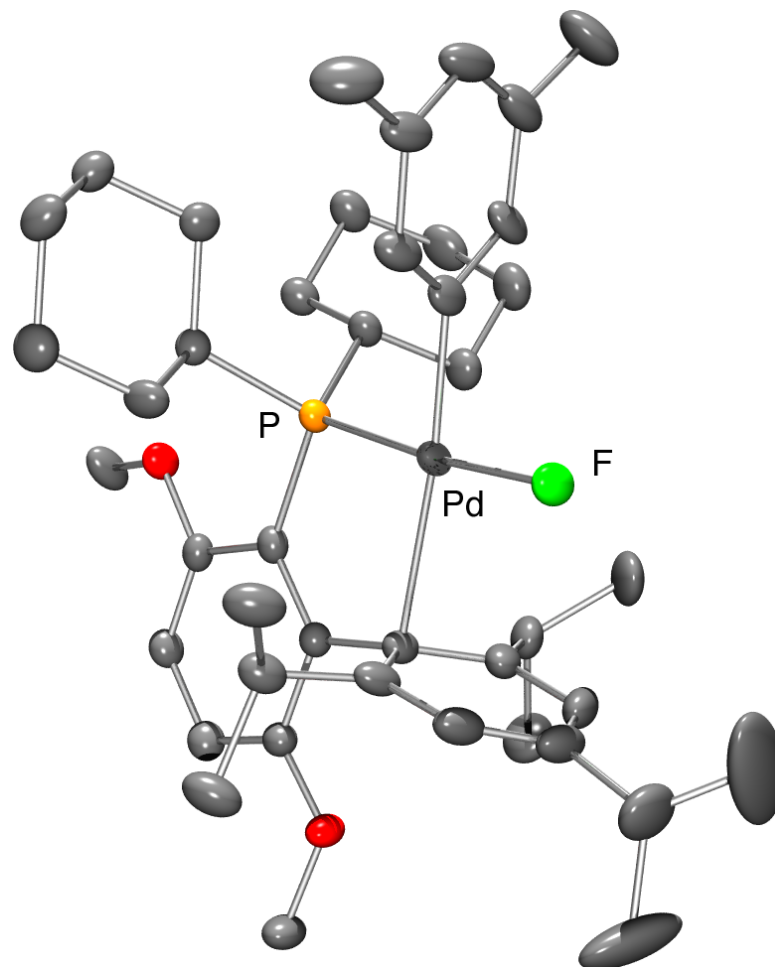


Periodic Table

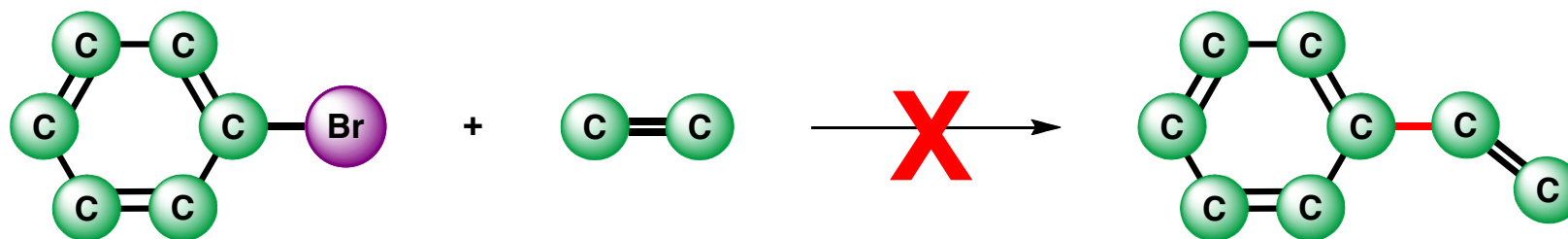
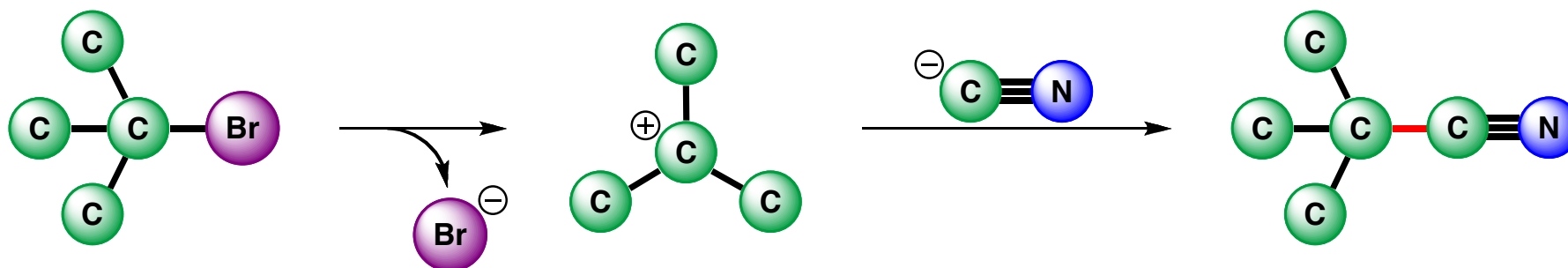
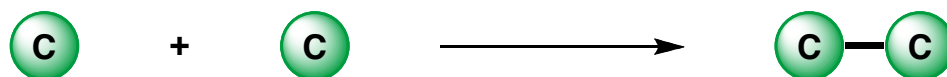
	1																	18
1	1 H Hydrogen 1.0079																	2 He Helium 4.0026
2	3 Li Lithium 6.941	4 Be Beryllium 9.0122											5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180
3	11 Na Sodium 22.990	12 Mg Magnesium 24.305											13 Al Aluminium 26.982	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulphur 32.065	17 Cl Chlorine 35.453	18 Ar Argon 39.848
4	19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.867	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.84	46 106.42 Pd Palladium			30 Zn Zinc 65.39	31 Ga Gallium 69.723	32 Ge Germanium 72.64	33 As Arsenic 74.922	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.798
5	37 Rb Rubidium 85.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.94	43 (96) Tc Technetium	44 Ru Ruthenium 101.07				48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.71	51 Sb Antimony 121.76	52 Te Tellurium 127.60	53 I Iodine 126.90	54 Xe Xenon 131.29
6	55 Cs Caesium 132.91	56 Ba Barium 137.33	57-71 La-Lu Lanthanides	72 Hf Hafnium 178.49	73 Ta Tantalum 180.95	74 W Tungsten 183.84	75 Re Rhenium 186.21	76 Os Osmium 190.23				80 Hg Mercury 200.59	81 Tl Thallium 204.38	82 Pb Lead 207.2	83 Bi Bismuth 208.98	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
7	87 Fr Francium (223)	88 Ra Radium (226)	89-103 Ac-Lr Actinides	104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (266)	107 Bh Bohrium (264)	108 Hs Hassium (277)	Mt Meitnerium (276)	Ds Darmstadtium (285)	Rg Roentgenium (288)	Uub Ununbium (294)	Uut Ununtrium (288)	Uuq Ununquadium (291)	Uup Ununpentium (288)	Uuh Ununhexium (293)	Uus Ununseptium (297)	Uuo Ununoctium (294)
			Lanthanides	57 La Lanthanum 138.91	58 Ce Cerium 140.12	59 Pr Praseodymium 140.91	60 Nd Neodymium 144.24	61 (145) Pm Promethium	62 Sm Samarium 150.36	63 Eu Europium 151.96	64 Gd Gadolinium 157.25	65 Tb Terbium 158.93	66 Dy Dyprosium 162.50	67 Ho Holmium 164.93	68 Er Erbium 167.26	69 Tm Thulium 168.93	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.97
			Actinides	89 Ac Actinium (227)	90 Th Thorium 232.04	91 Pa Protactinium 231.04	92 U Uranium 238.03	93 (237) Np Neptunium	94 (244) Pu Plutonium	95 (243) Am Americium	96 (247) Cm Curium	97 (247) Bk Berkelium	98 (251) Cf Californium	99 (252) Es Einsteinium	100 (257) Fm Fermium	101 (258) Md Mendelevium	102 (259) No Nobelium	103 (262) Lr Lawrencium

Image adapted from 0178120181524.deviantart.com

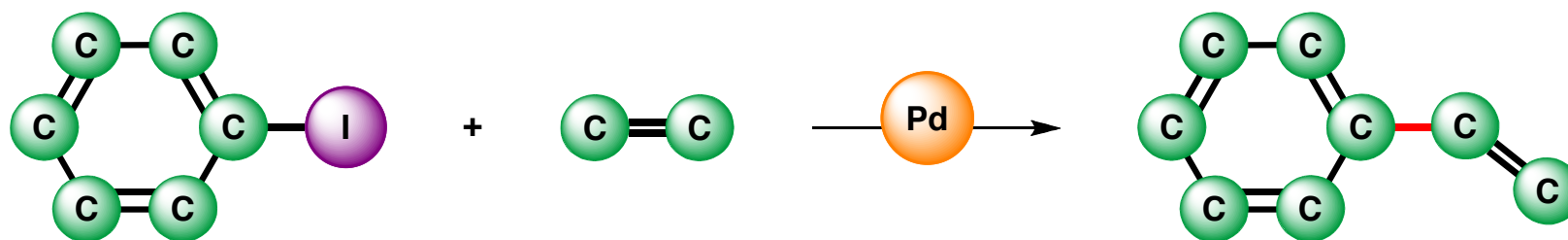
Forms of Palladium



Bringing Carbons Together



Heck's Discovery: Palladium Brings Carbons Together



The Heck Reaction

1968, 1972

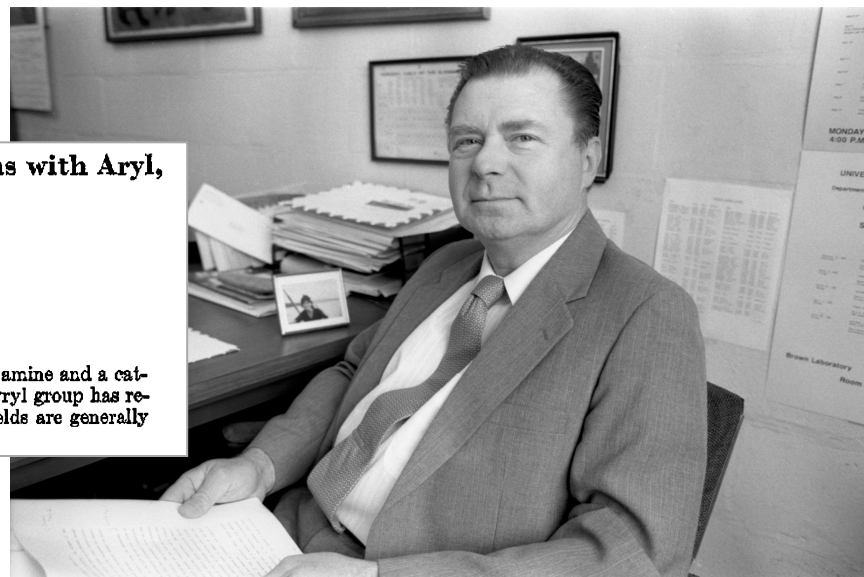
Palladium-Catalyzed Vinylic Hydrogen Substitution Reactions with Aryl, Benzyl, and Styryl Halides

R. F. HECK* AND J. P. NOLLEY, JR.

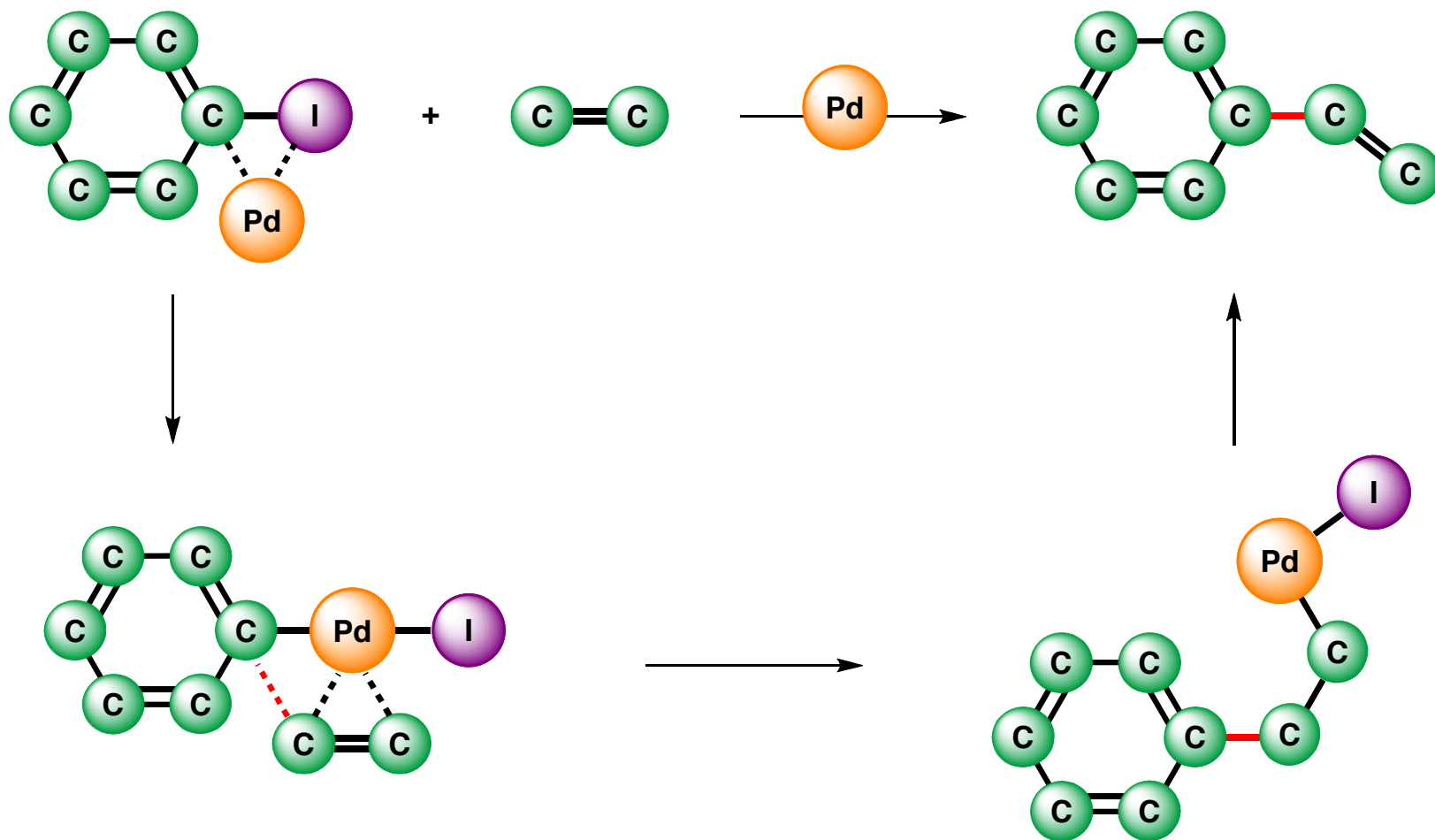
University of Delaware, Newark, Delaware 19711

Received January 13, 1972

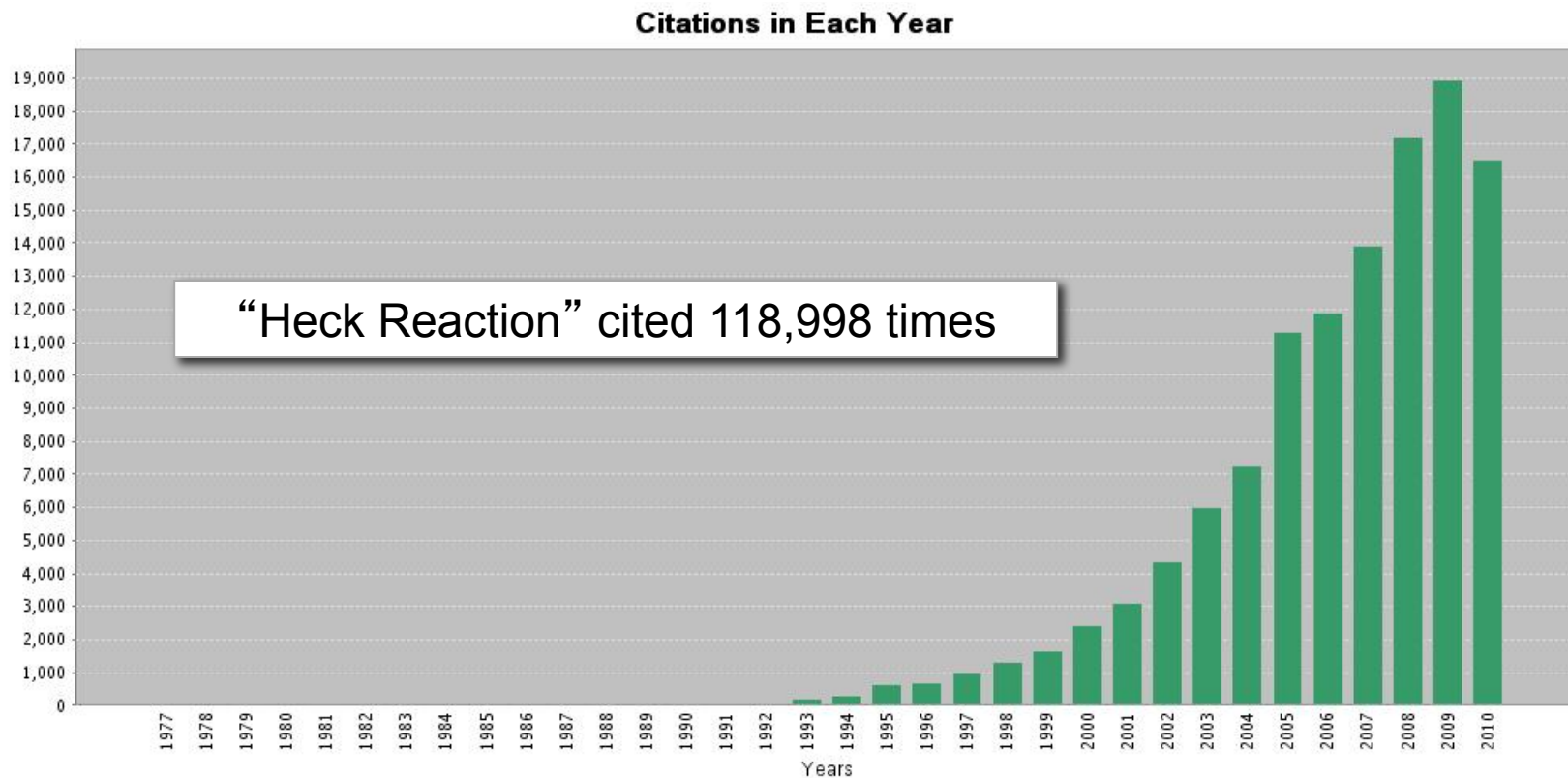
Aryl, benzyl, and styryl halides react with olefinic compounds in the presence of a hindered amine and a catalytic amount of palladium metal to form vinylic derivatives in which the aryl, benzyl, or styryl group has replaced a vinylic hydrogen of the original olefin. The reactions occur readily at 100° and yields are generally good.



The Heck Reaction



Revolutionary Impact

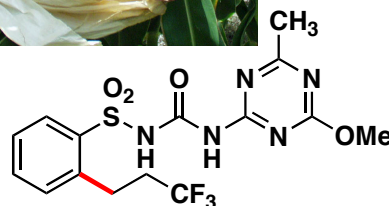


*The Heck Reaction changed **the way** molecules are made and changed **what molecules** can be made.*

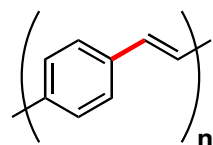
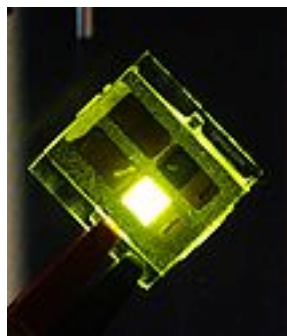
Revolutionary Impact



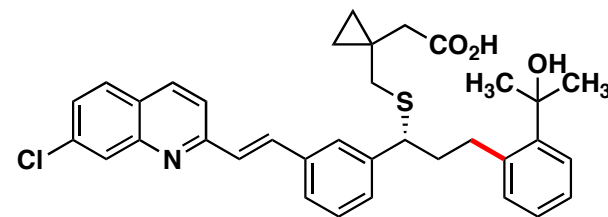
naproxen
anti-inflammatory



Prosulfuron™
herbicide

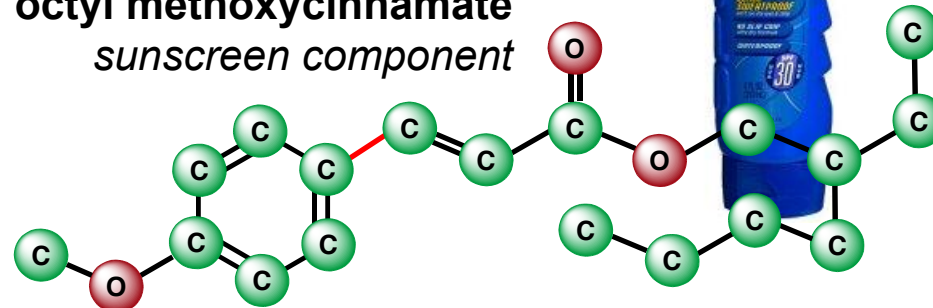


PPV
OLED's

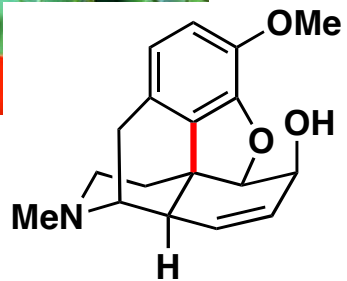


Singulair™
asthma treatment

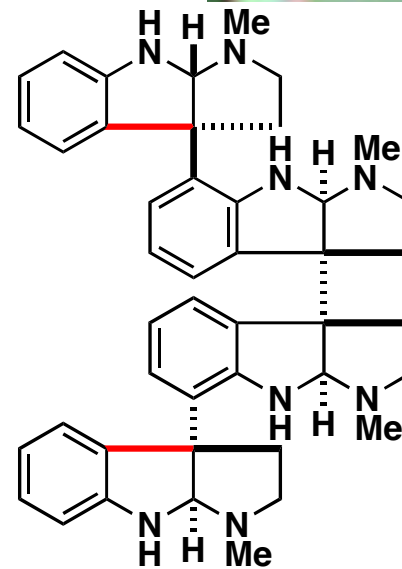
octyl methoxycinnamate
sunscreen component



Revolutionary Impact



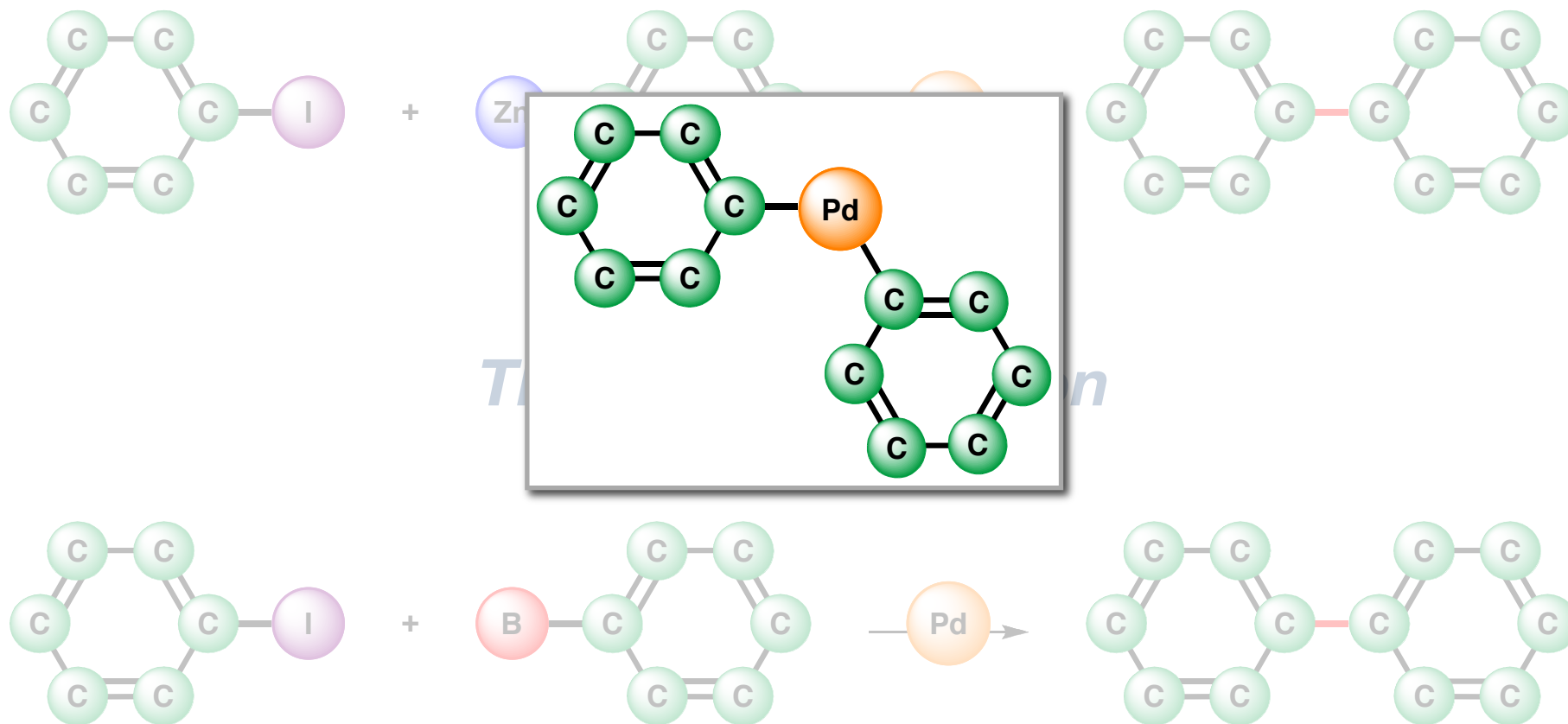
morphine
opiate analgesic



quadrigemine C
antibacterial, analgesic

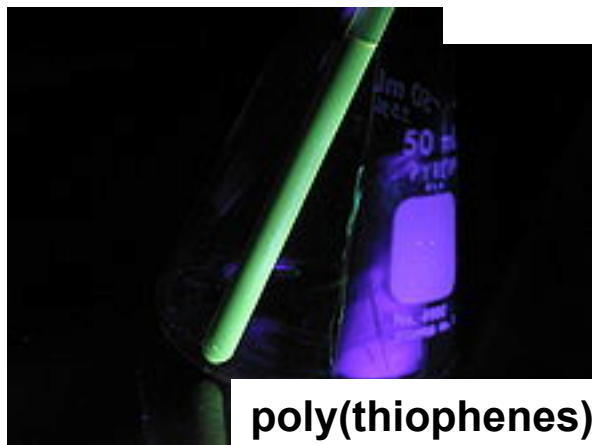
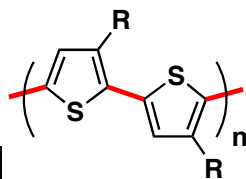
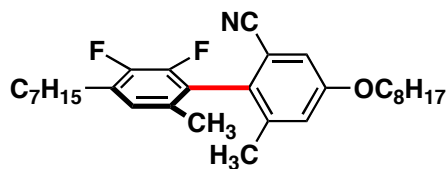
The Negishi Reaction

1977

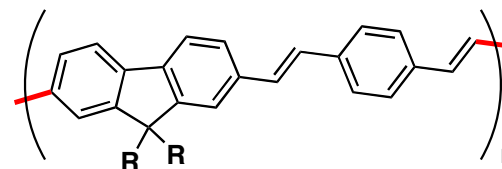


Important Applications

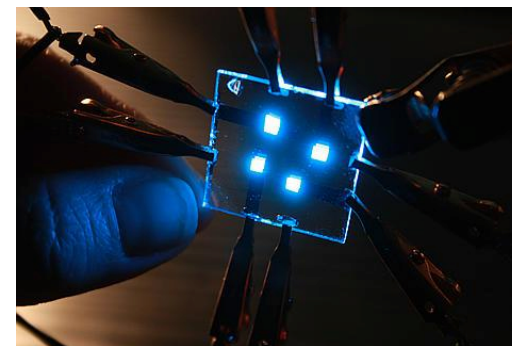
Dopant for liquid crystal displays



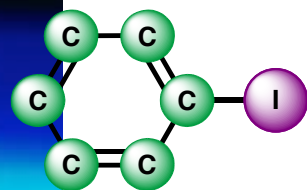
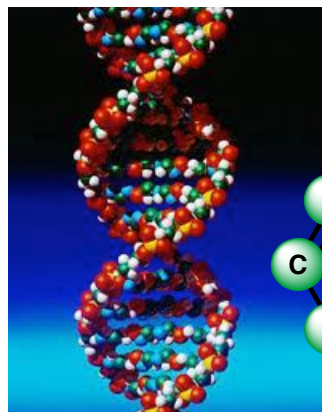
poly(thiophenes)
*conducting polymers,
solar cells*



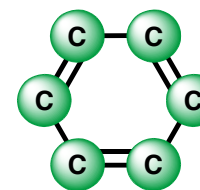
PPV
OLED



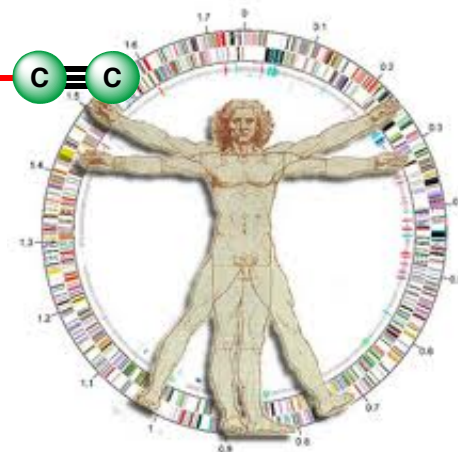
Heck's Other Discoveries



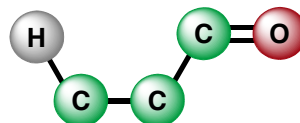
+



*Enabled Human Genome Project
(Sonogashira Coupling)*



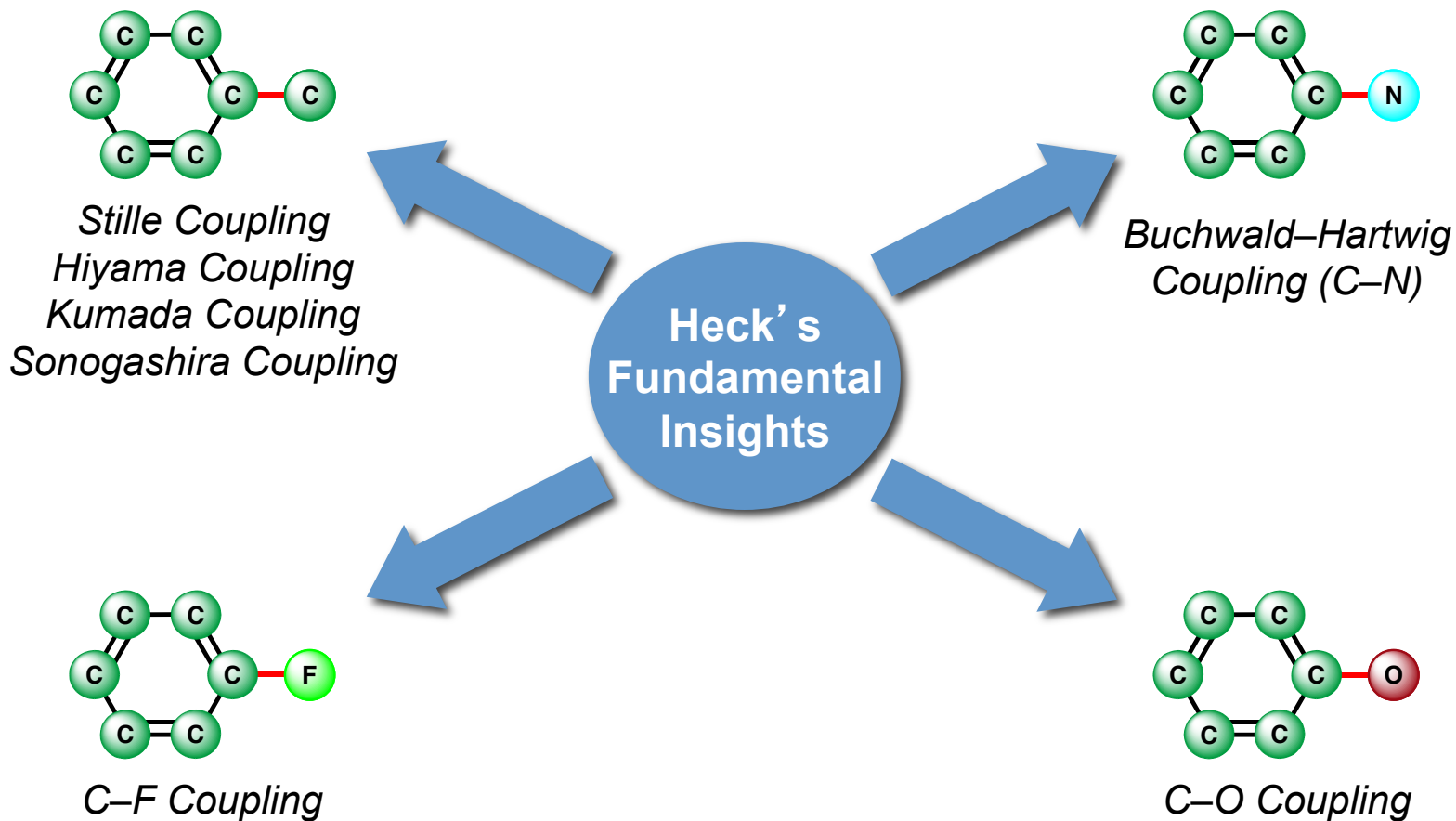
Mechanism of Hydroformylation



Used to produce 15 billion lbs/year
of alcohols and aldehydes



Heck's Legacy



UD's Heck Award and Lectureship

“To recognize visionary leadership in the field of organometallic chemistry and to honor the contributions of Richard F. Heck”



S. Buchwald, MIT
2005
C–N Couplings
(Pd Catalysis)



R. Grubbs, CalTech
2006
Olefin Metathesis



R. Bergman, Berkeley
2007
C–H Activation



L. Overman, Irvine
2008
Intramolecular Heck Reactions
(Pd Catalysis)



B. Trost, Stanford
2009
Tsuji–Trost Reaction
(Pd Catalysis)



J. Hartwig, Illinois
2010
C–N Couplings
(Pd Catalysis)

Heck's Chemical Path to Prominence

