Solid State Lighting: A Bright Opportunity for Nanotechnology to Impact Energy Efficiency

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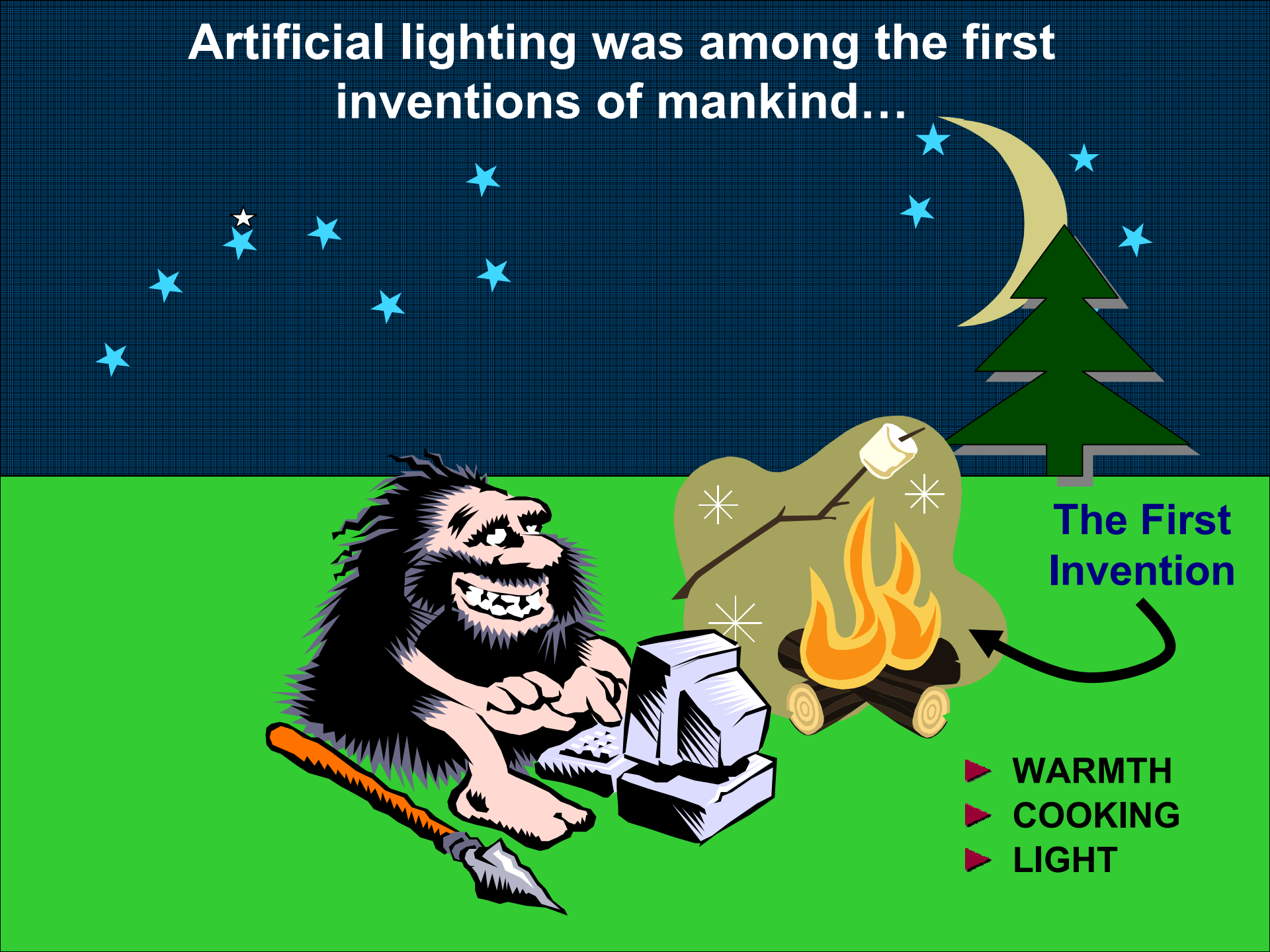
Items for Discussion

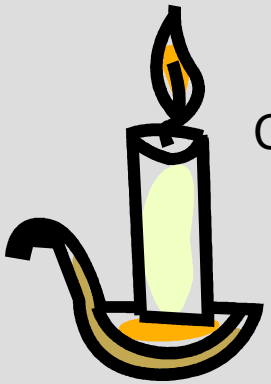
- Solid state lighting as a high payoff research area in energy efficiency
- The Department of Energy's Basic Research Needs Report in Solid State Lighting
- The role of nanoscience in optimizing next generation solid state lighting

Artificial lighting was among the first inventions of mankind…



- WARMTH
- COOKING
- LIGHT

Each subsequent improvement in lighting led to major lifestyle improvements
and improvements in the energy efficiency of the light



Candle: 0.05 lumens per watt

Gaslamp: 0.5 lumens per watt

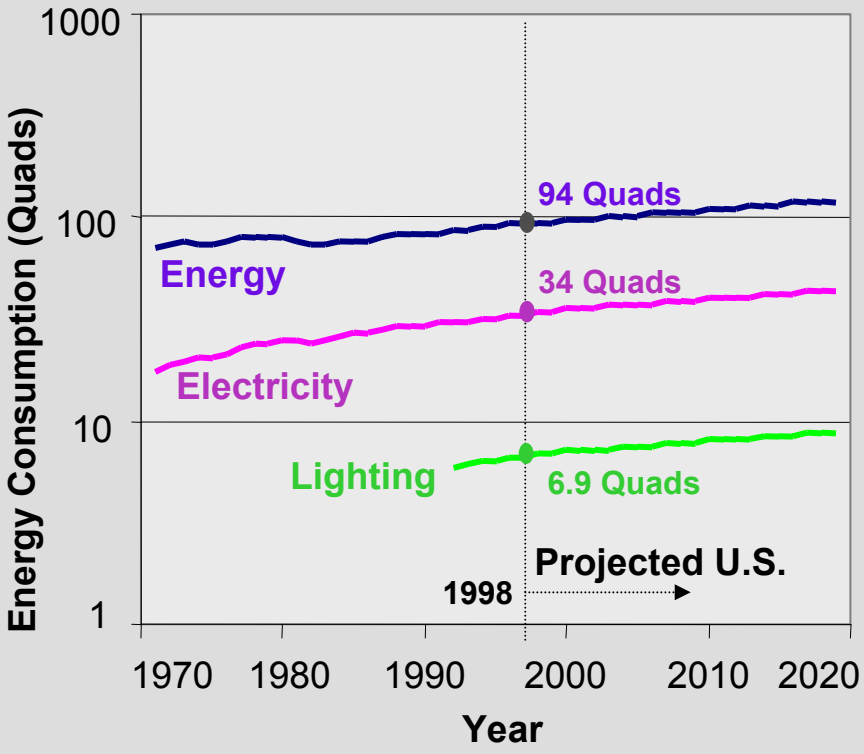
“Incandescent” Lightbulb
15 lumens per watt
(5% efficient)

Why does lighting impact energy conservation?

- Lighting consumes 22% of the electricity generated in the U.S.A.
- That's 8% of the total energy consumption
- Costs $50 billion per year
- Releases 150 million tons of CO_2 into the atmosphere each year
- Much of it is 19th century technology with poor efficiency

We should be able to do better

- **Lighting is a highly attractive target for reducing energy consumption!**



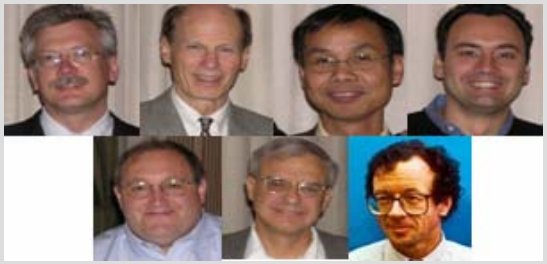
Efficiencies of energy technologies in buildings:

Heating:	70 - 80%
Elect. motors:	85 - 95%
Fluorescent:	**20%**
Incandescent:	**5%**

Basic Research Needs for Solid State Lighting

May 22-24, 2006

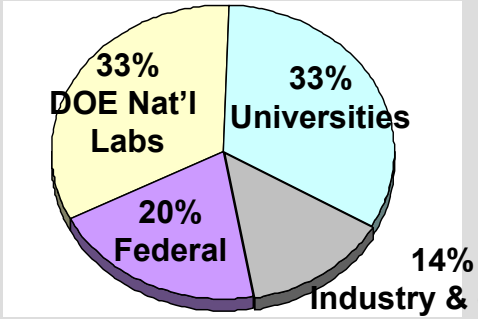
Workshop Chairs: **Julia Phillips** (Sandia National Labs)
Paul Burrows (Pacific Northwest National Lab)



Science Panel Chairs:

LED:	Jerry Simmons (SNL)
	Bob Davis (Carnegie Mellon U)
OLED:	Franky So (U of Florida)
	George Malliaras (Cornell)
Cross-Cutting:	Jim Misewich (BNL)
	Arto Nurmikko (Brown U)
	Darryl Smith (LANL)

Total 79 participants



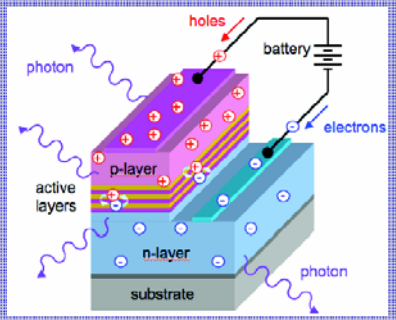
Charge: identify transformational science
Output: www.sc.doe.gov/bes/reports/list.html

Workshop Output

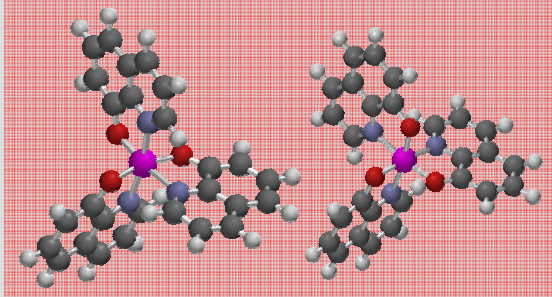
- 12 Priority Research Directions (PRDs), each specific to an individual panel
- 2 Grand Challenges (GCs) which overarch all panels

www.sc.doe.gov/bes/reports/list.html

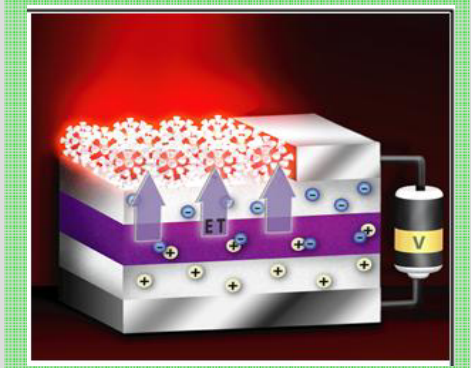
LED Science



OLED Science



Cross-cutting Science

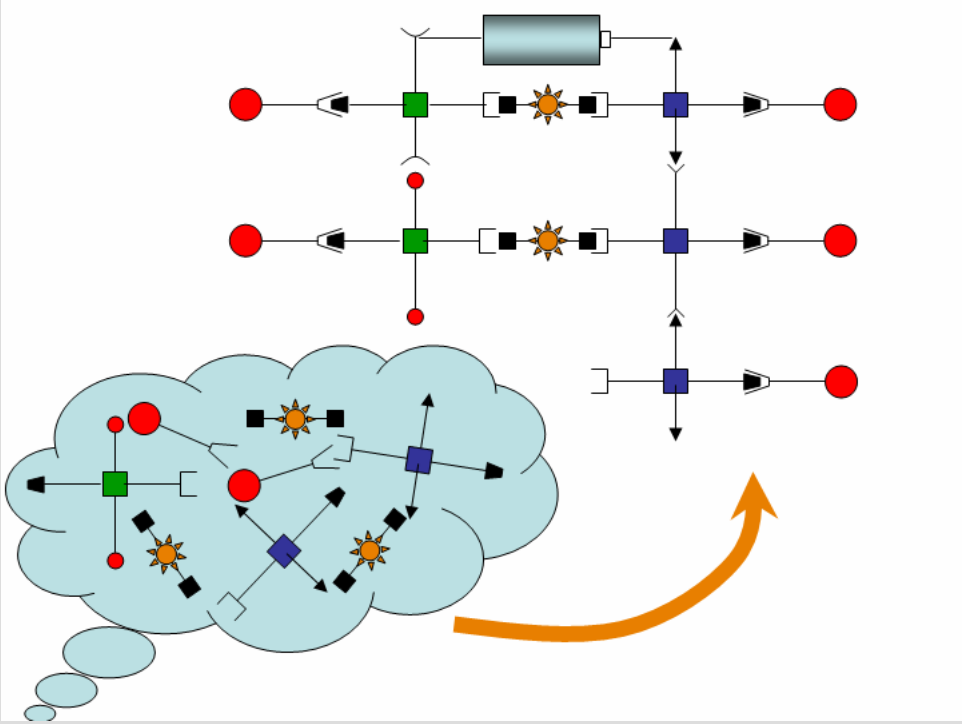


GRAND CHALLENGE 1:
Rational design of solid-state lighting structures

Today, light-emitting solid state materials are discovered rather than designed.

The CHALLENGE:

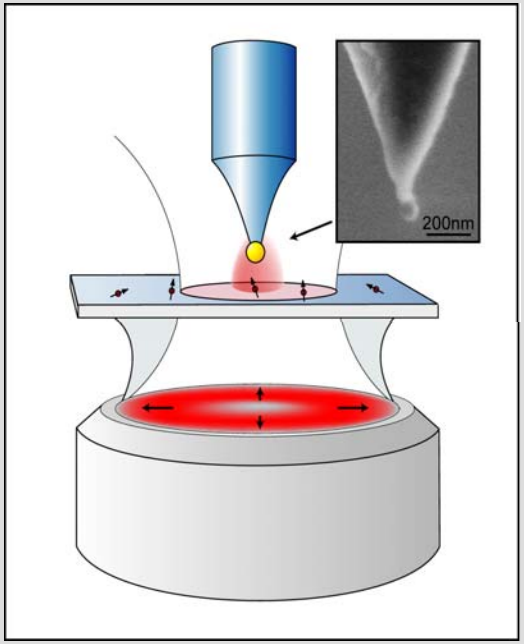
Can we design optimized device components that assemble into a high efficiency charge-to-light conversion system?

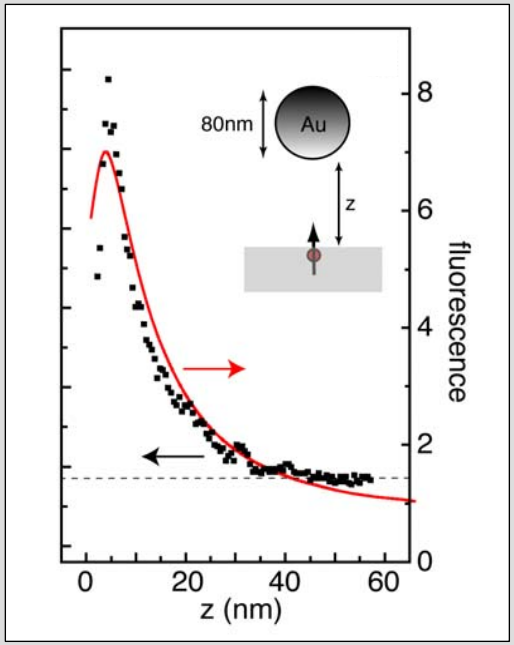


GRAND CHALLENGE 2: Control of radiative and nonradiative processes in light-emitting materials

Light-emitting efficiency is determined by competition between radiative and non-radiative processes.

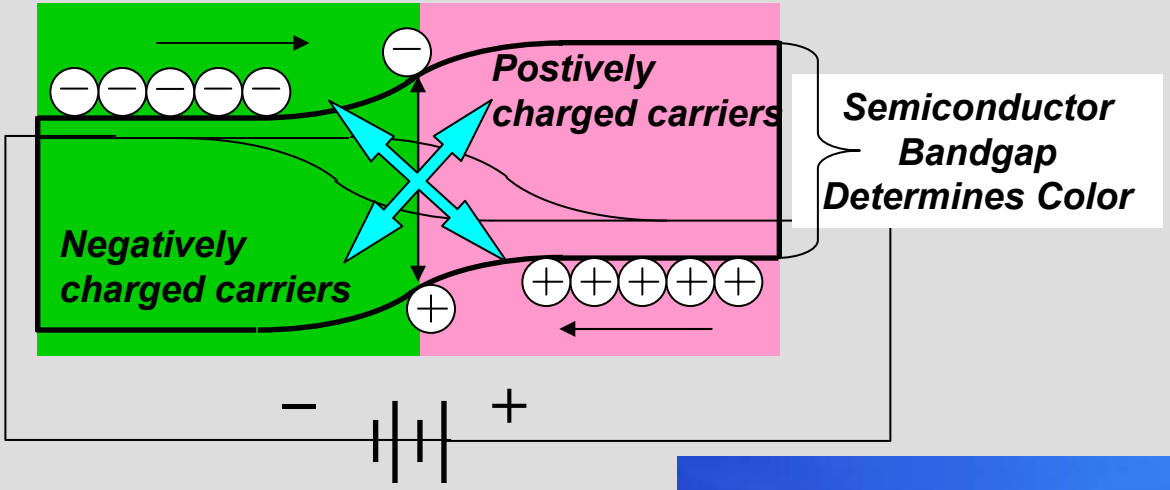
The CHALLENGE:
Can we understand and control the physics of photon generation and emission?





Inorganic solid state lighting

Composition and nanostructure determine color



Colored LEDs:

Red, Yellow - AlInGaP

Blue, Green – InGaN

White LEDs:

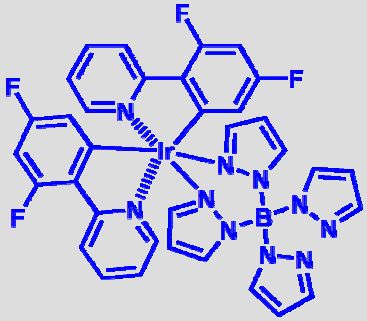
Red + Green + Blue, or

Blue + phosphor

- With applied voltage positive and negative charge carriers recombine
- Energy may be released as light or heat
- Theoretically they can be 100% efficient with unlimited life!

  (compared to incandescent which is 5% efficient, 2000 hour life)
- Commercial LEDs can be expected to reach 50% efficiency and possibly more

Courtesy George Craford, Philips Lumileds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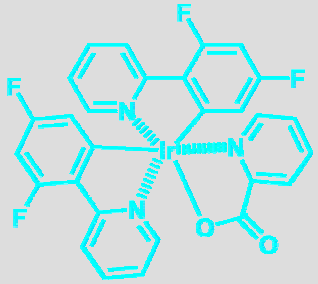
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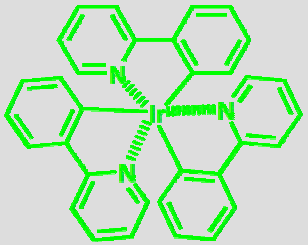
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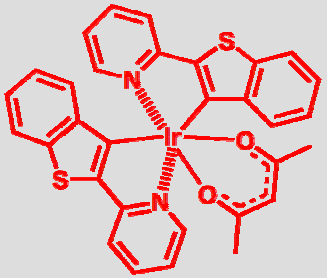
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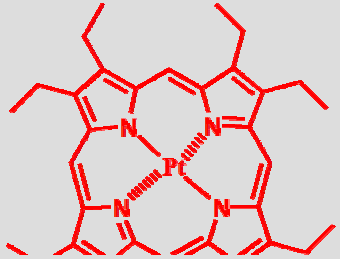
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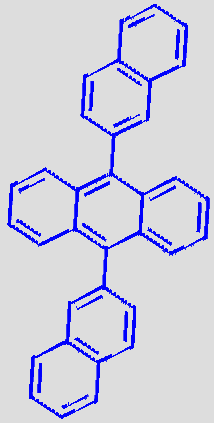

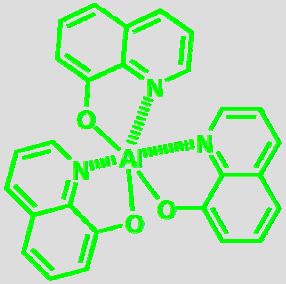
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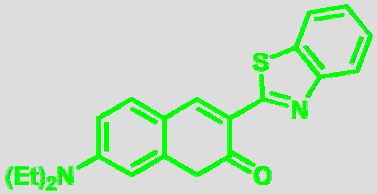
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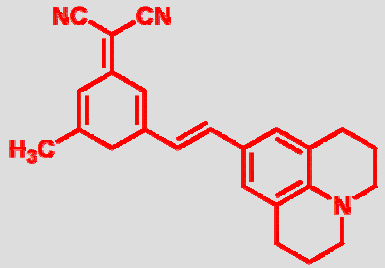
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