



# Molecular Toys








Adam M. Azman  
19 March 2008



# Platonic Solids (the blocks)

- Exactly 5

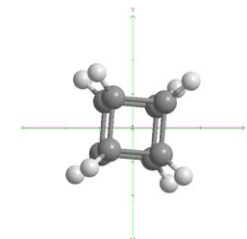
The Five Convex Regular Polyhedra (Platonic solids)				
Tetrahedron	Hexahedron or Cube	Octahedron	Dodecahedron	Icosahedron
				
Fire	Earth	Air		Water



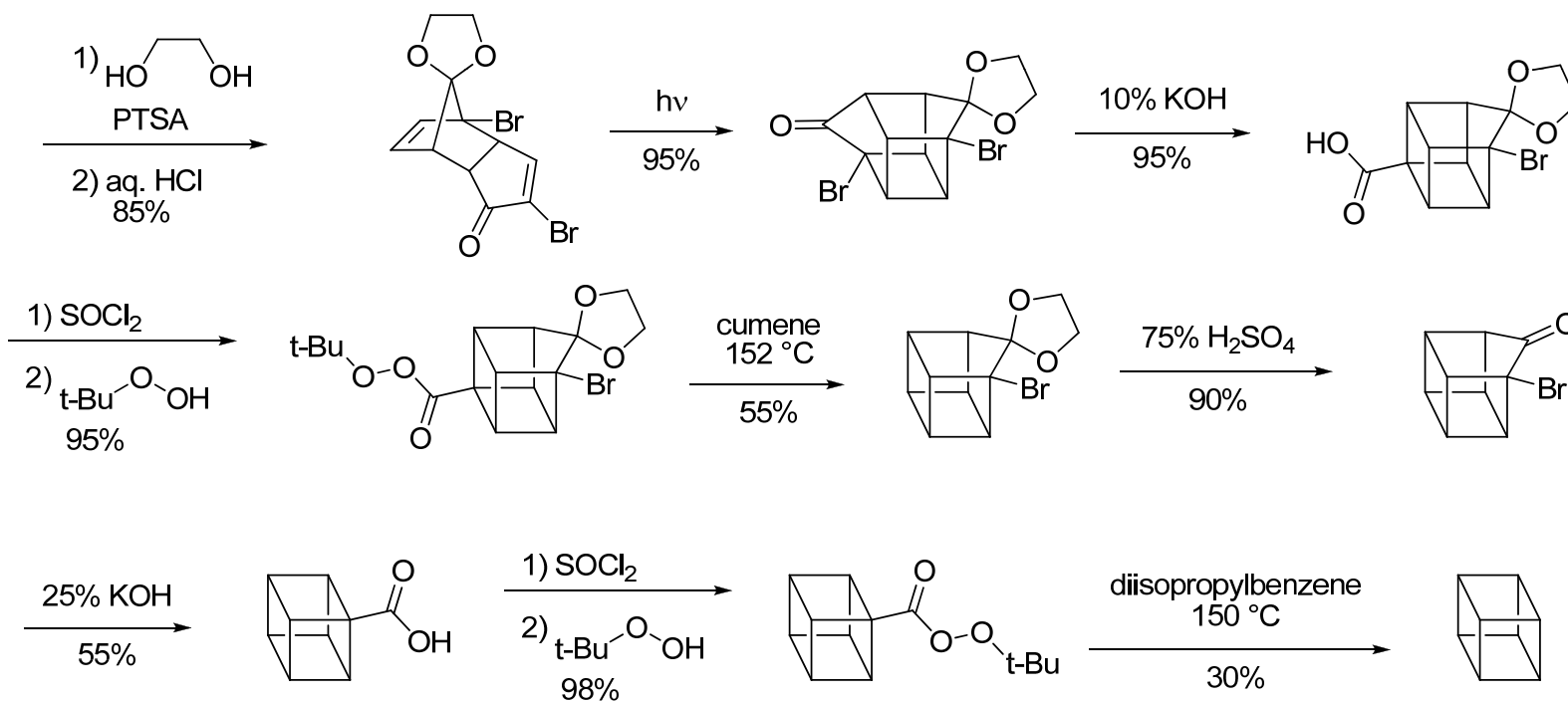
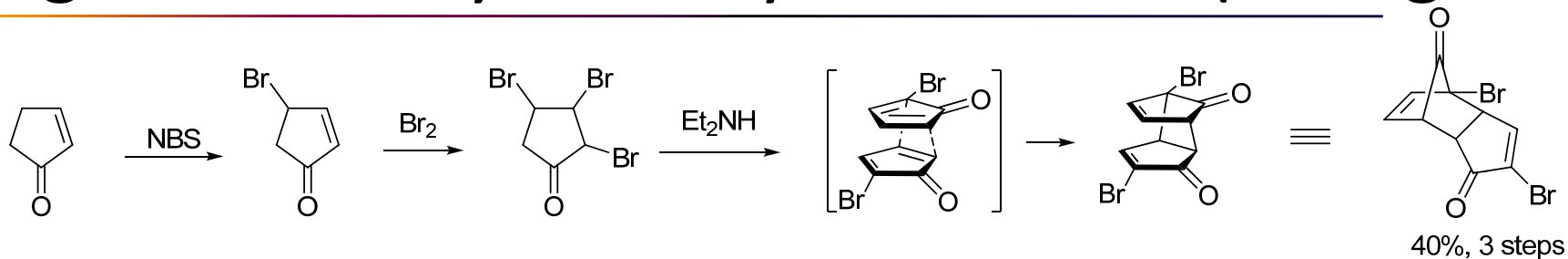
- Plato theorized the classical elements were constructed from the platonic solids
- Octahedrane and icosahedrane are impossible hydrocarbons
- Tetrahedrane only possible if substituted
- Cubane and dodecahedrane successfully synthesized



# Blocks - Cubane

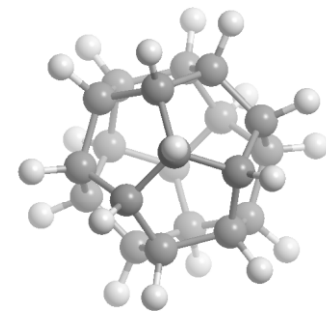


- First synthesized in 1964 by Eaton
- Highest density of all hydrocarbons ( $1.29 \text{ gmL}^{-1}$ )

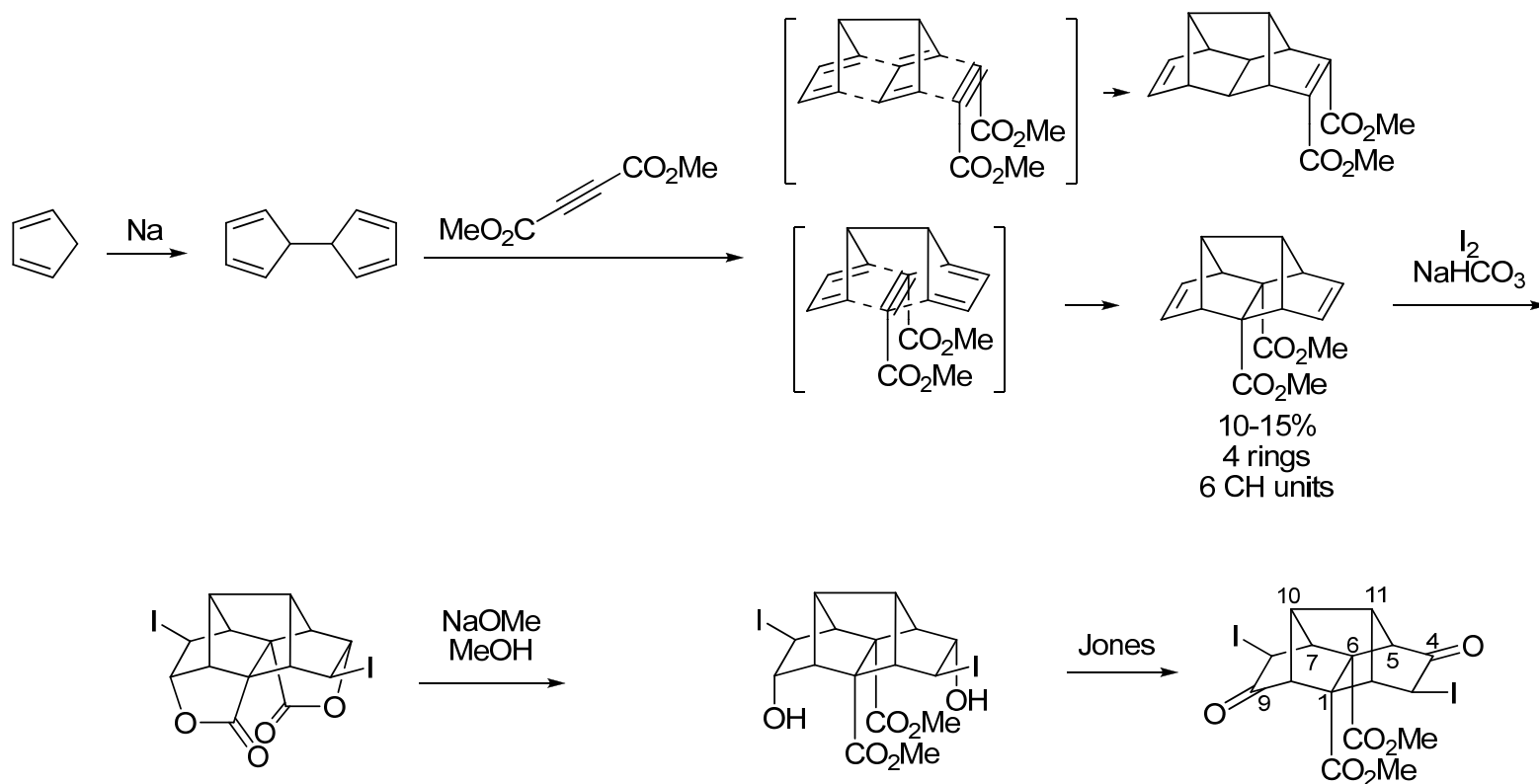


Eaton, P. E.; Cole, T. W. *J. Am. Chem. Soc.* 1964, 86, 962-964.  
 Eaton, P. E.; Cole, T. W. *J. Am. Chem. Soc.* 1964, 86, 3157-3158.

# Blocks - Dodecahedrane

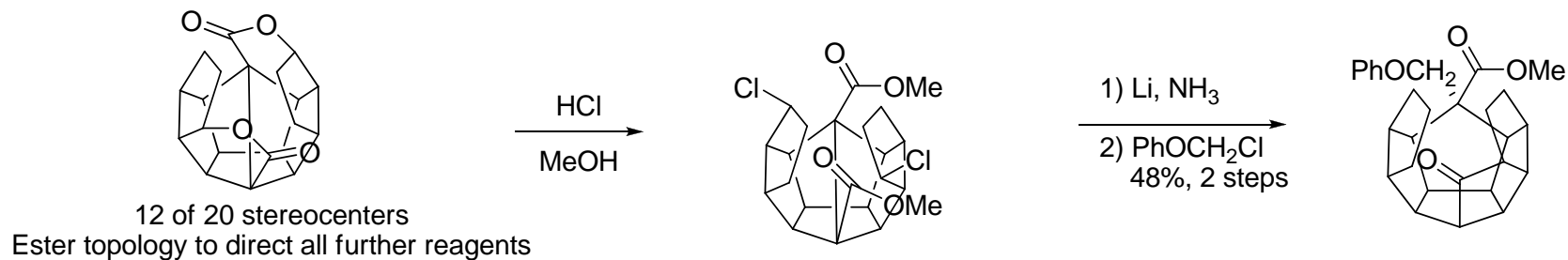
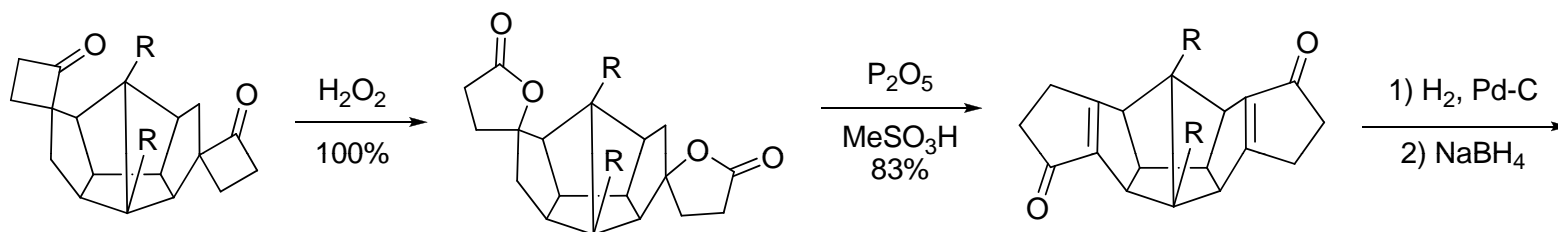
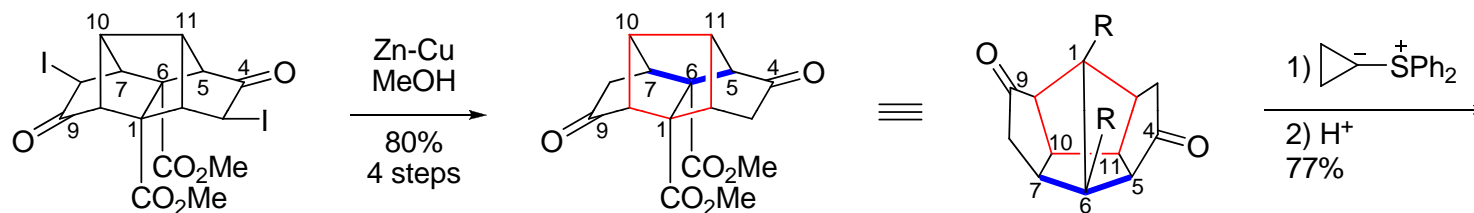
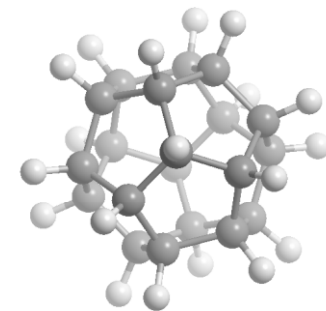


- Synthetic efforts began in 1964 (Woodward)
- First total synthesis in 1982 by Paquette



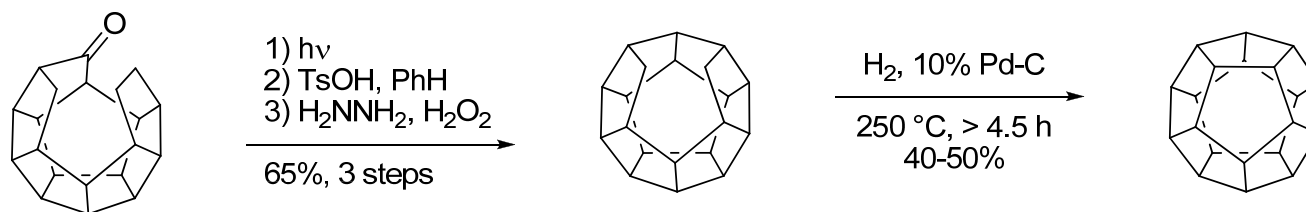
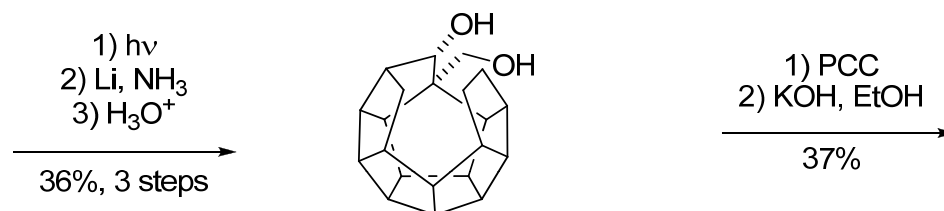
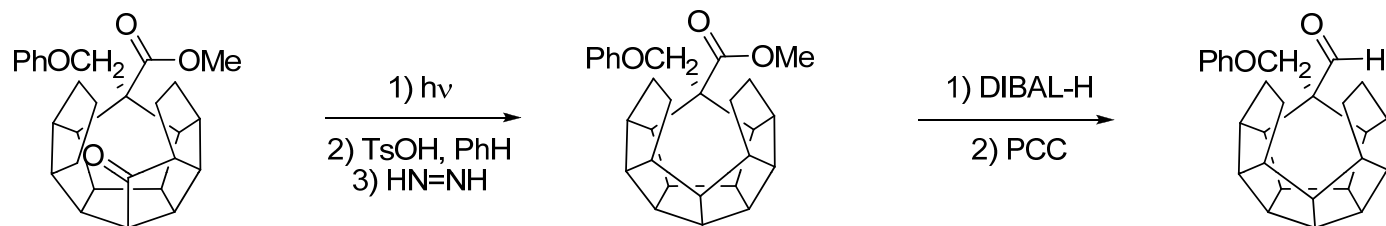
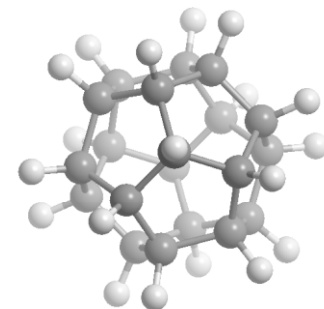
- 1) Paquette, L. A.; Balogh, D. W. *J. Am. Chem. Soc.*, **1982**, *104*, 774-783. 2) Paquette, L. A.; Ternansky, R. J.; Balogh, D. W. *J. Am. Chem. Soc.*, **1982**, *104*, 4502-4503. 3) Ternansky, R. J.; Balogh, D. W.; Paquette, L. A. *J. Am. Chem. Soc.*, **1982**, *104*, 4503-4504. 4) Paquette, L. A.; Ternansky, R. J.; Balogh, D. W.; Kentgen, G. *J. Am. Chem. Soc.*, **1983**, *105*, 5446-5450.

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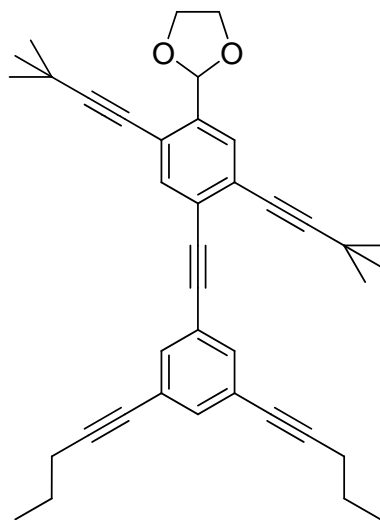
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# Dolls - NanoPutians

- Named after Lilliputians in Jonathan Swift's *Gulliver's Travels*
- 2 nm-tall anthropomorphic molecules
- **0.006 ng** =  $1.105 \times 10^{-14}$  mol =  $6.6 \times 10^9$  molecules  
= “current world population”

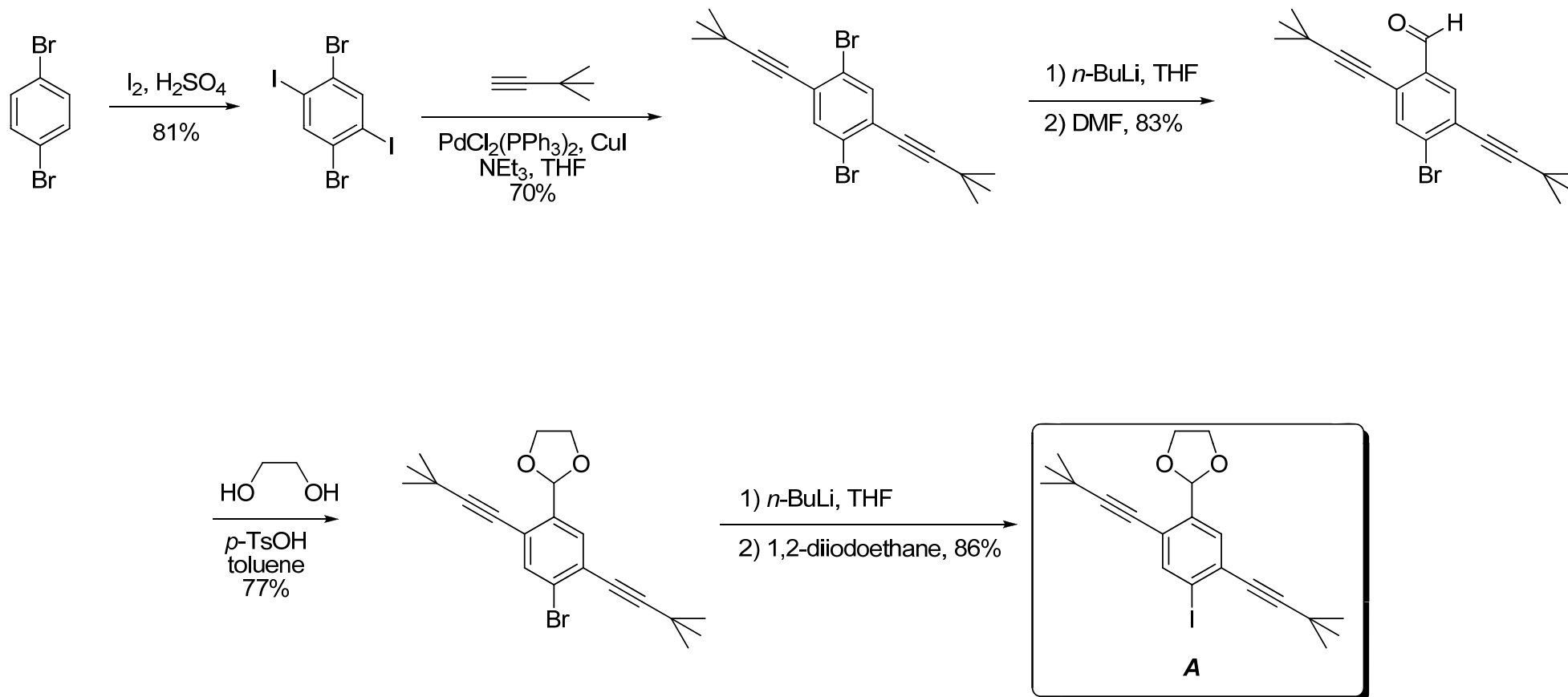
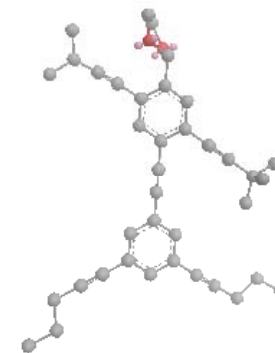


NanoKid

Chanteau, S. H.; Ruths, T.; Tour, J. M. *J. Chem. Ed.*, **2003**, *80*, 395-400.

Chanteau, S. H.; Tour, J. M. *J. Org. Chem.*, **2003**, *68*, 8750-8766.

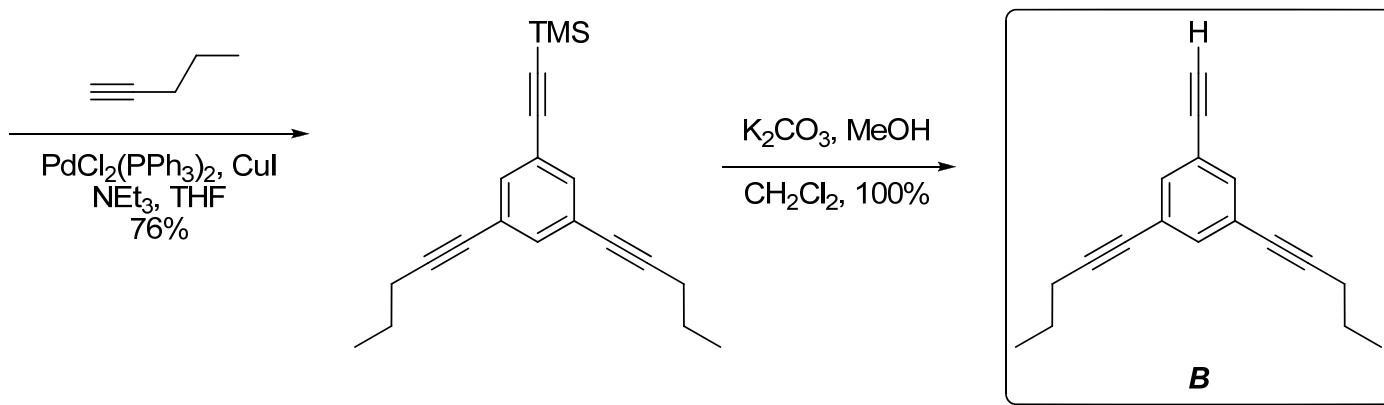
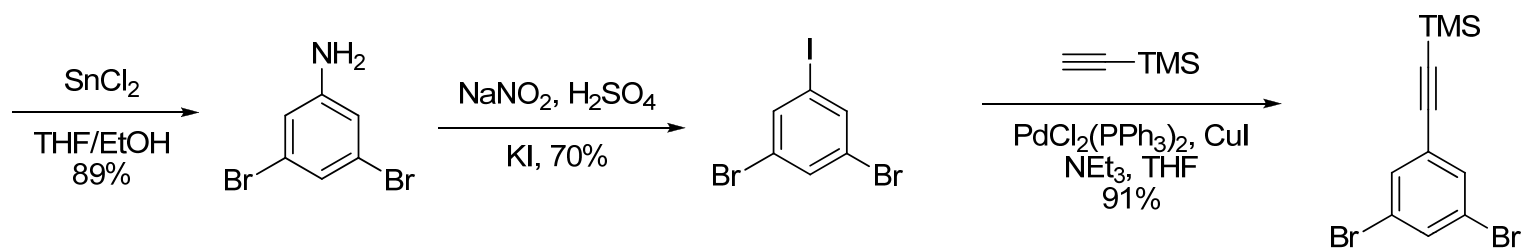
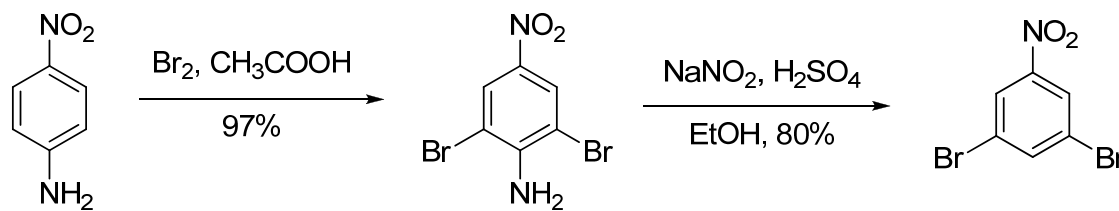
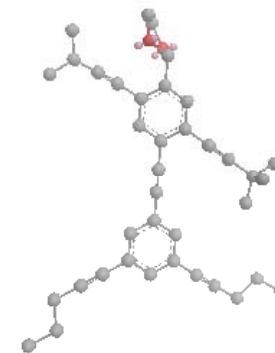
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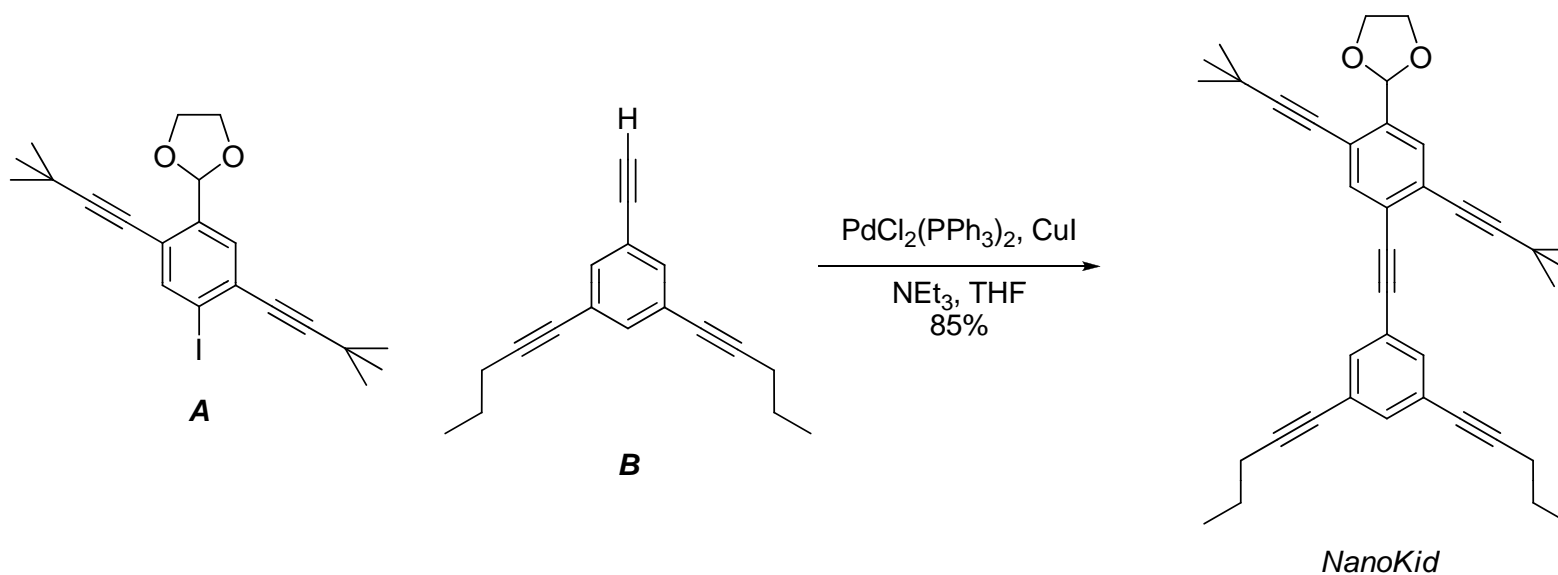
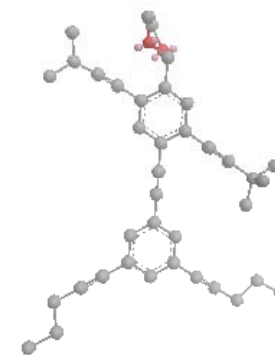
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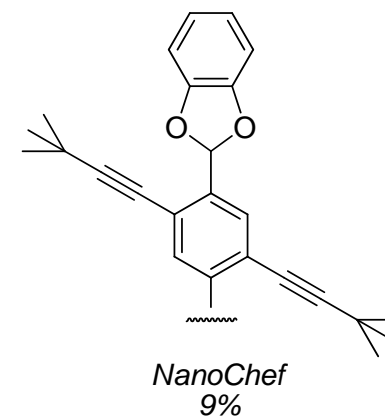
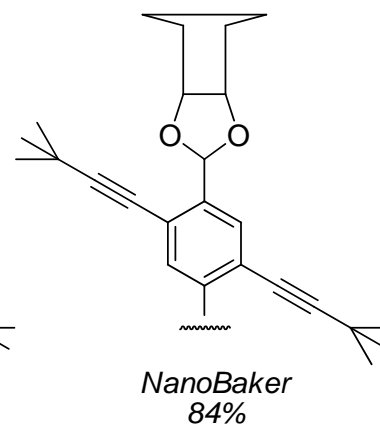
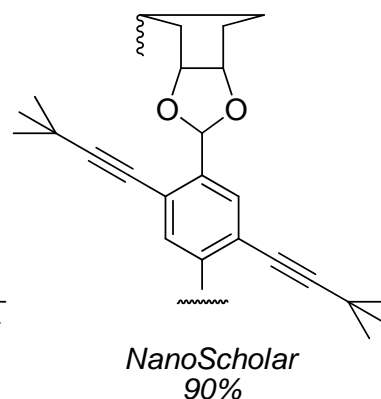
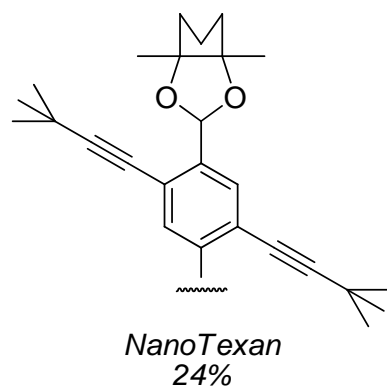
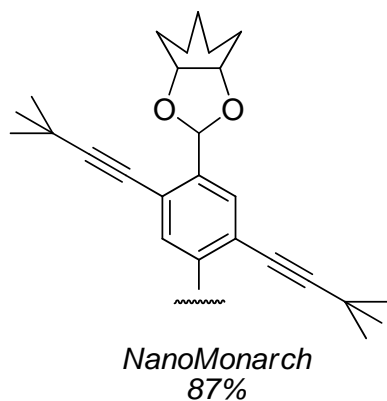
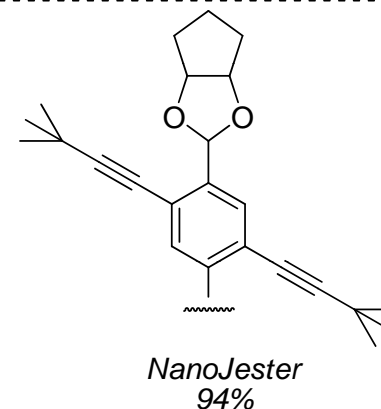
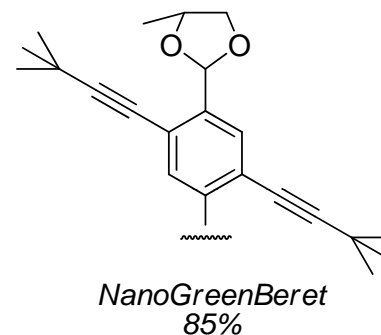
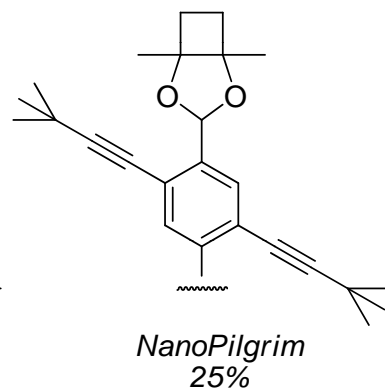
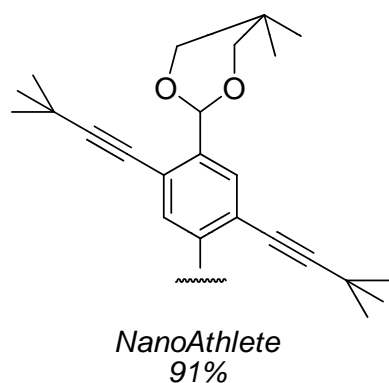
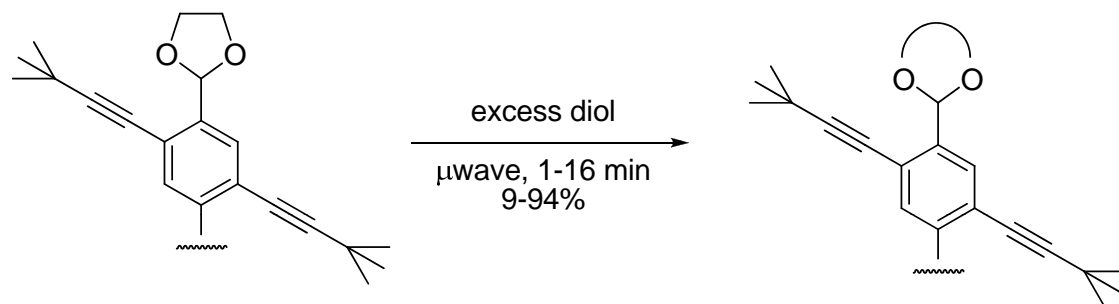
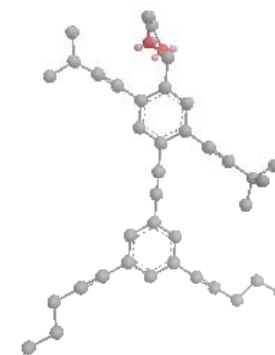
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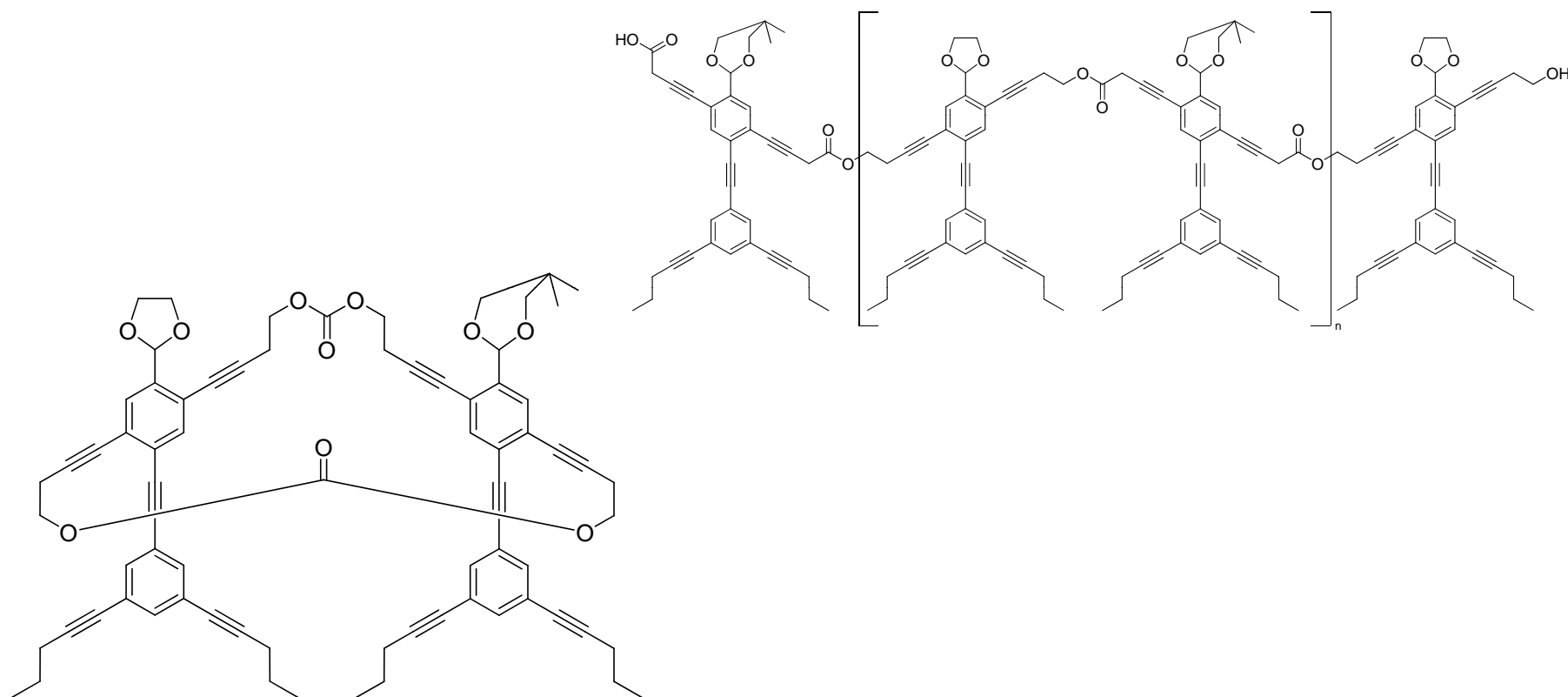
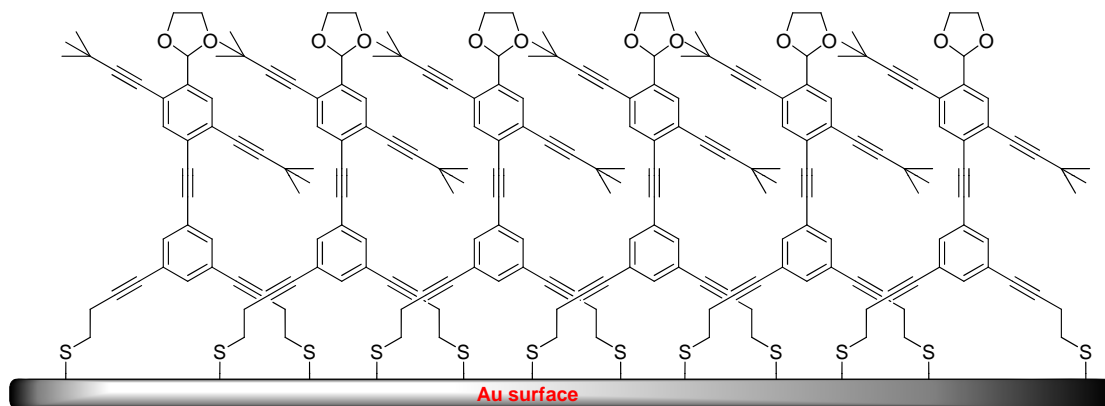
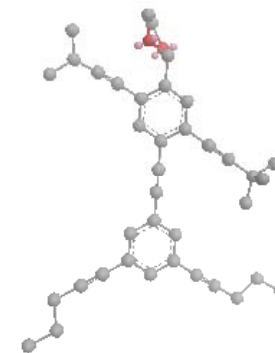
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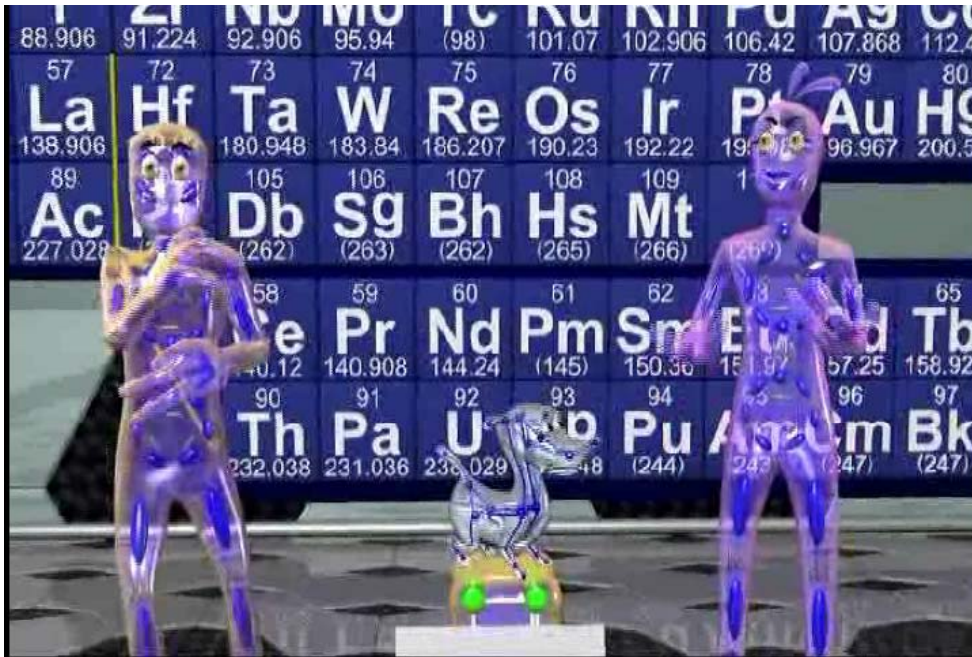
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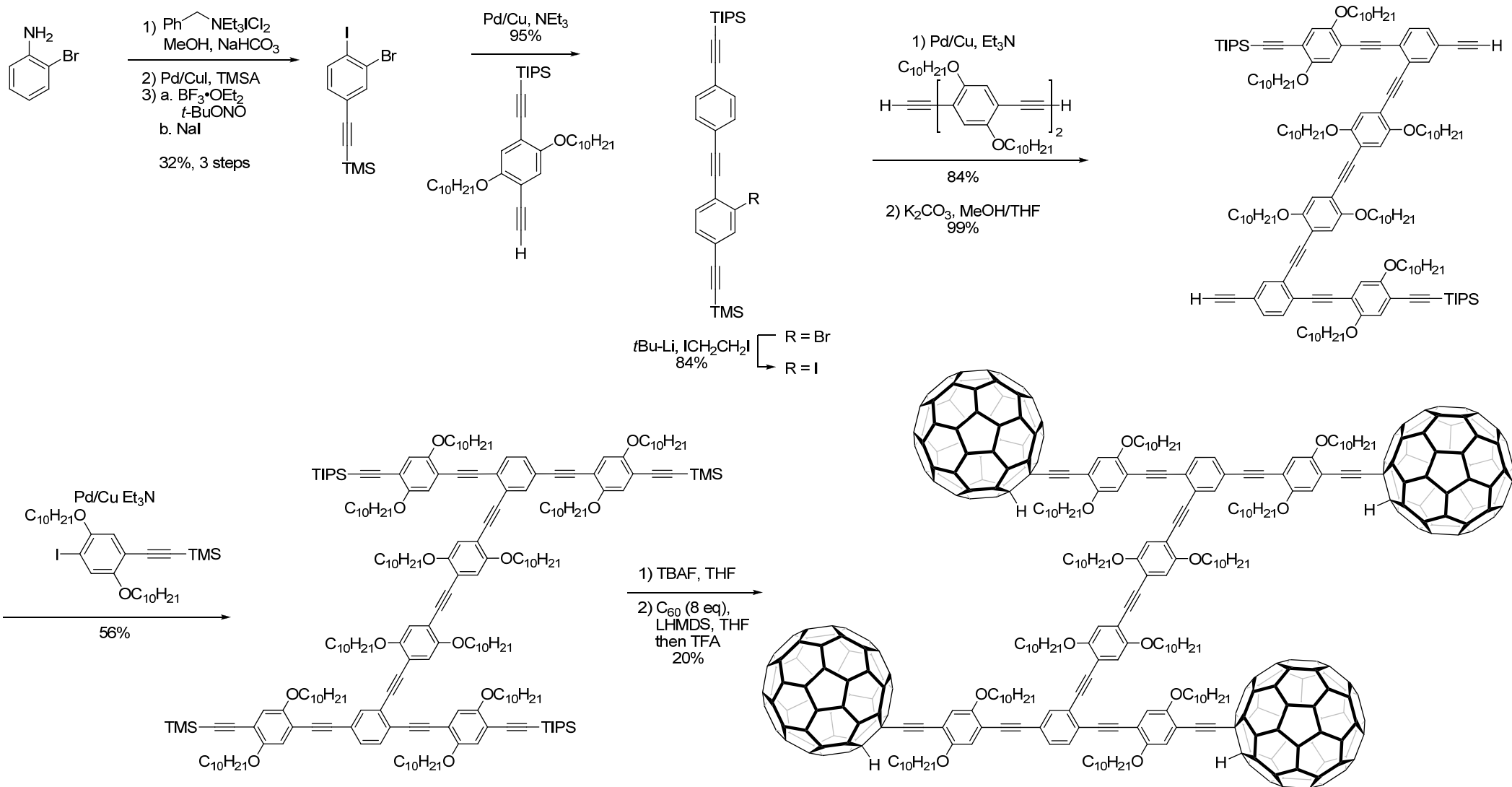
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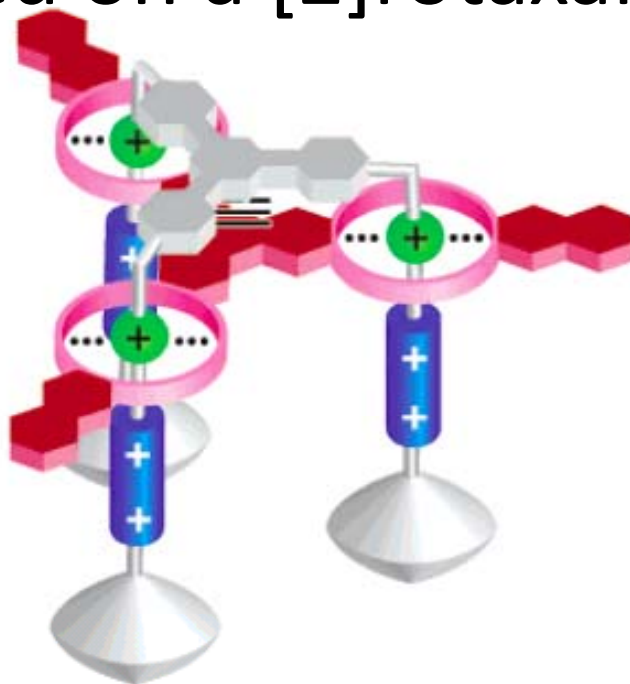
# Racecar - Nanocar

- Actually shown to move by “rolling” – not stick-slip or sliding
- Approximately 3x4 nm



# Elevator

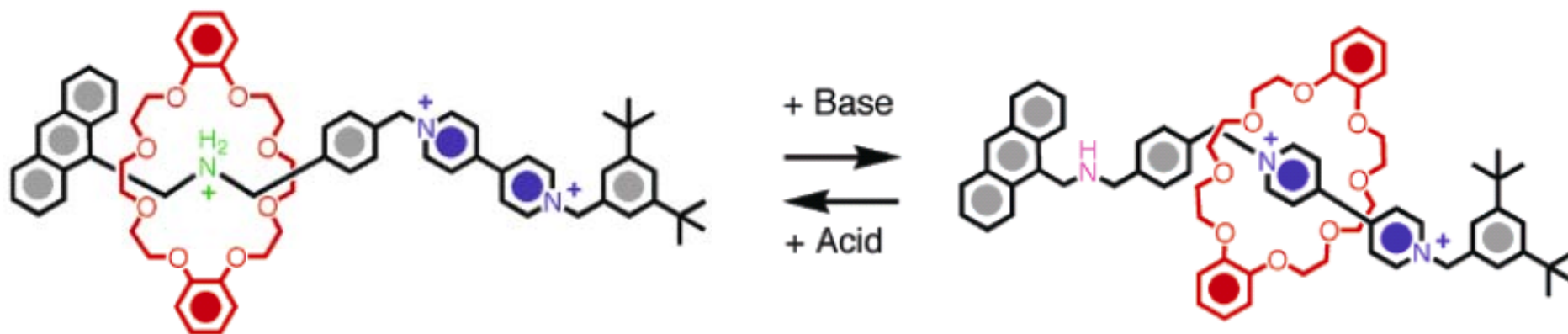
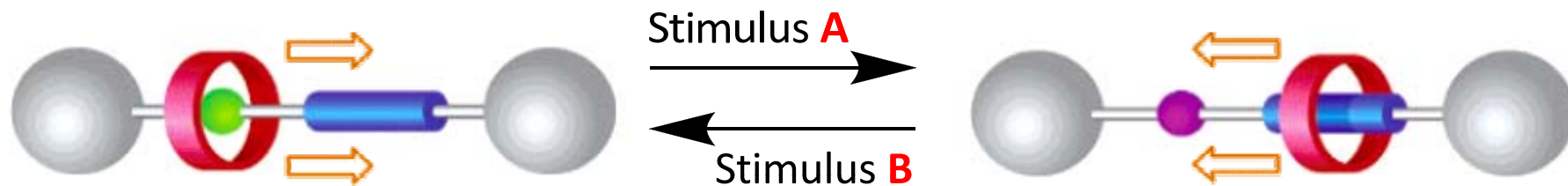
- Ca. 2.5 nm height x 3.5 nm diameter
- Distance between “floors” = 0.7 nm
- Movement from “upper” to “lower” “floor” can generate 200 pN
- Designed based on a [2]rotaxane



Badjić, J. D.; Balzani, V.; Credi, A.; Silvi, S.; Stoddart, J. F. *Science*, **2004**, *303*, 1845-1849.

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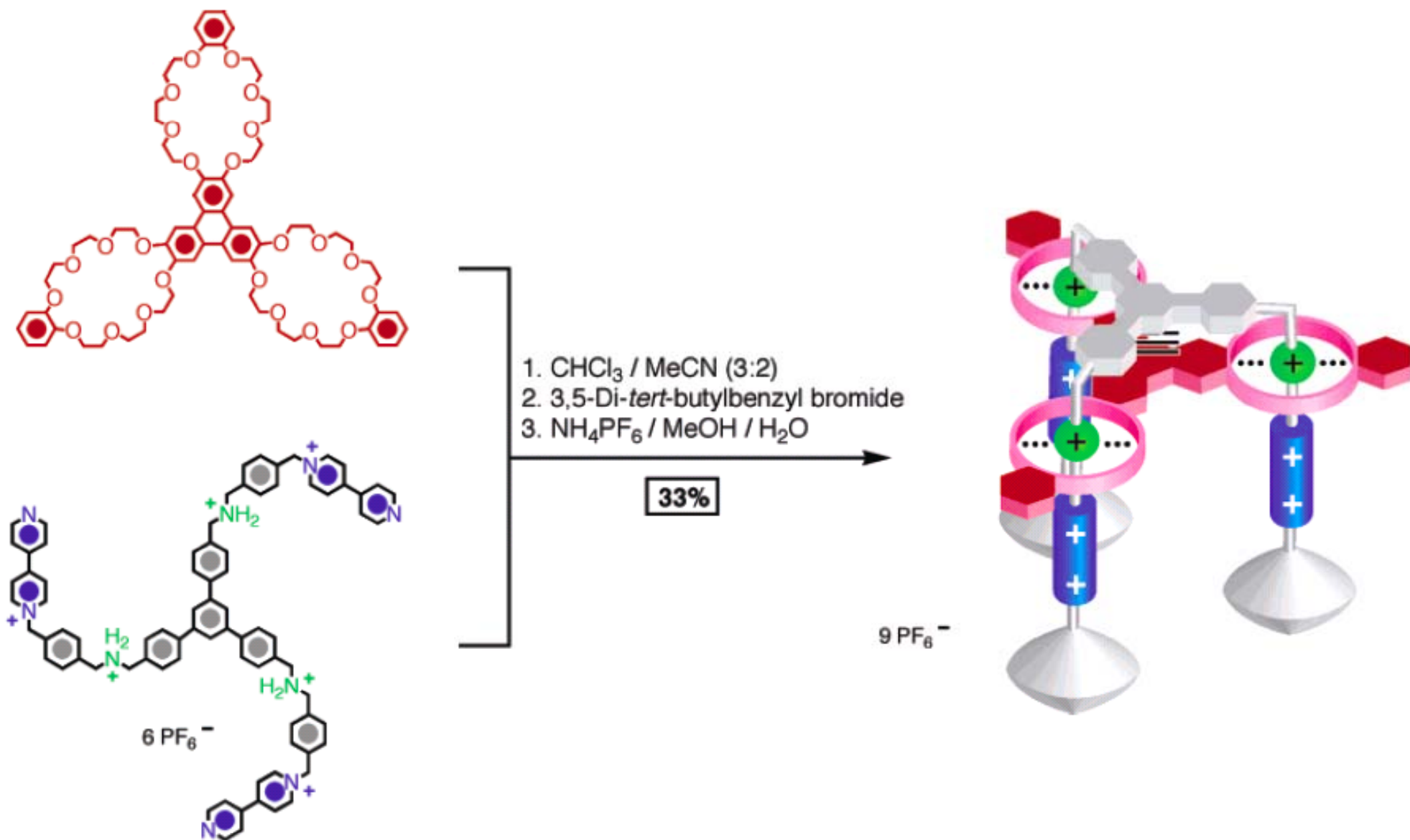
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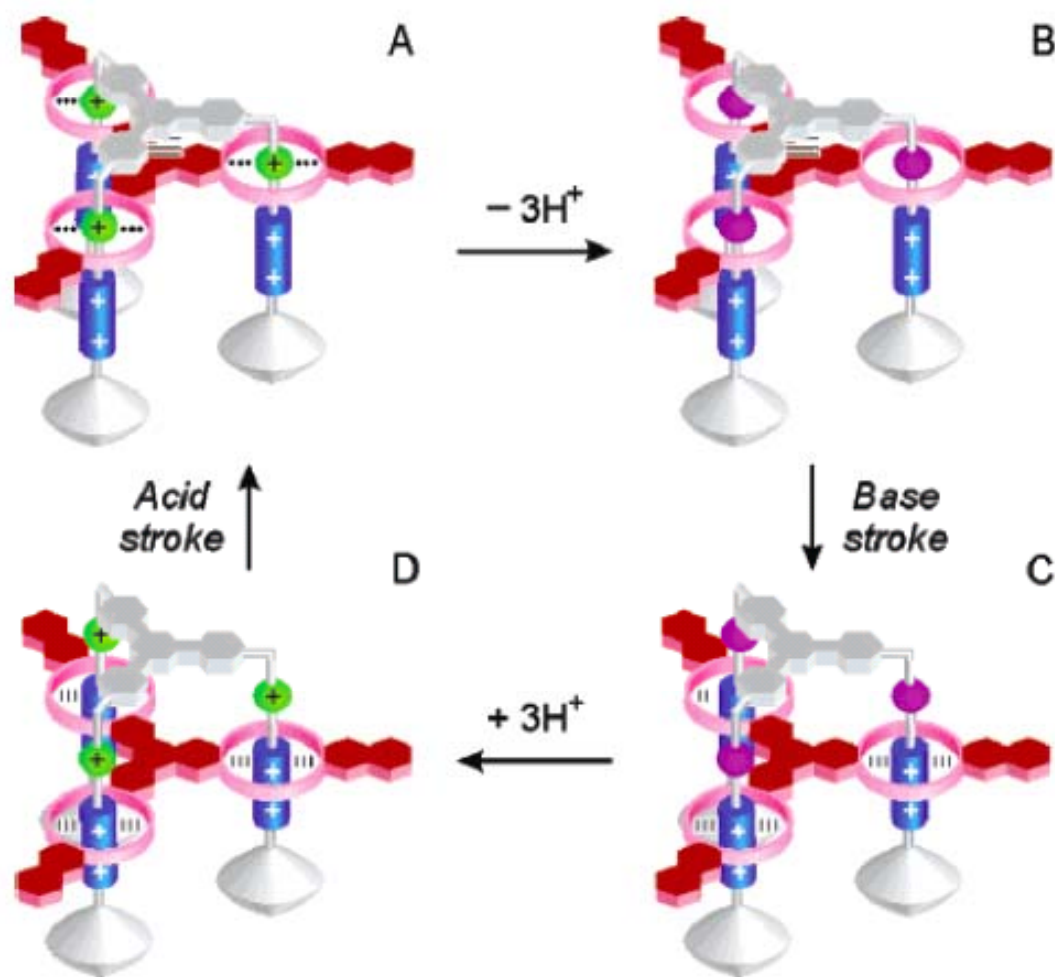
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# Elevator

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- Other molecular machines include
  - Motors
  - Switches
  - Shuttles
  - Turnstiles
  - Gears
  - Bearings
  - Gyroscopes
- Future is in incorporating several molecular machines into a functional macro-molecular machines