Light-Driven Molecular Motor

M1 Toyama

2019/10/03

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2016 Nobel Prize in Chemistry

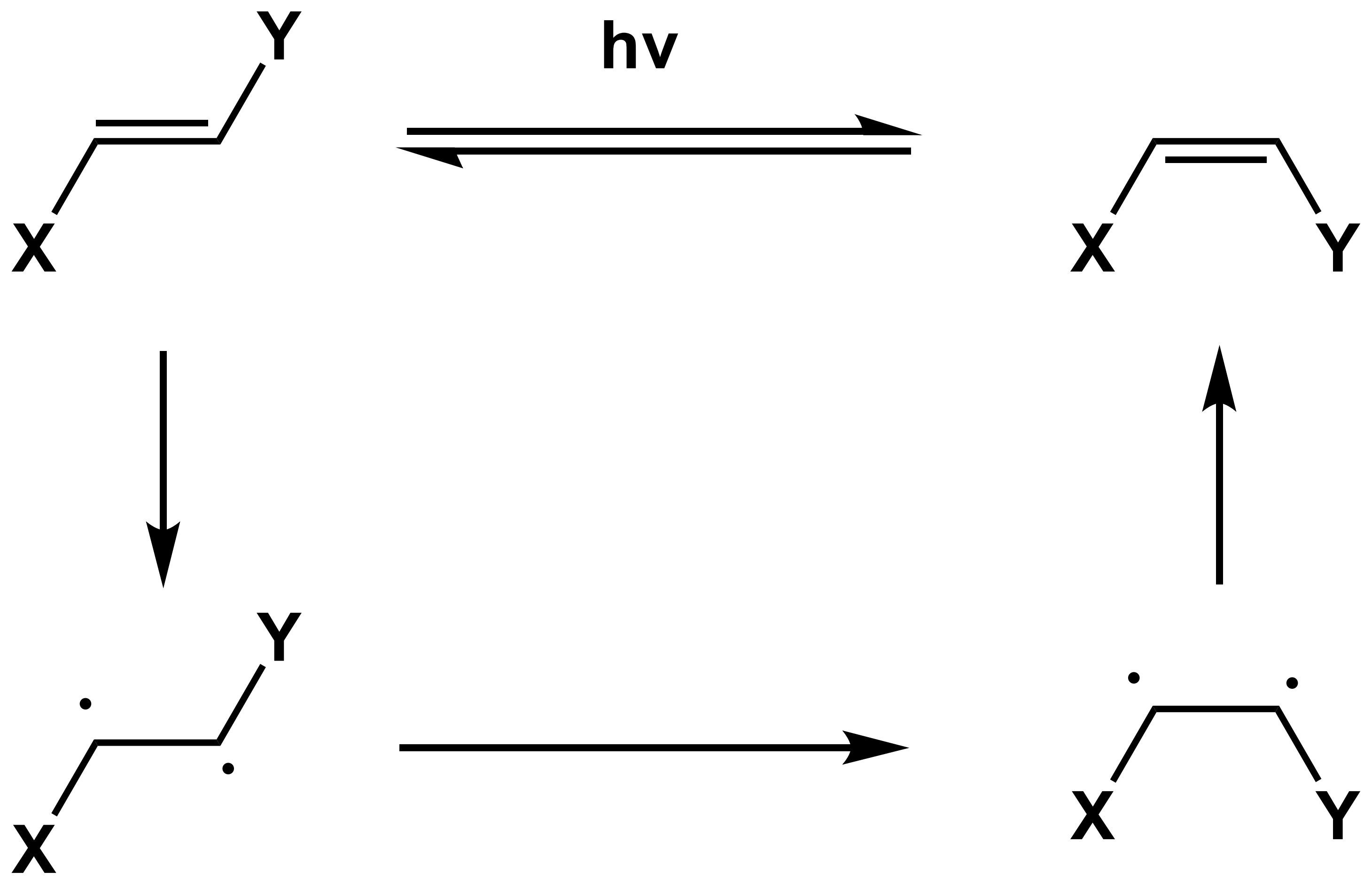
"for the design and synthesis of molecular machines."

Sauvage

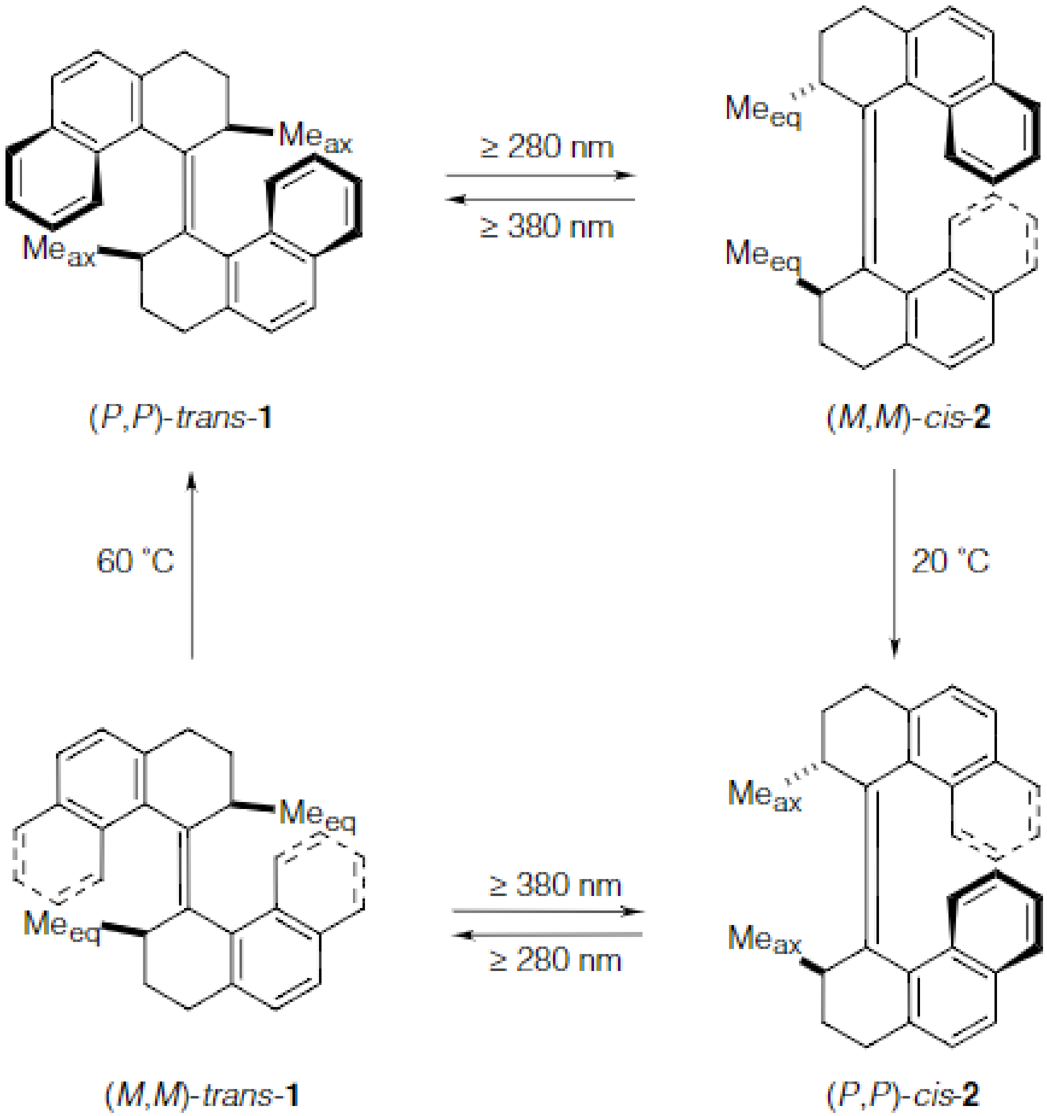
Stoddart

Feringa

Photoisomerization of Alkene

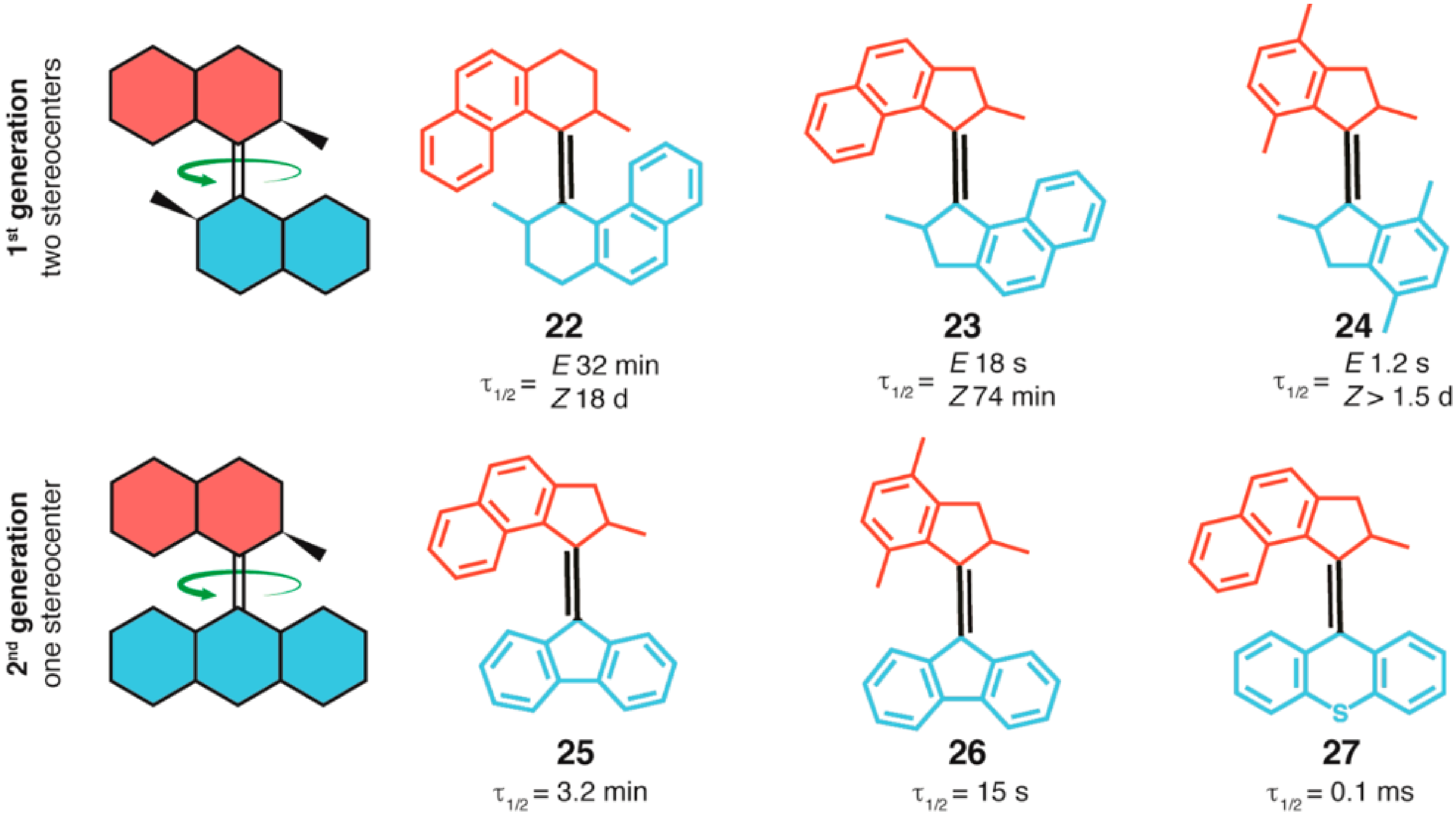


Light-Driven Monodirectional Molecular Motor



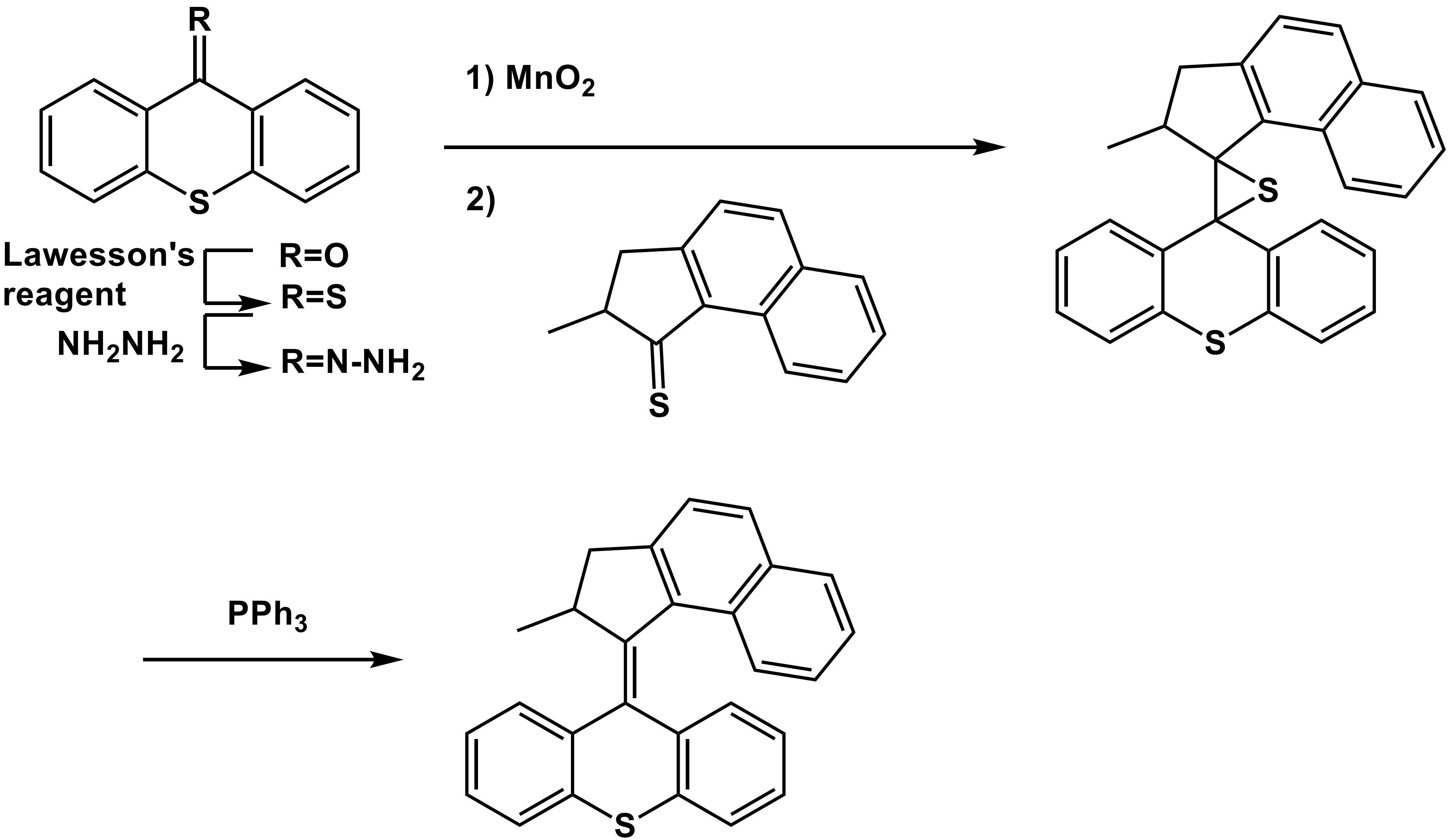
N. Koumura, R. W. Zijlstra, R. A. van Delden, N. Harada and B. L. Feringa, *Nature*, **1999**, *401*, 152.

First and Second Generation of Motor



M. Baroncini, S. Silvi and A. Credi, *Chem. Rev.*, , DOI:10.1021/acs.chemrev.9b00291.

Synthesis of Motor



B. L. Feringa, et al. *J. Am. Chem. Soc.*, **2016**, *138*, 660.

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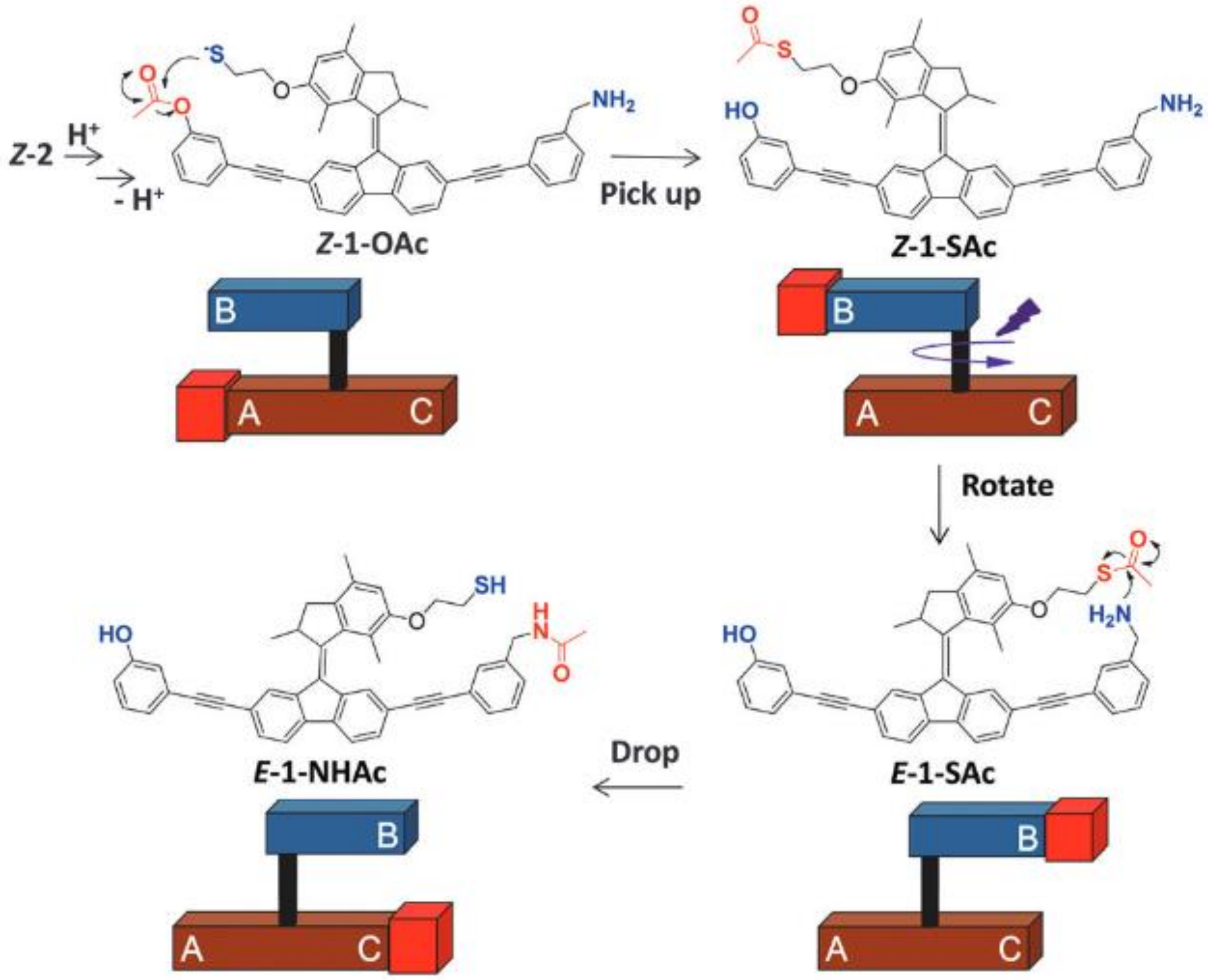
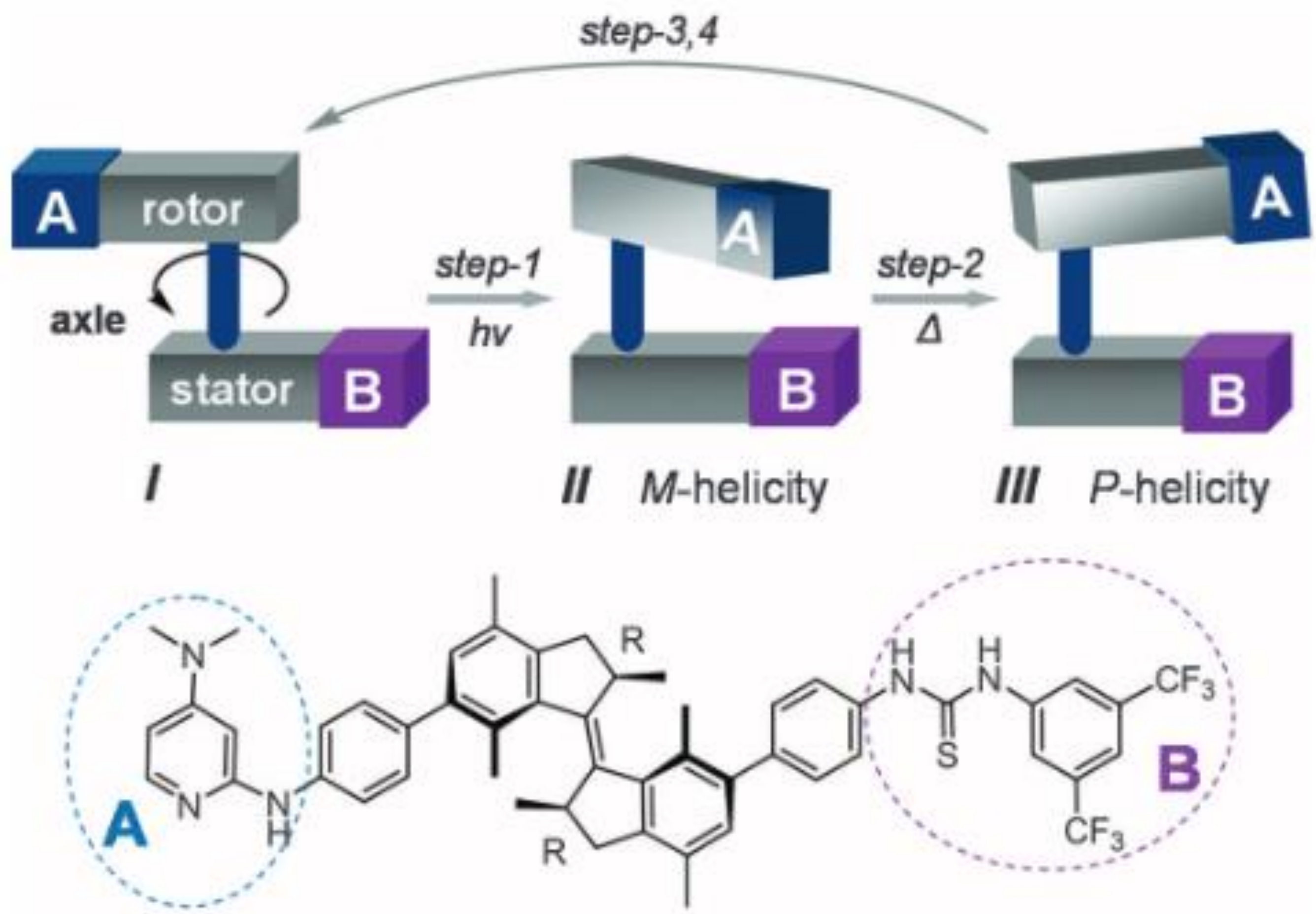
Intramolecular Transport of Acetyl Group



J. Chen, S. J. Wezenberg and B. L. Feringa, *Chem. Commun.* , **2016**, *52*, 6765.

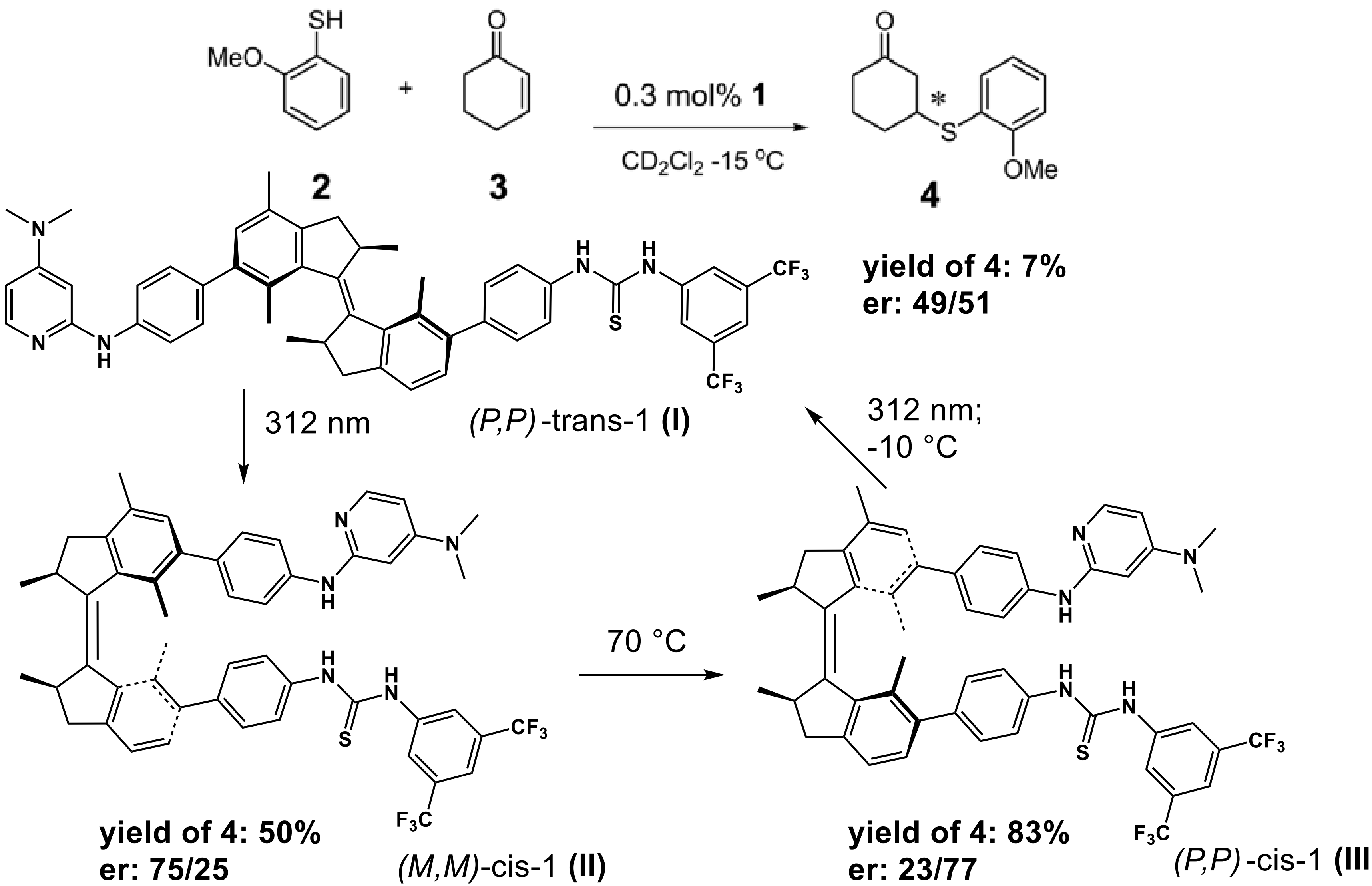
Asymmetric Reaction Control (1)



(2R,2'R)-(P,P)-trans-**1**

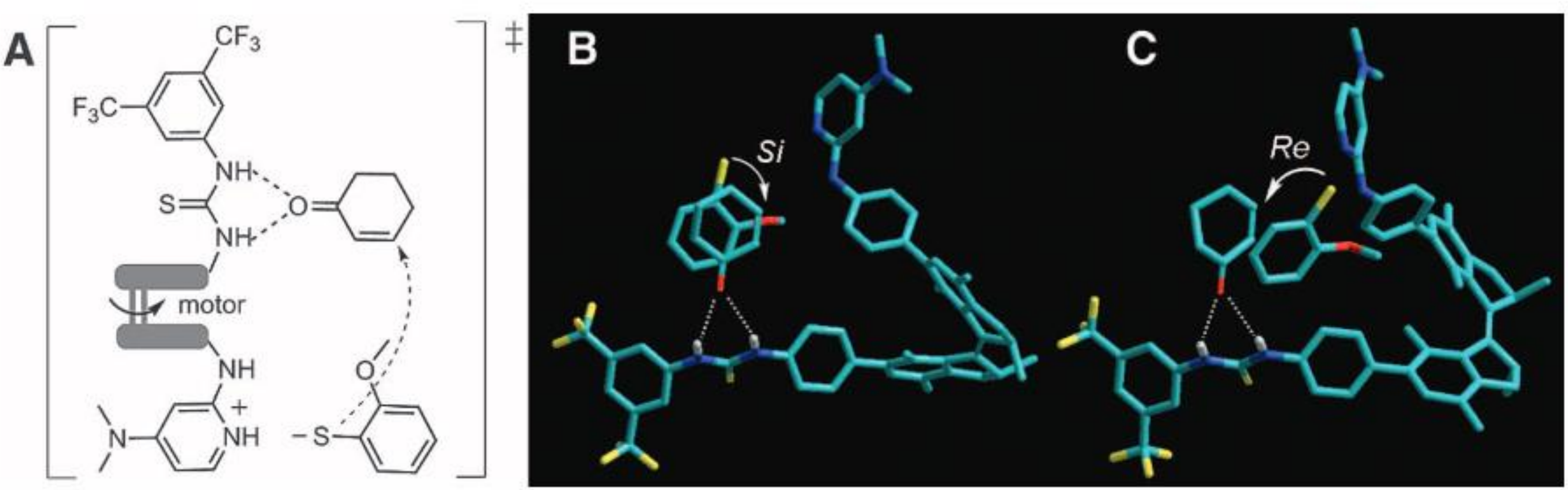
J. Wang and B. L. Feringa, *Science*, **2011**, *331*, 1429.

Asymmetric Reaction Control (1)



J. Wang and B. L. Feringa, *Science*, **2011**, *331*, 1429.

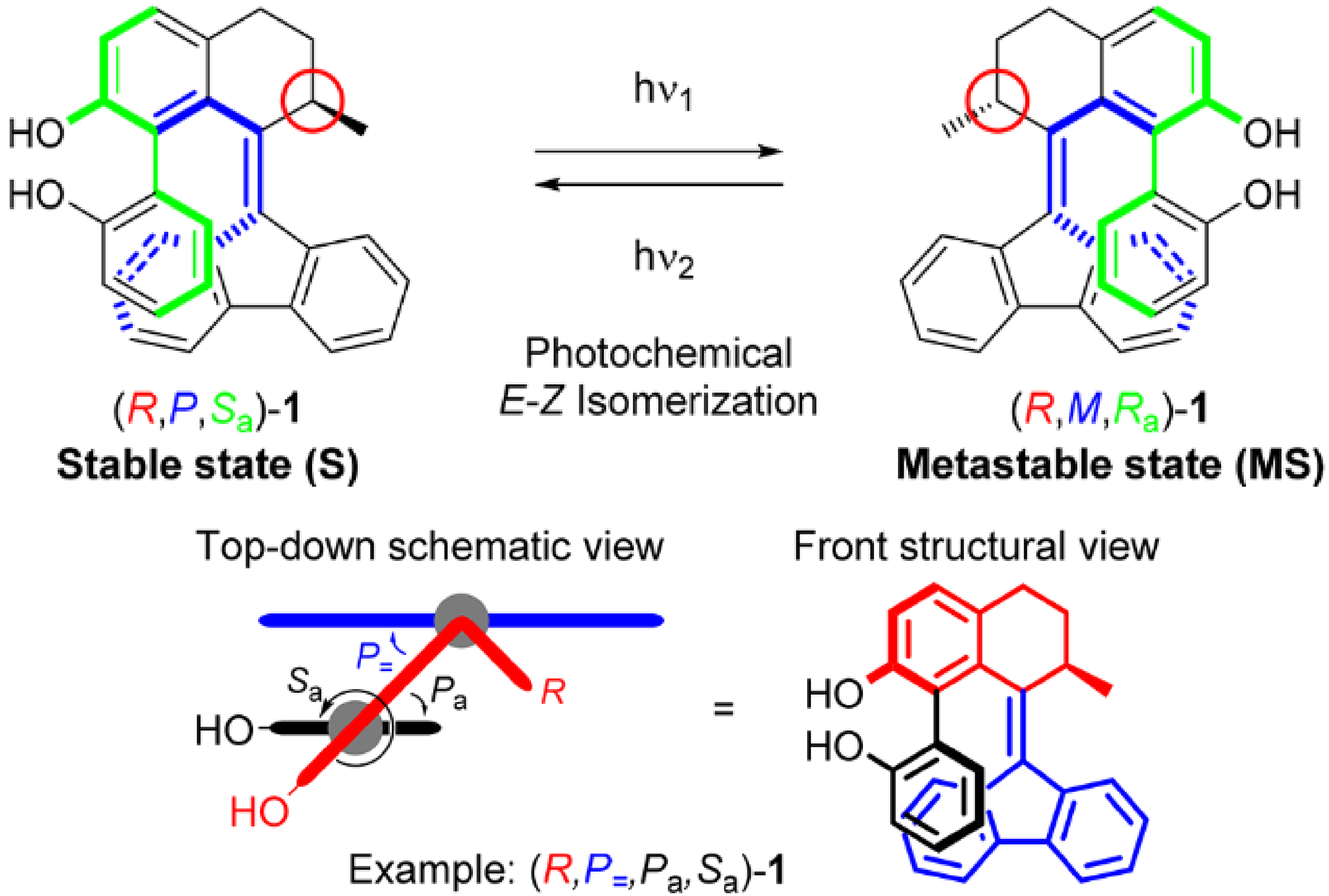
Asymmetric Reaction Control (1)



- Hydrogen bonding between enone and thiourea
- Thiol deprotonation by DMAP

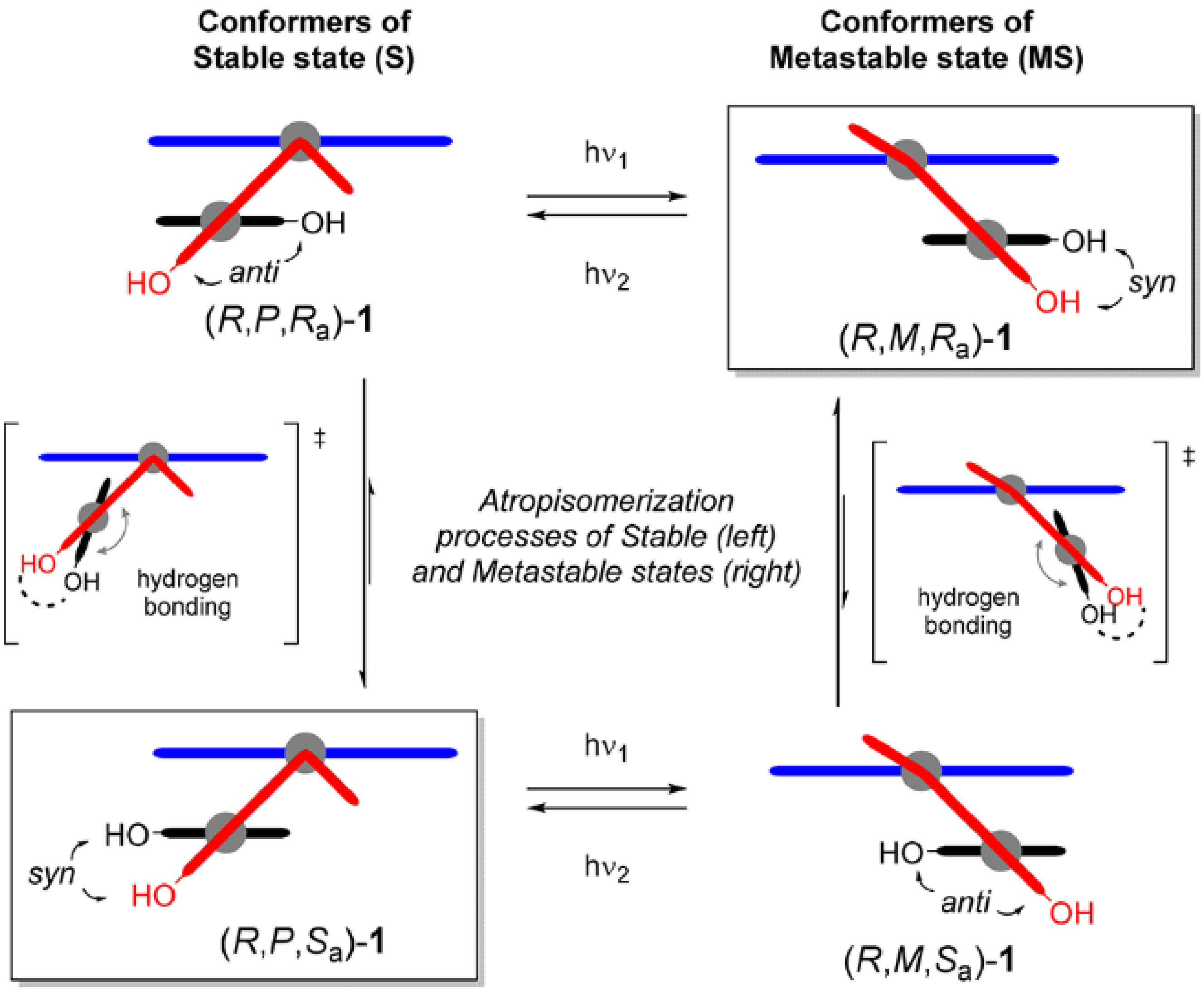
J. Wang and B. L. Feringa, *Science*, **2011**, *331*, 1429.

Asymmetric Reaction Control (2)



B. L. Feringa, et al. *J. Am. Chem. Soc.*, **2018**, *140*, 17278.

Asymmetric Reaction Control (2)



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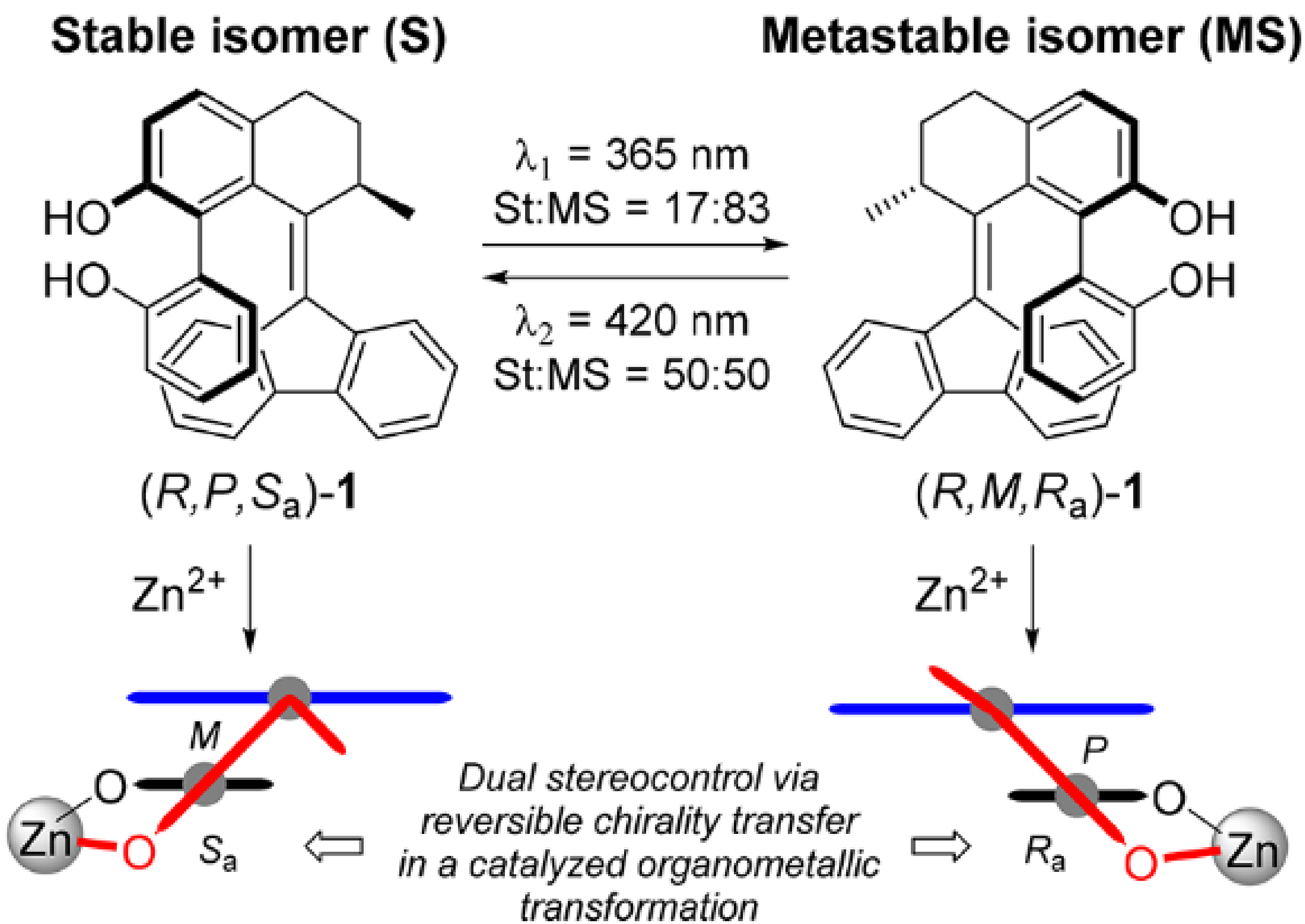

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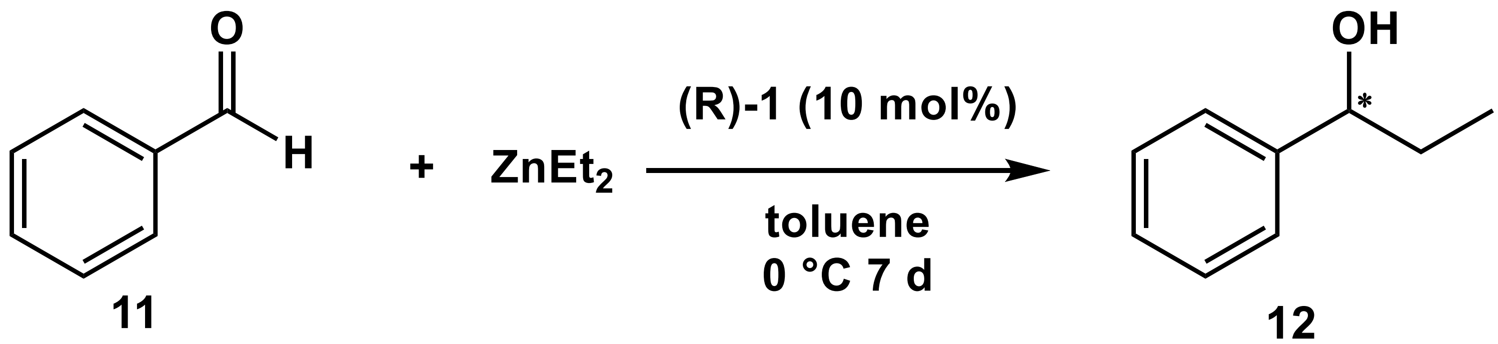
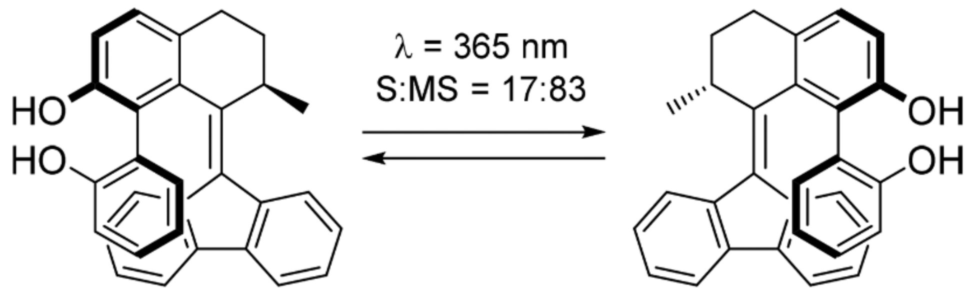




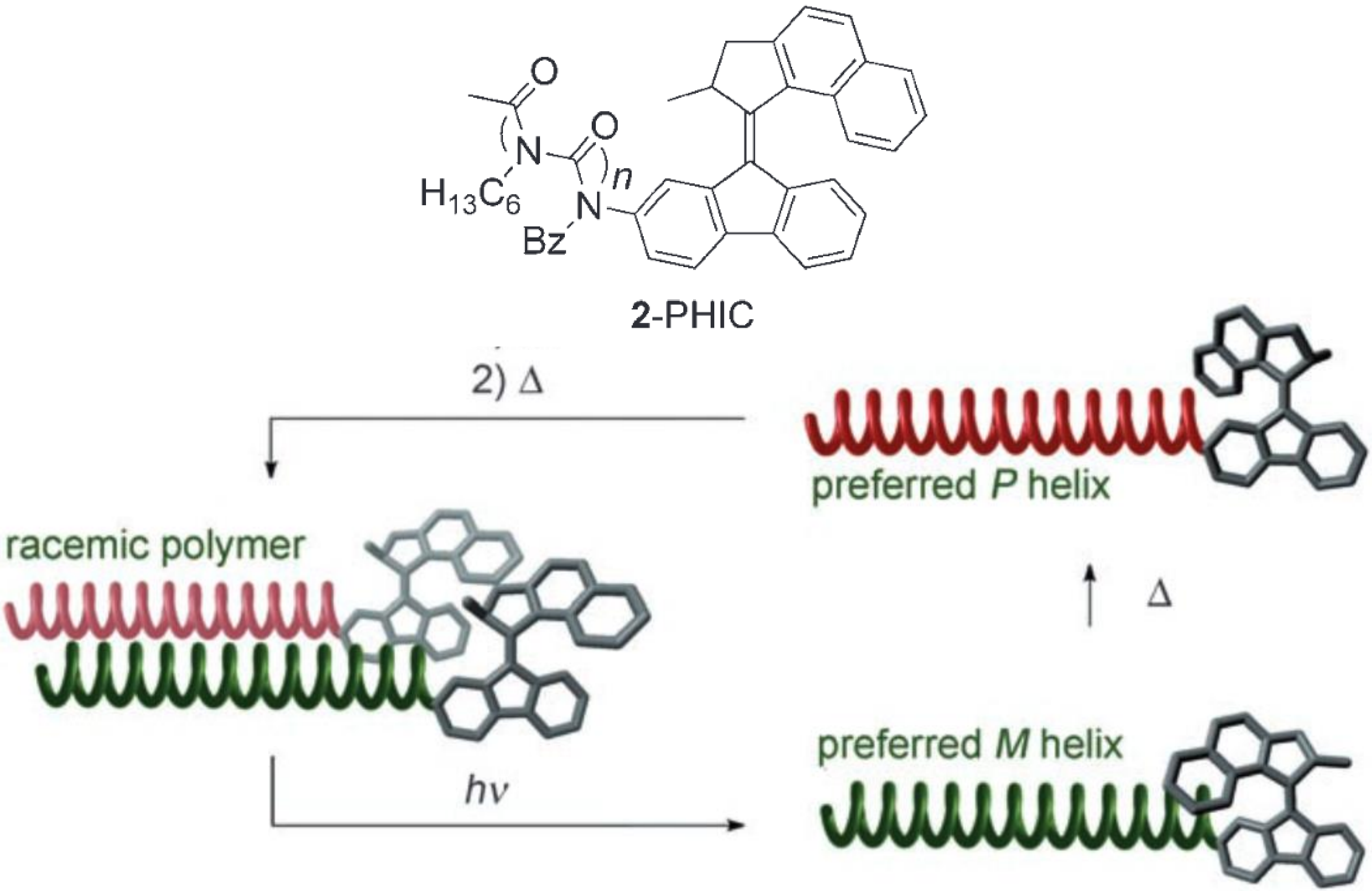
(R,P,S_a)-**1**
Stable isomer (S)

(R,M,R_a)-**1**
Metastable isomer (MS)

Entry	Catalyst	Yield	ee
1	(R)-1	86%	68% (R)-12
2	(R) + 365 nm	87%	45% (S)-12

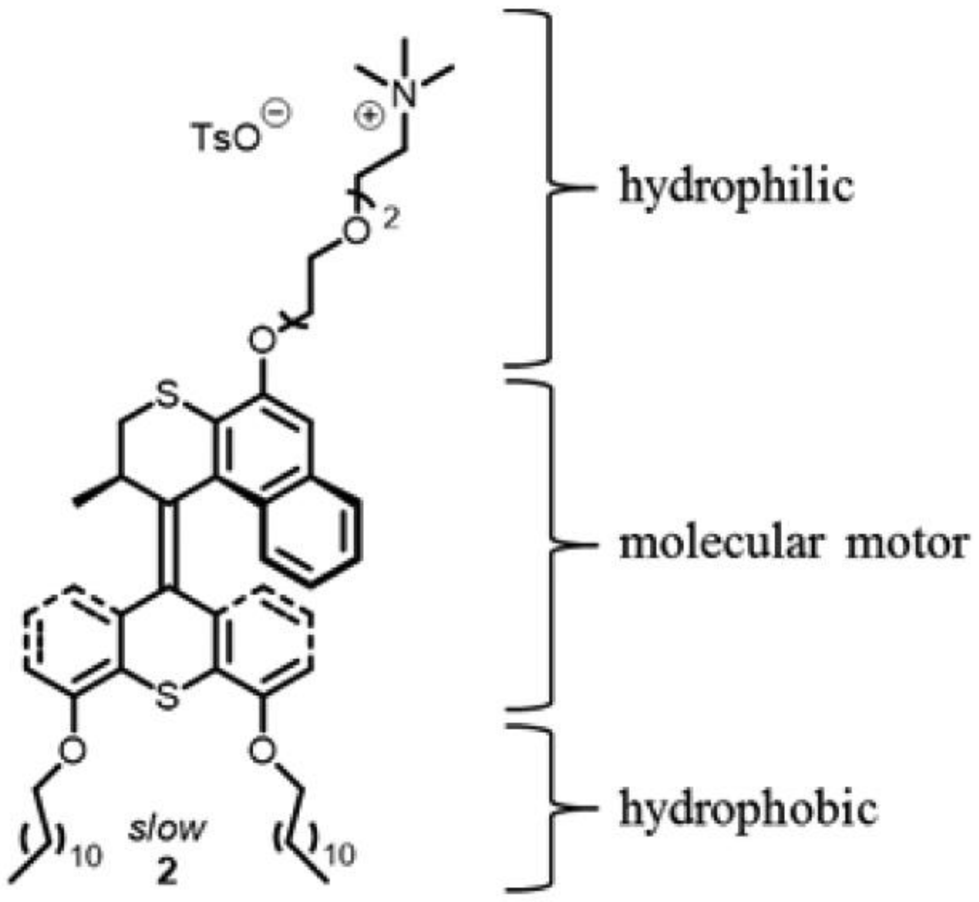
B. L. Feringa, et al. *J. Am. Chem. Soc.*, **2018**, *140*, 17278.

Controlling the Twist Sense of a Helical Polymer



D. Pijper and B. L. Feringa, *Angew. Chem. Int. Ed Engl.*, **2007**, *46*, 3693.

Self-Assembly Supramolecular in Water



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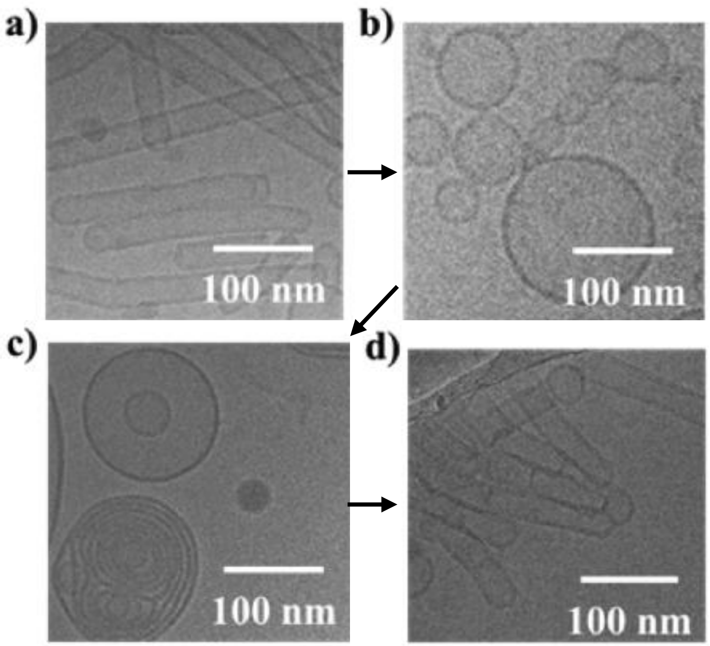
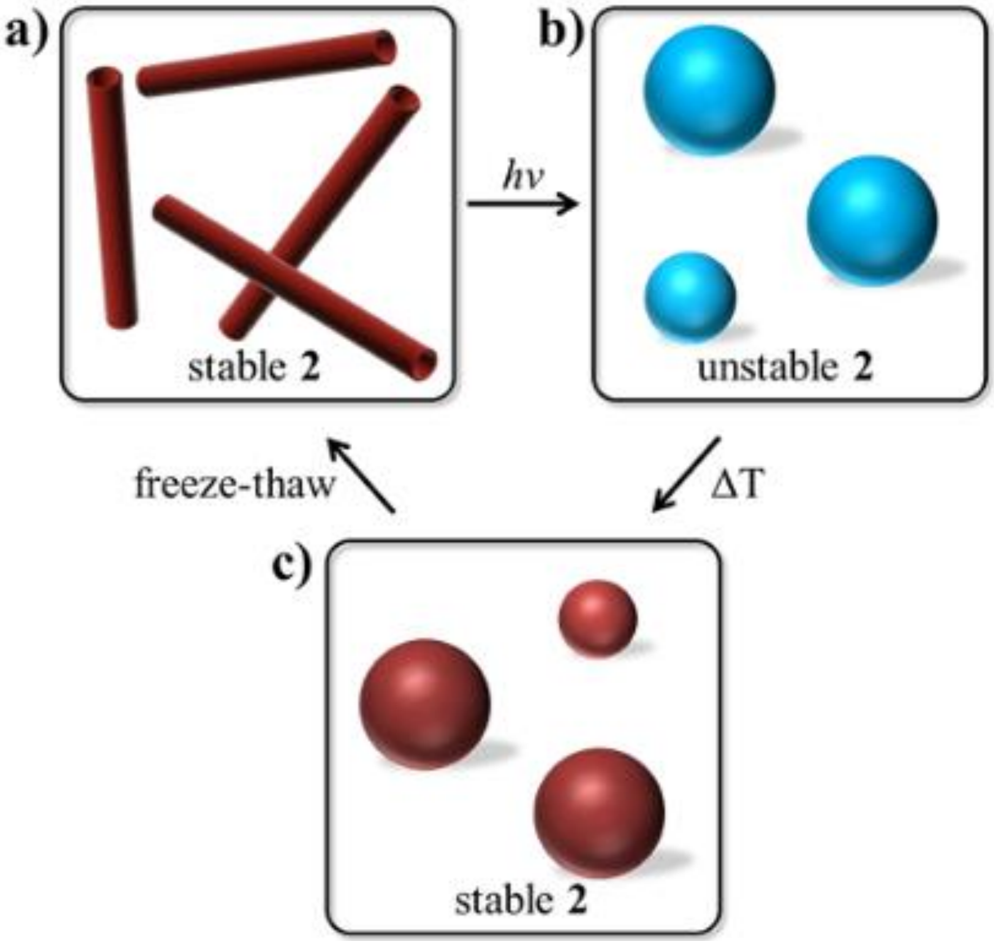
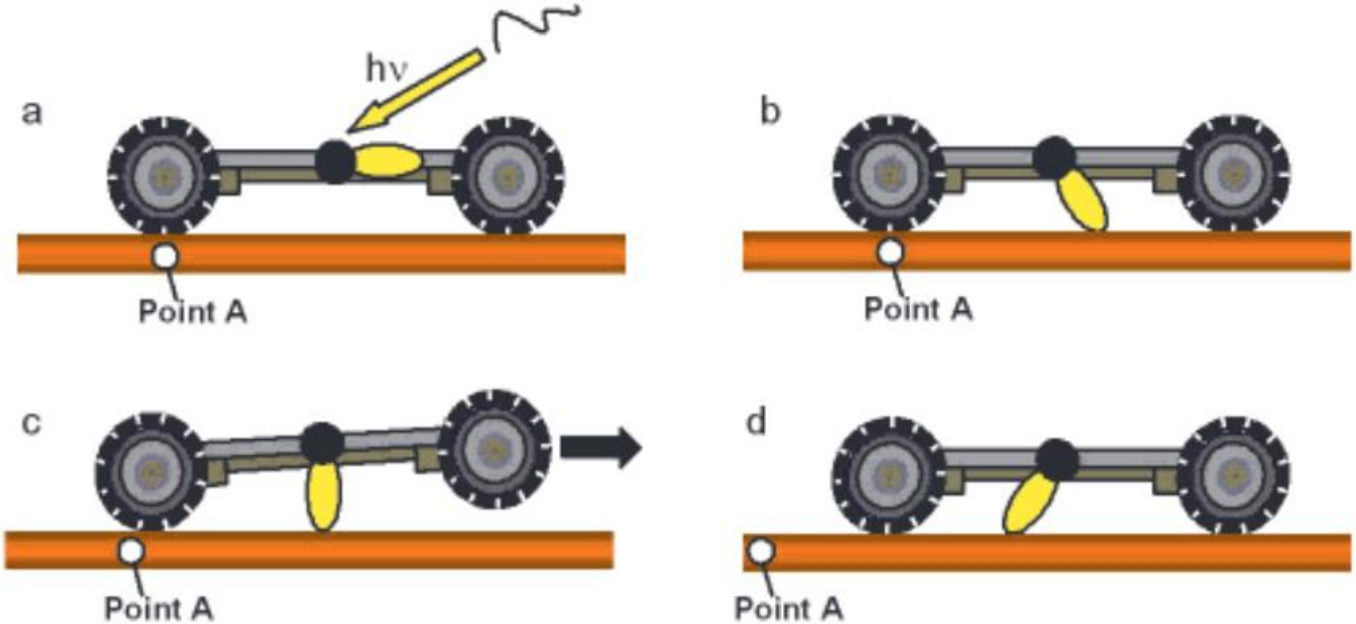
Self-Assembly Supramolecular in Water

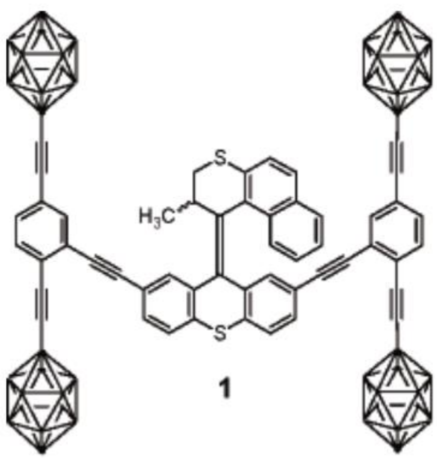




B. L. Feringa, et al. *J. Am. Chem. Soc.*, **2016**, *138*, 660.

Motorized Nanocar (1)



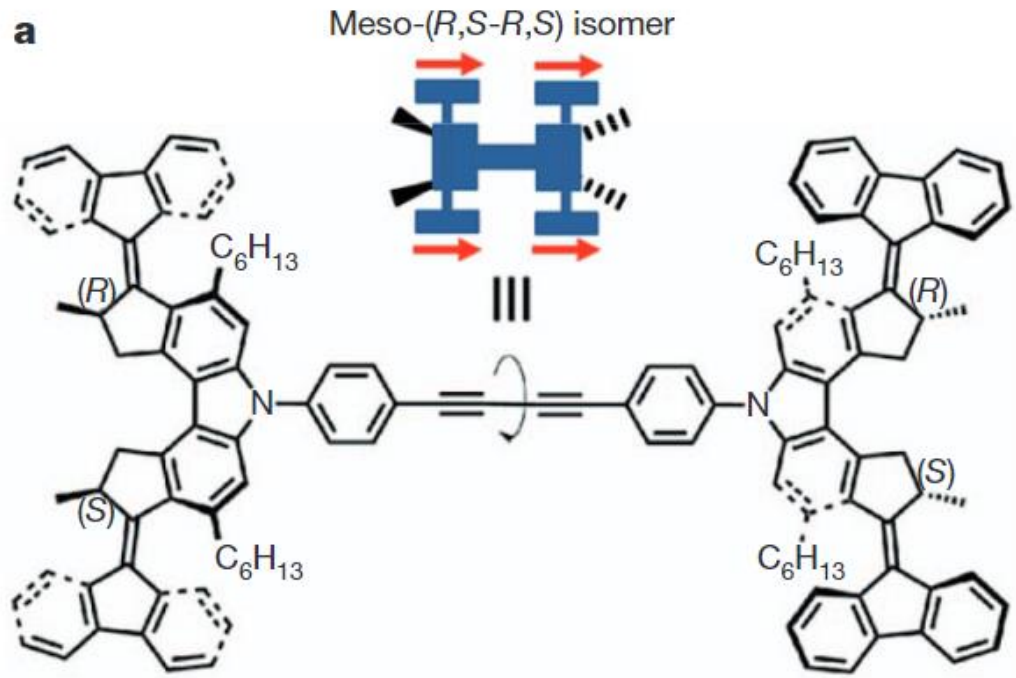


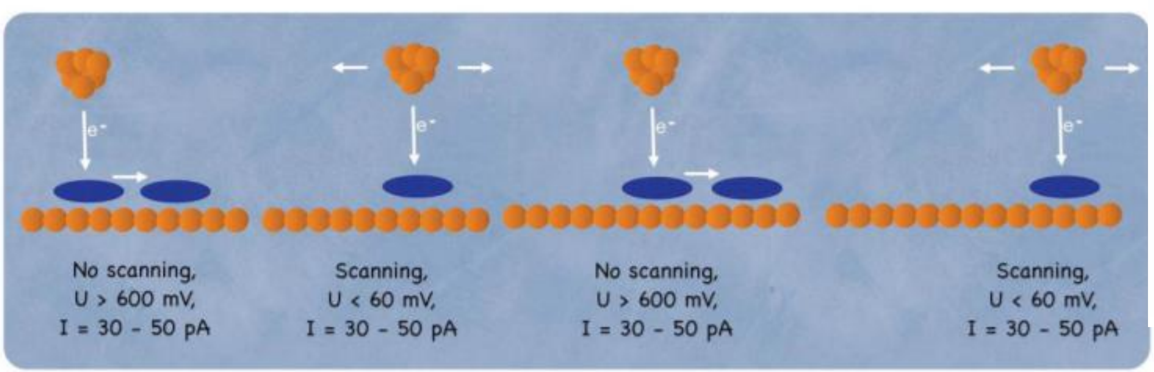
1

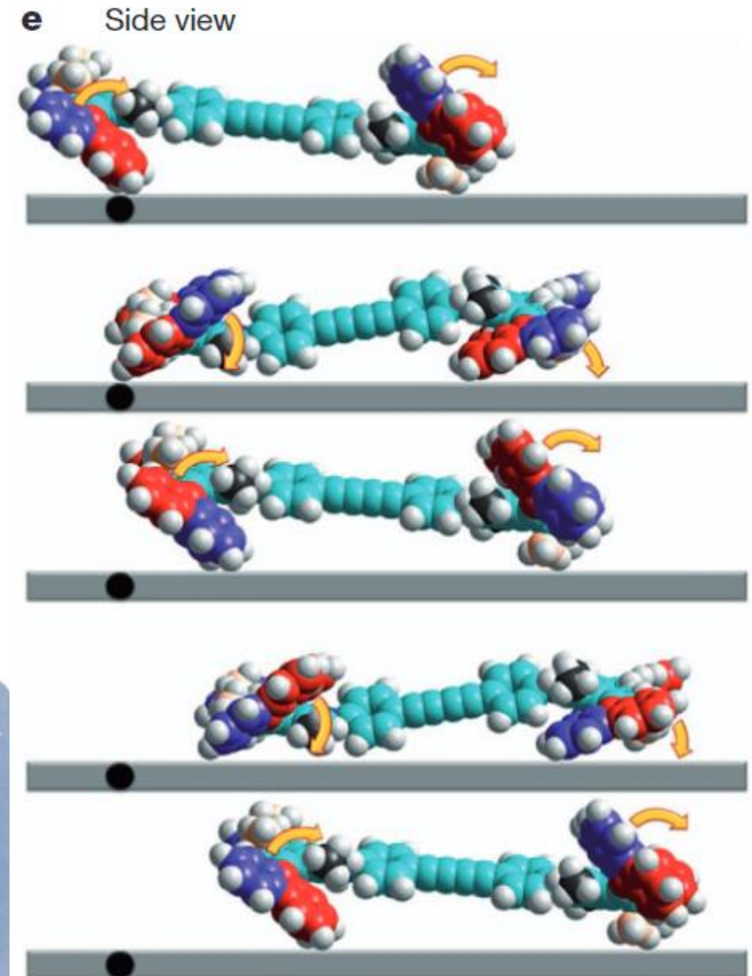
Unsuccessful – intramolecular quenching of the photoexcited state by fullerene wheels

J.-F. Morin, Y. Shirai and J. M. Tour, *Org. Lett.*, **2006**, *8*, 1713.

Motorized Nanocar (2)





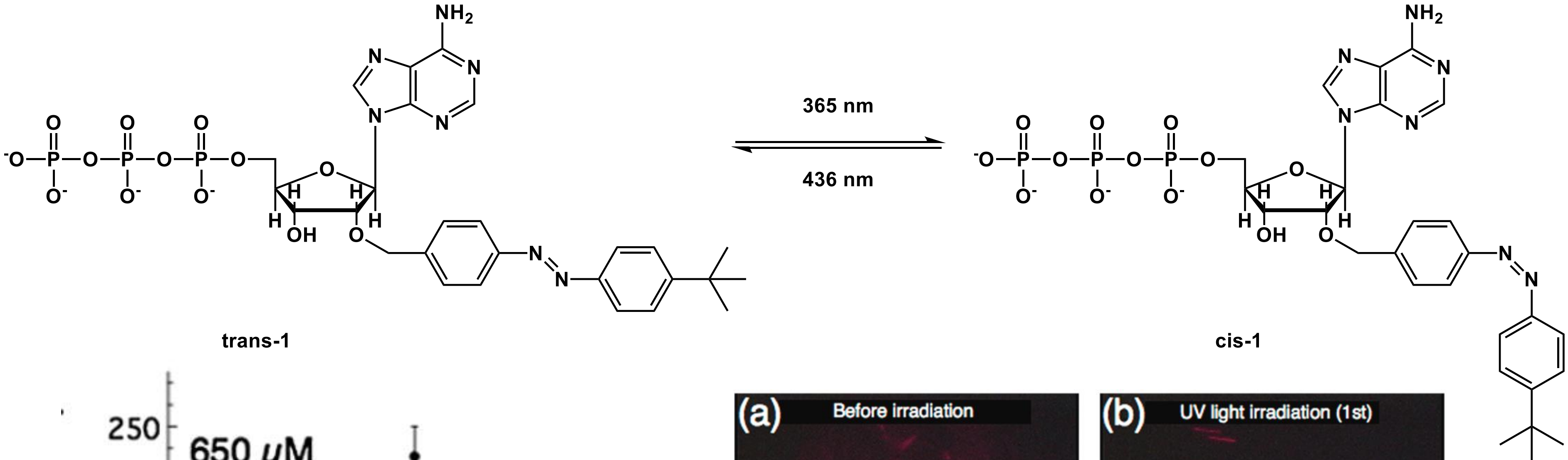


L. Feringa, et al. *Nature*, **2011**, *479*, 208–211.

Motorized Nanocar (2)

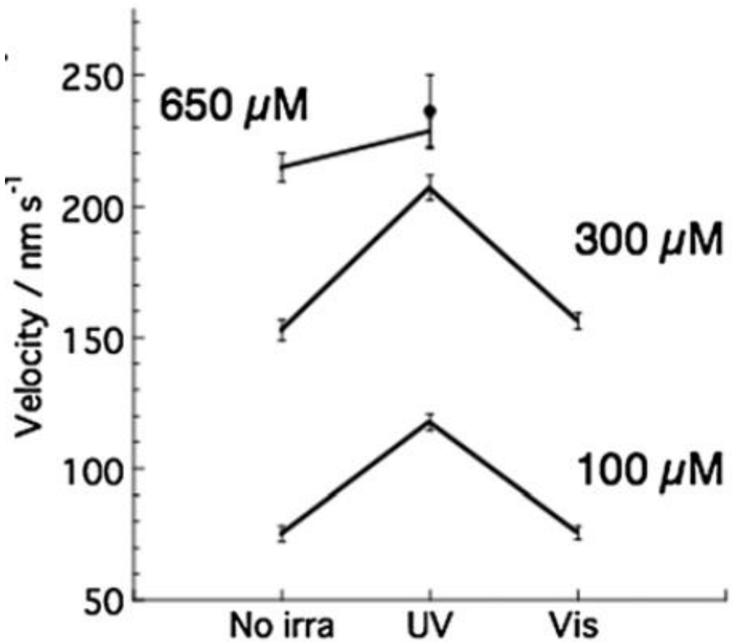
L. Feringa, et al. *Nature*, **2011**, *479*, 208–211.

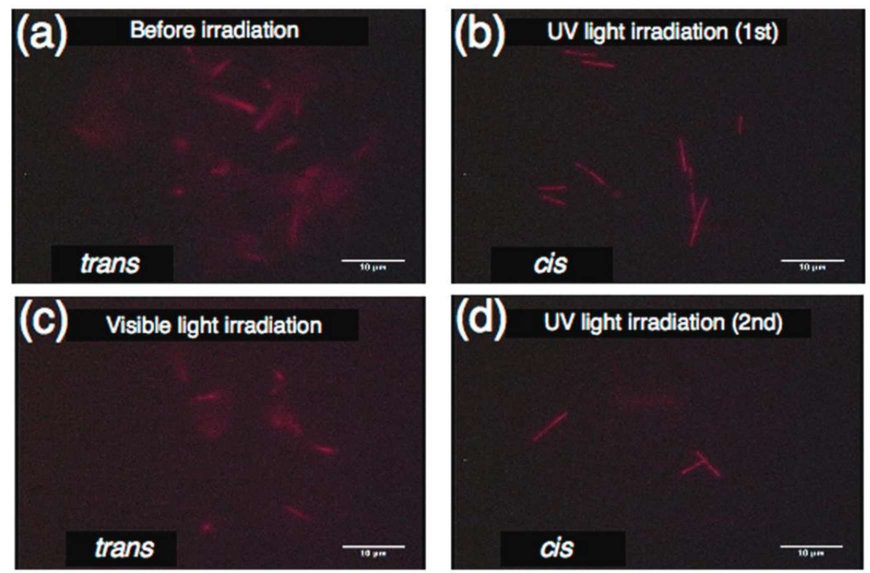
Photo-Switchable ATP analogue



trans-1

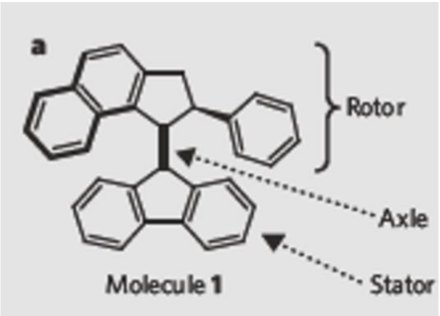
cis-1

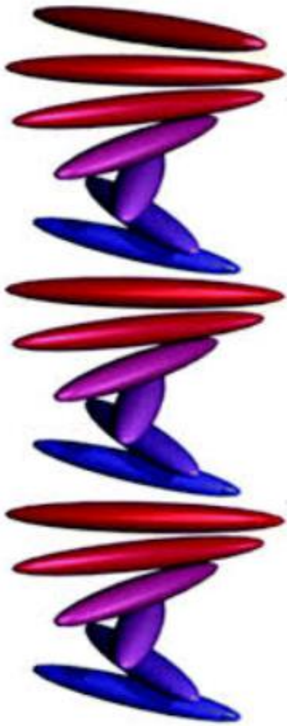




T. Kamei, T. Fukaminato and N. Tamaoki, *Chem. Commun.* , **2012**, *48*, 7625.

Nanomotor rotates microscale objects

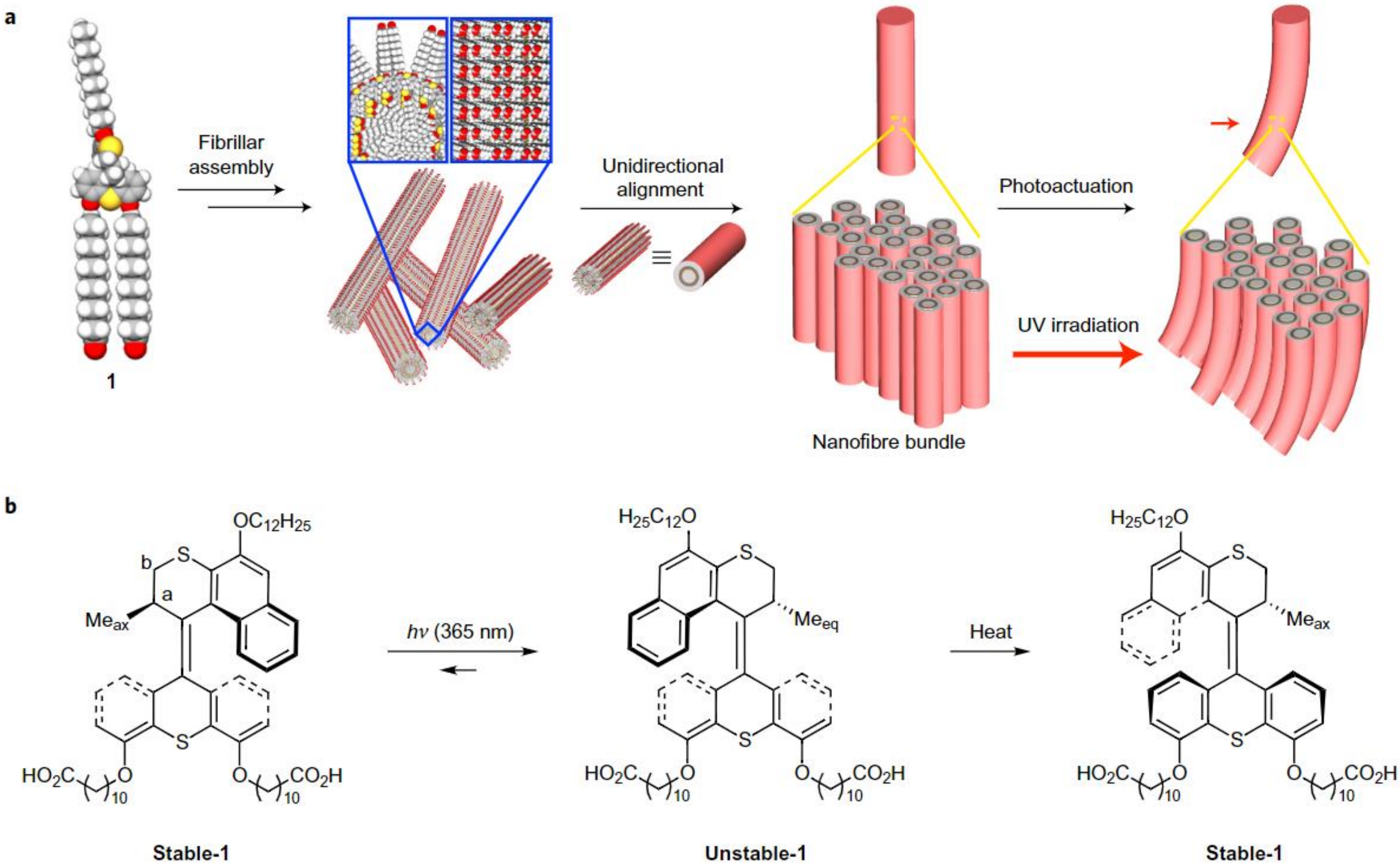




Feringa, et al. *Nature*, **2006**, *440*, 163.

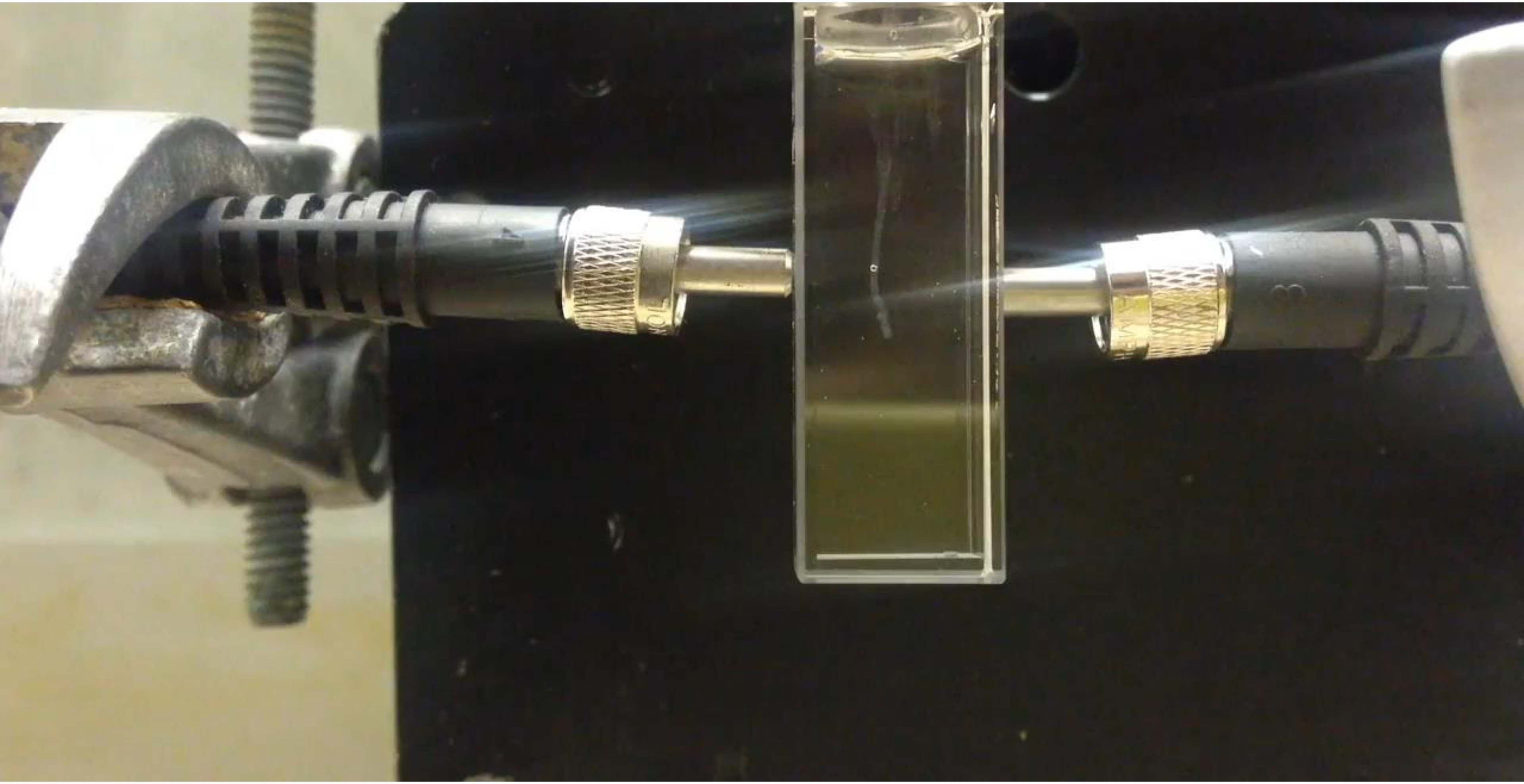
Cholesteric liquid crystal

Artificial Muscle-Like Function



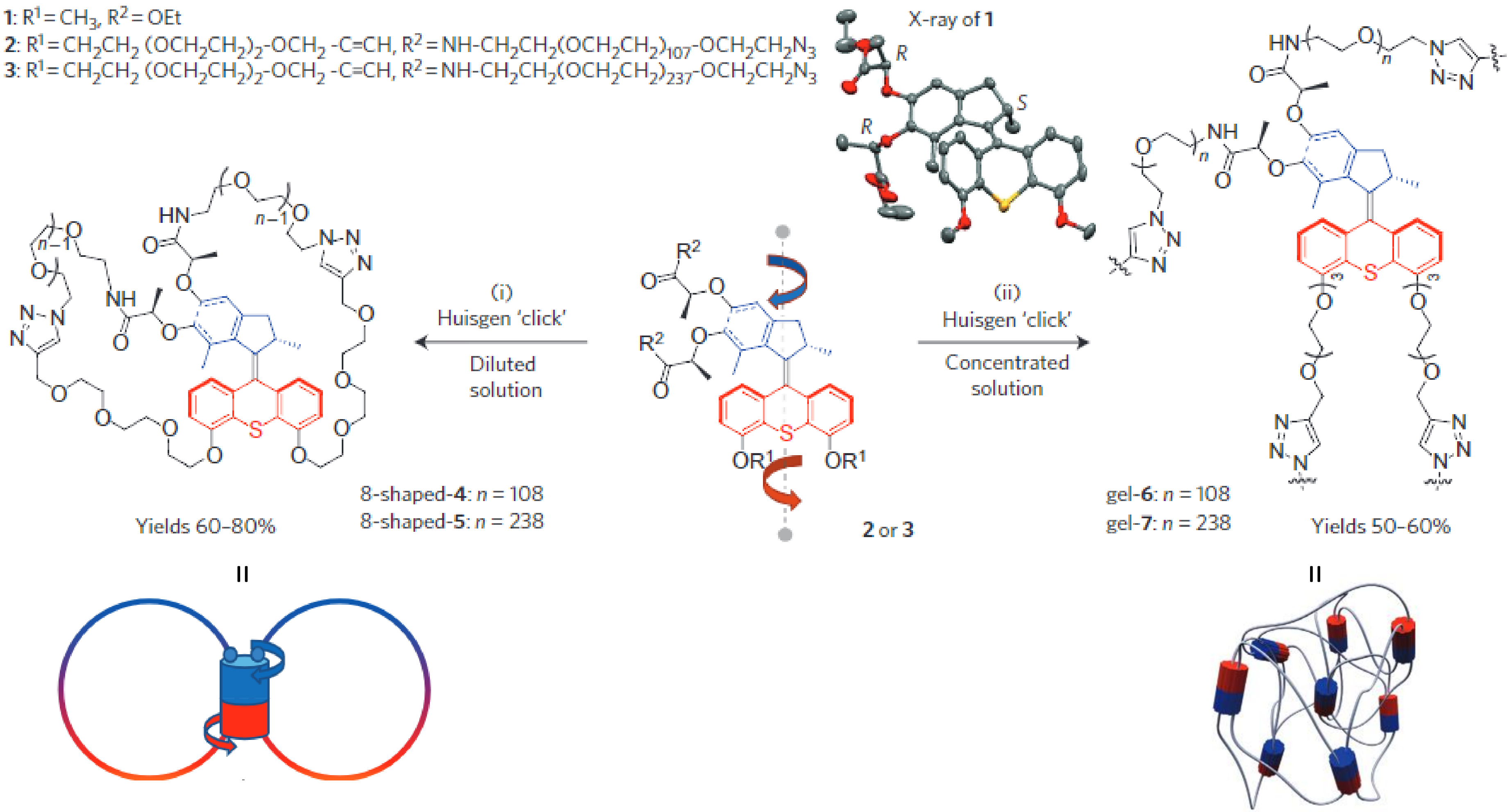
Feringa, et al. *Nat. Chem.*, **2018**, *10*, 132.

Artificial Muscle-Like Function



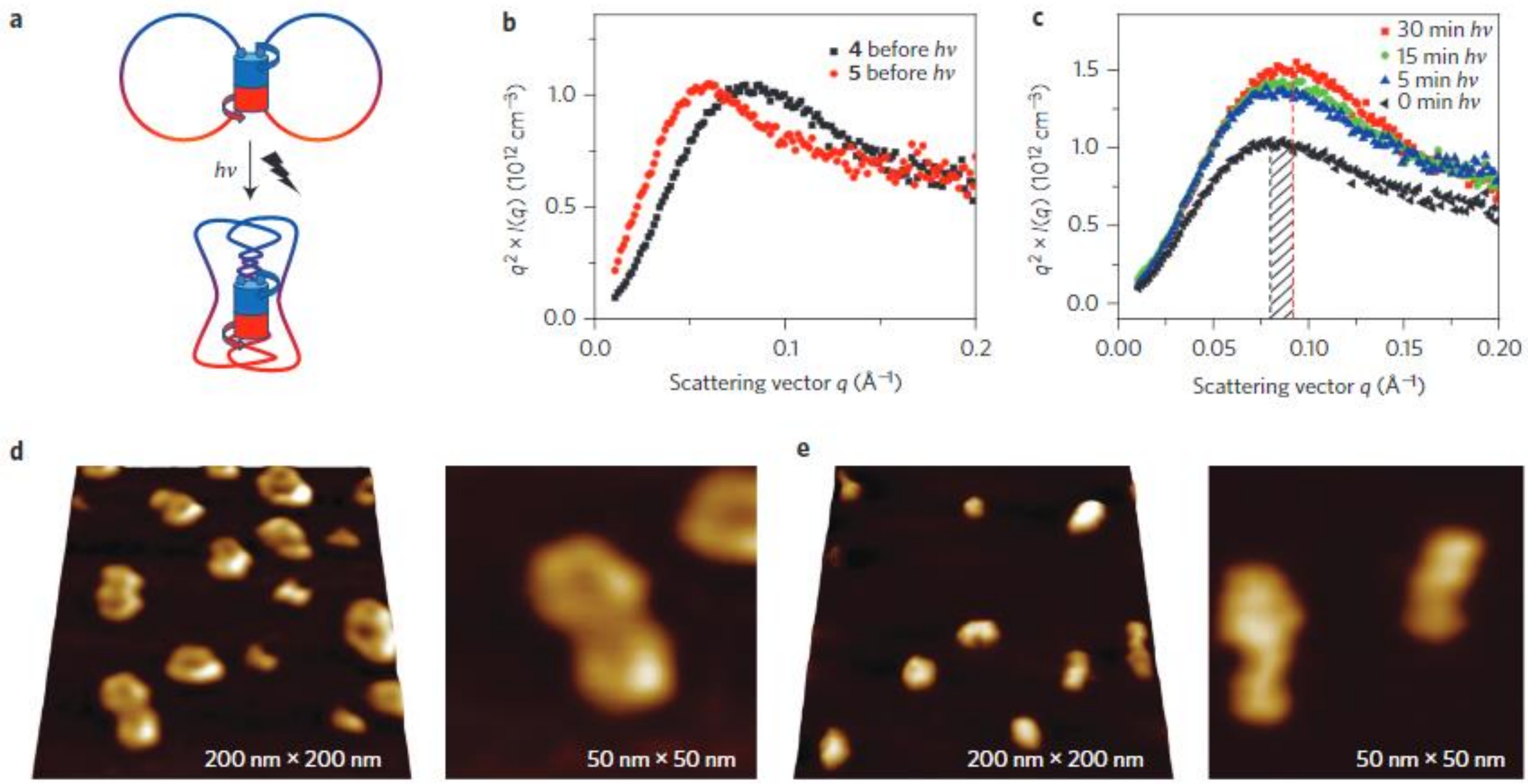
Feringa, et al. *Nat. Chem.*, **2018**, *10*, 132.

Contraction of Gel



N. Giuseppone, et al. *Nat. Nanotechnol.*, **2015**, *10*, 161.

Contraction of Gel



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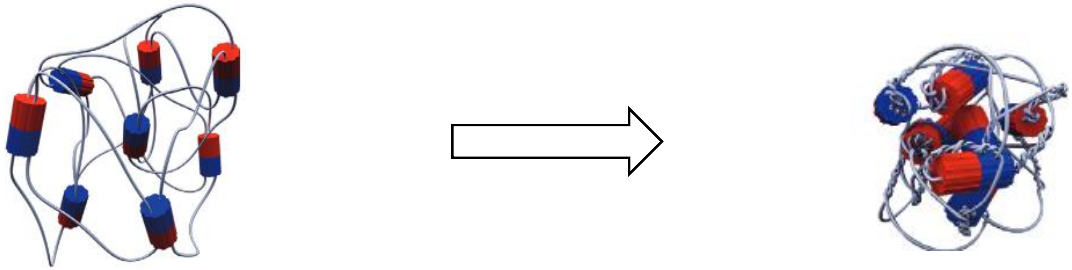

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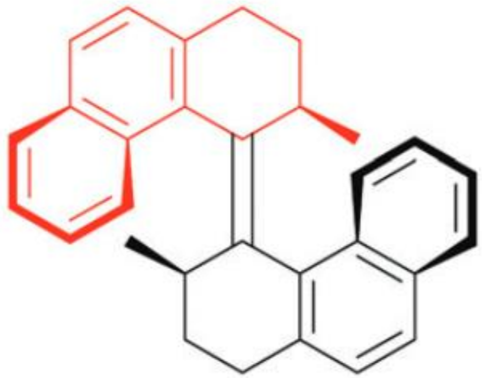
Summary

- Light-driven mono directional rotation
  on double bond



- Many applications –
Asymmetric reaction control, Helical control of polymer,
Nano car, Dynamic control of molecular assembly

Chemical Intramolecular Transport