Leibniz Universität Hannover

Institut für Organische Chemie

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Biologische Chemie
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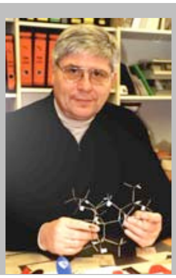

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Ferrocene Based Molecular Wires

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Molecular Electronics - Why?

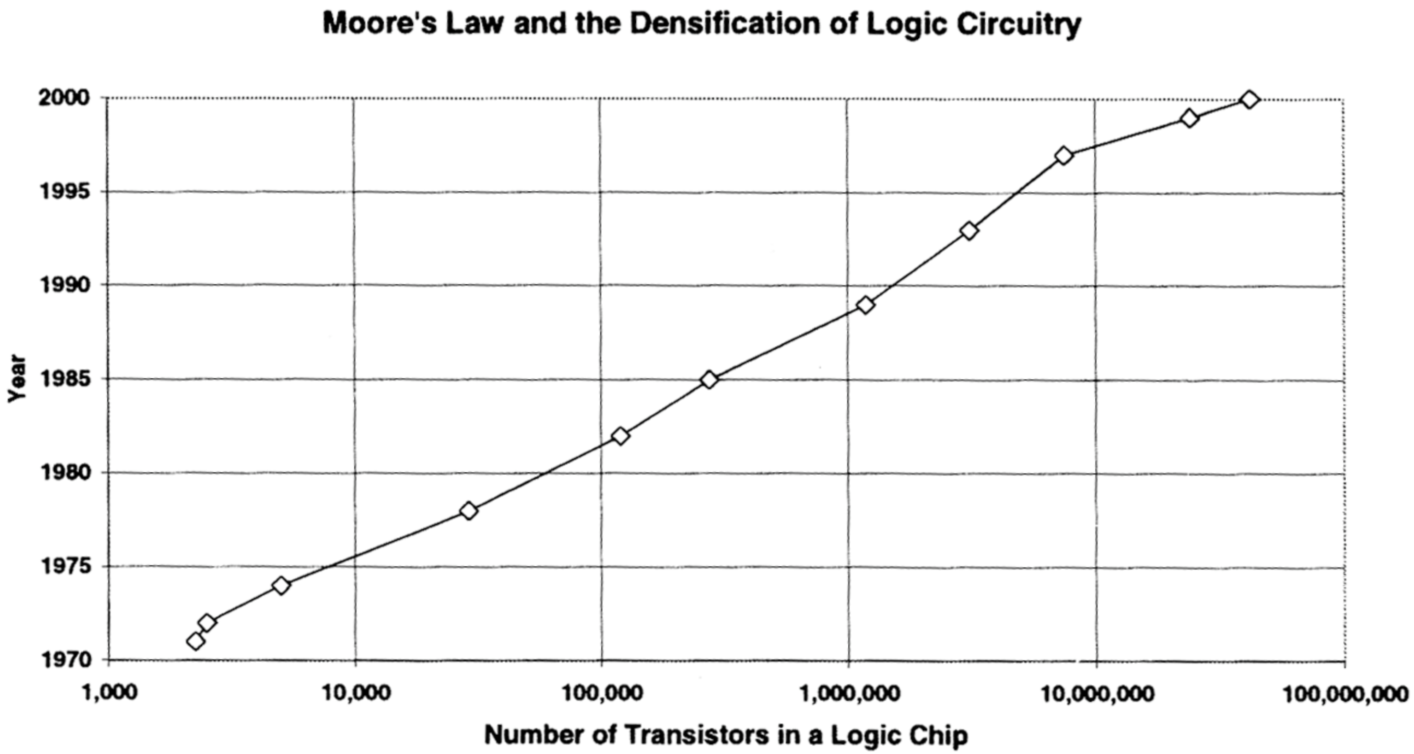


Figure 2.1 The number of transistors in a logic chip has increased exponentially since 1972 (Intel Data).

J. M. Tour, Molecular Electronics: Commercial Insights, Chemistry, Devices, Architecture and Programming, World Scientific, New Jersey 2003.

Silicon Technology Comes to an End

Altogether different, however, is the wall that is now being approached by silicon. The wall is not a technological wall but a fundamental physical wall related to the silicon material itself. That wall cannot be overcome by engineering. For instance, charge leakage becomes a problem when the insulating silicon oxide layers are thinned to about three silicon atoms thick, which will be reached commercially by 2004.[17] Moreover, silicon no longer possesses its band structure when it is restricted to very small sizes. Even the world's best engineers cannot overcome physical science barriers that are inherent in the materials properties. Therefore, the wall that silicon is now approaching is quite different than the wall that was previously overcome by clever technologists. Small materials modifications such as the use of silicon nitride might slow the collision, but industry insiders predict that silicon will hit that physical science barrier by 2008-2012, and the only way around this wall is a draconian change in the technology itself.

J. M. Tour, Molecular Electronics: Commercial Insights, Chemistry, Devices, Architecture and Programming, World Scientific, New Jersey 2003.

We Need a Revolution!

A new technology would be of interest to the semiconductor industry if it only addressed one of the problems in the chip manufacturing processes. But a new technology that produces faster and smaller logic and memory, reduces fabrication complexity, saves days to weeks of manufacturing time, and reduces the consumption of natural resources, would be revolutionary. Since silicon is approaching its fundamental materials science limits, a new platform would be the only solution. Can molecular electronics be the answer? Many think so.

J. M. Tour, Molecular Electronics: Commercial Insights, Chemistry, Devices, Architecture and Programming, World Scientific, New Jersey 2003.

Mechanically Controllable Break Junction

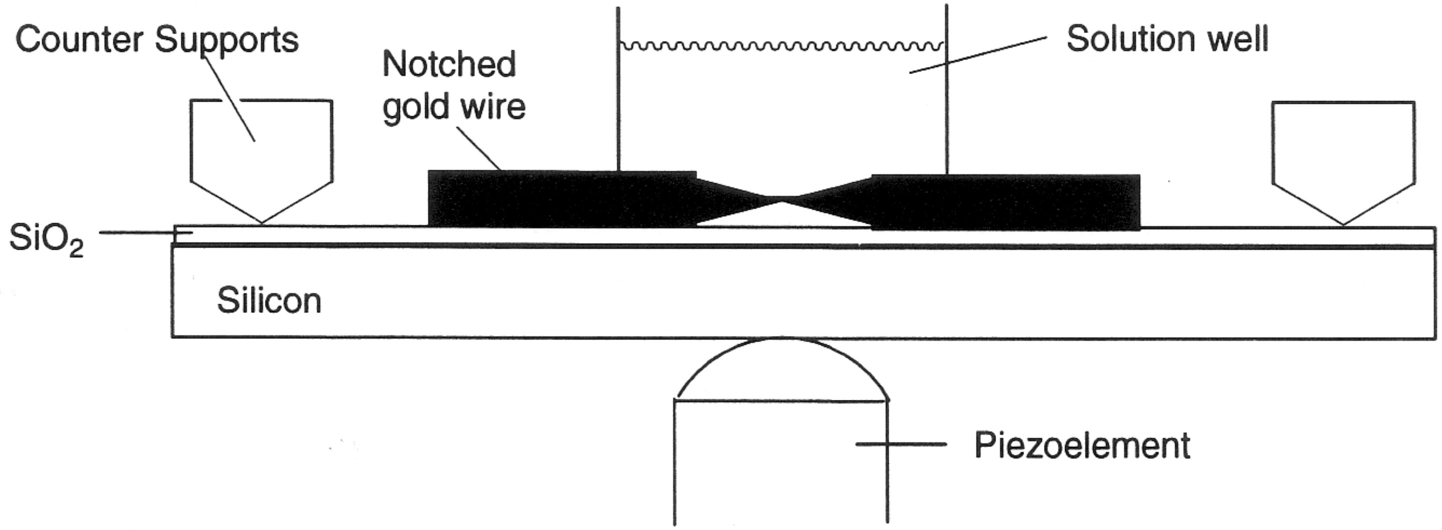
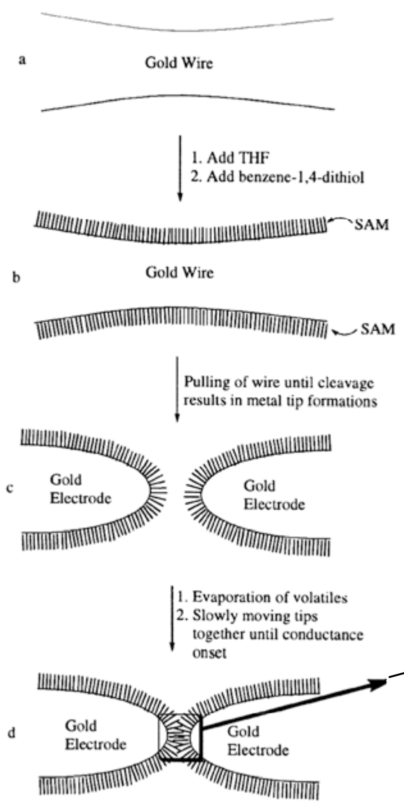


Figure 4.8 A schematic of the mechanically controllable break junction showing the bending beam formed from a silicon wafer, the counter supports, the notched gold wire which is glued to the surface, the piezo element for controlling the tip-to-tip distance through bending of the silicon platform, and the glass capillary tube containing the solution of molecular wires.

J. M. Tour, Molecular Electronics: Commercial Insights, Chemistry, Devices, Architecture and Programming, World Scientific, New Jersey 2003.

Creating the Contact



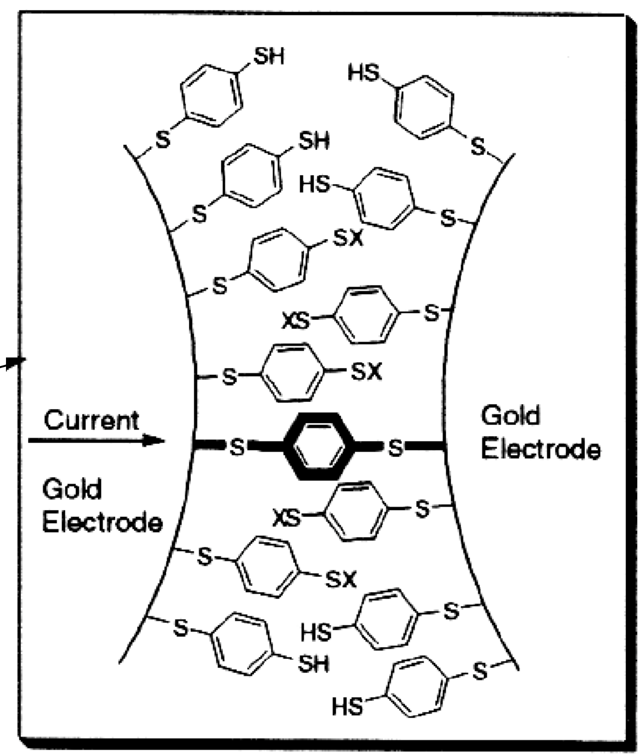
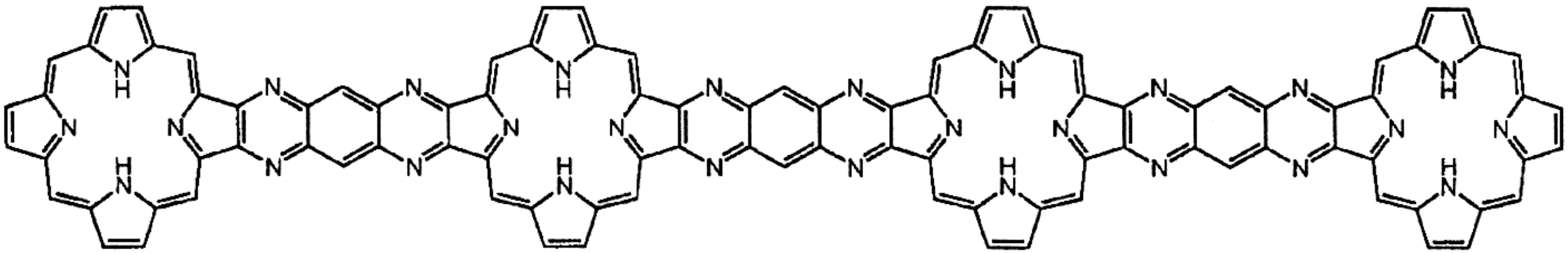
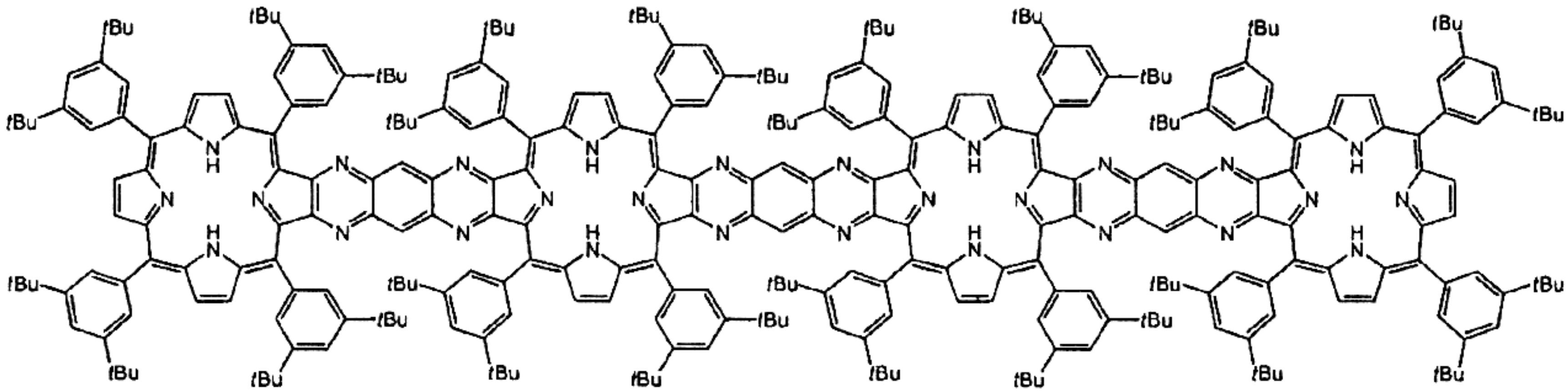


Figure 4.9 A representation of the technique used in the mechanically controllable break junction for recording the current through a single molecule. (a) The Au wire was coated with a SAM of the molecular wires (b) and then broken, under solution (c), via extension of the piezo element under the silicon surface (see Figure 4.8). Evaporation of the volatile components and slow movement of the piezo downward (see Figure 4.8) permits one molecule to bridge the gap (d) that is shown, in expanded view, in the insert. The insert shows a benzene-1,4-dithiolate molecule between proximal Au electrodes. The thiolate is normally H-terminated after deposition; end groups denoted as X can be H or Au, the Au potentially arising from a previous contact/retraction event.

J. M. Tour, Molecular Electronics: Commercial Insights, Chemistry, Devices, Architecture and Programming, World Scientific, New Jersey 2003.

Molecular Wires - Examples





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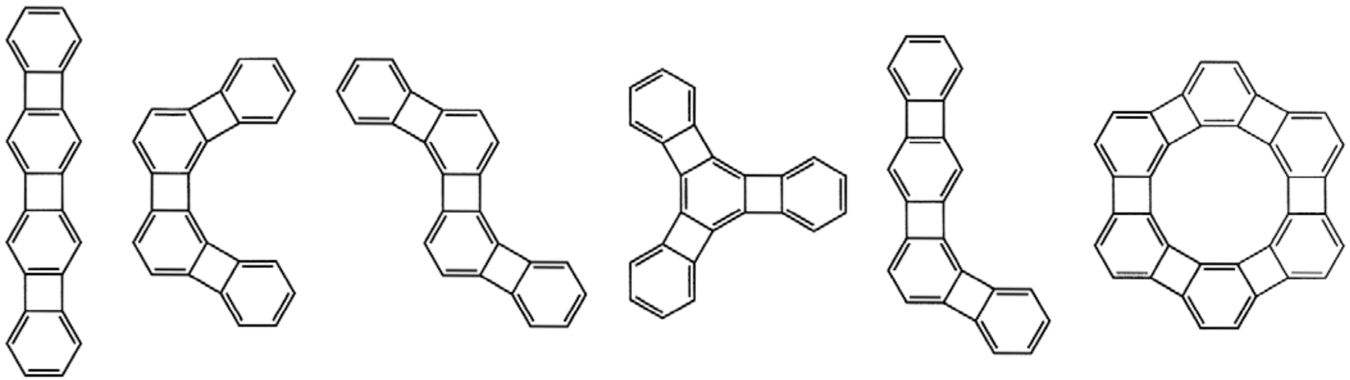
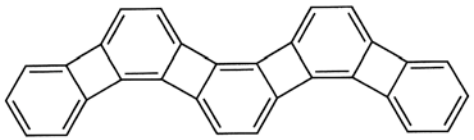
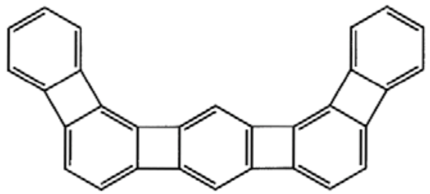
Molecular Wires - Examples

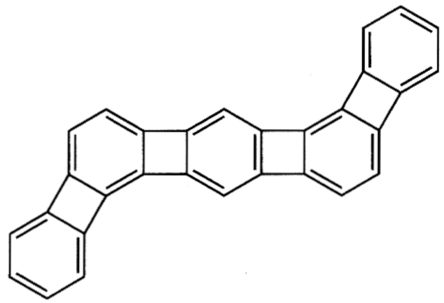


(a) (b) (c) (d) (e) (f)

Figure 4.2. Simple phenylene topologies: (a) linear [4]-, (b) angular [4]-, (c) zigzag [4]-, (d) branched [4]-, (e) (mixed) bent [4]-, and (f) circular [6]phenylene.







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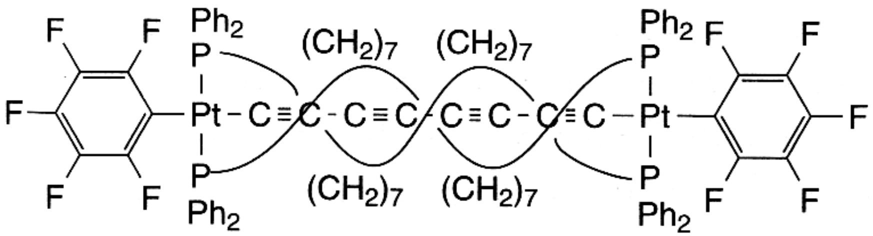
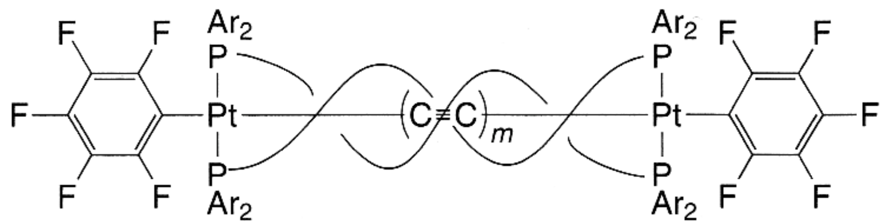
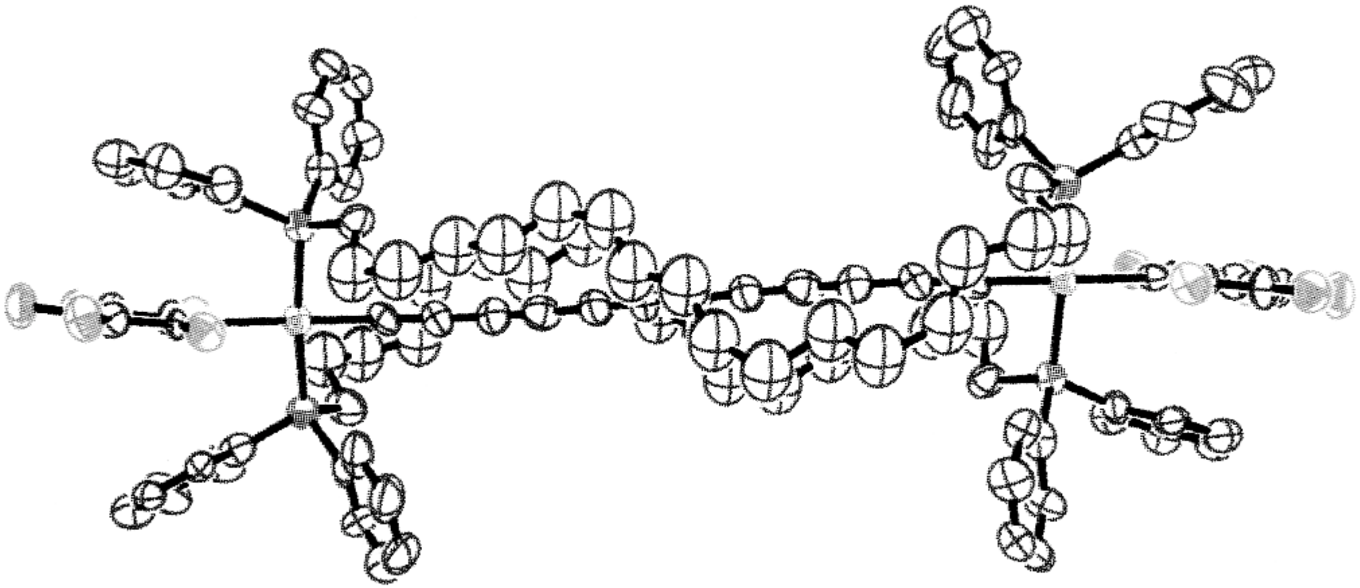
Molecular Wires - Examples





$m = 4, 6$



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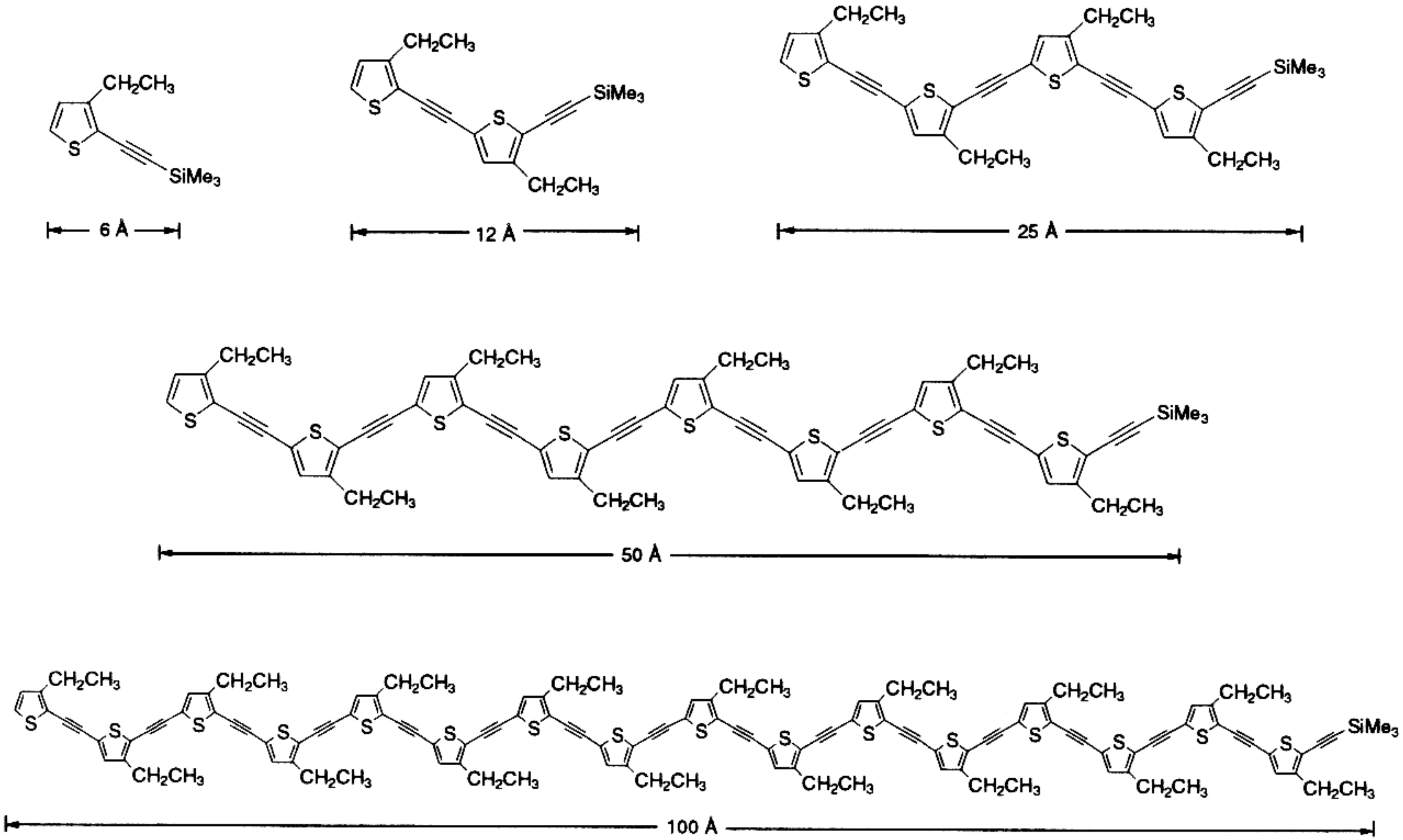
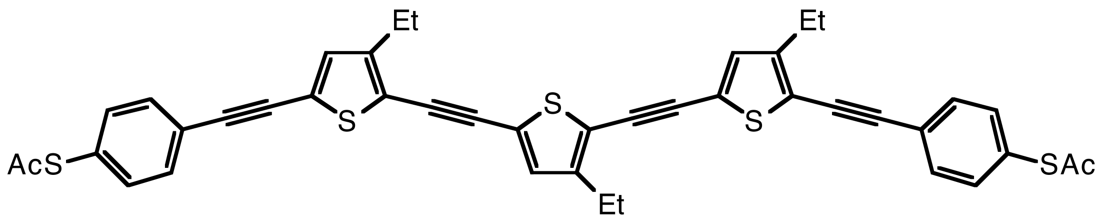
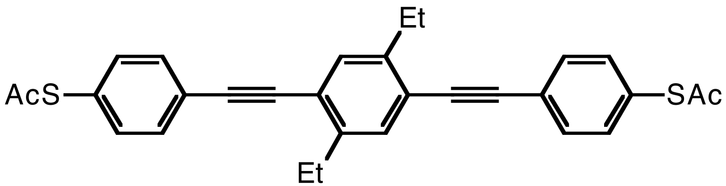
Molecular Wires - Examples

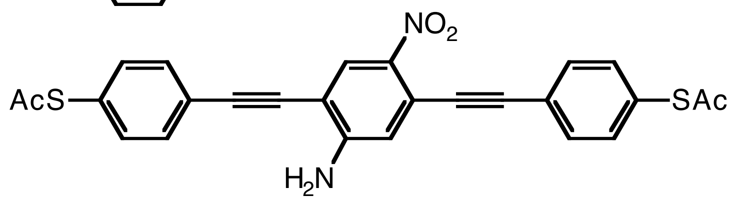


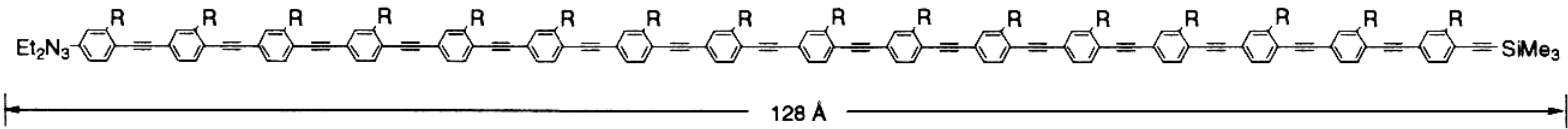
J. M. Tour, *Molecular Electronics: Commercial Insights, Chemistry, Devices, Architecture and Programming,* World Scientific, New Jersey **2003**.

Molecular Wires - Examples









R = 3-ethylheptyl
R = $C_{12}H_{25}$

J. M. Tour, *Molecular Electronics: Commercial Insights, Chemistry, Devices, Architecture and Programming,* World Scientific, New Jersey **2003**.

Molecular Device

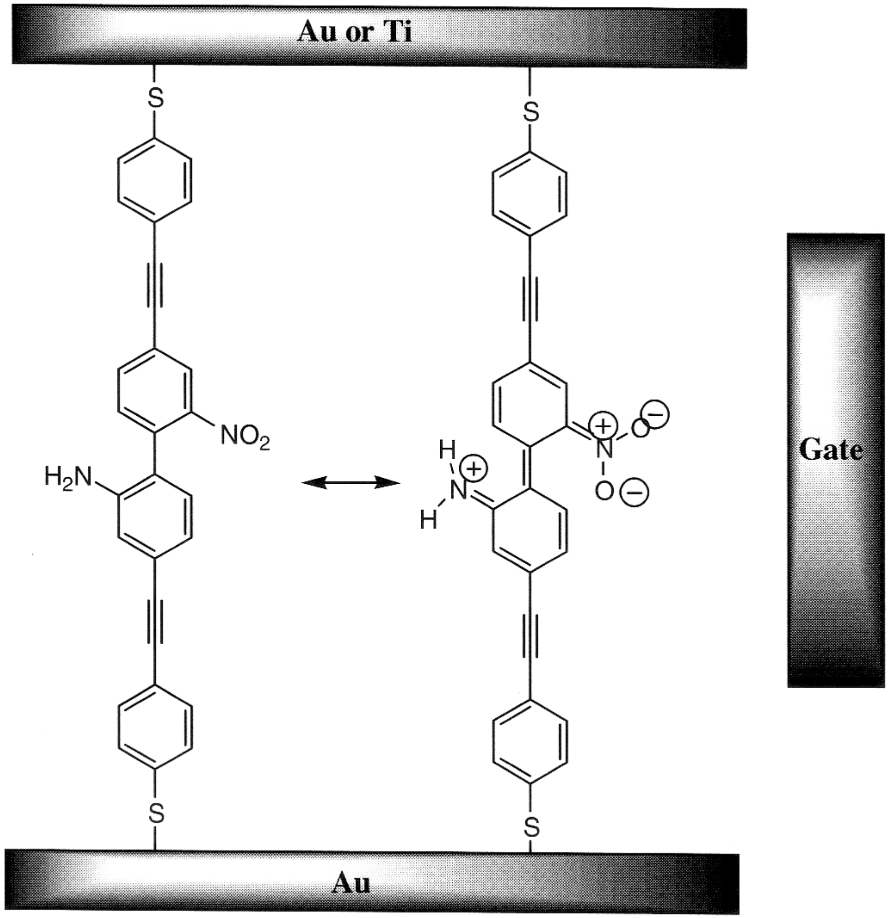
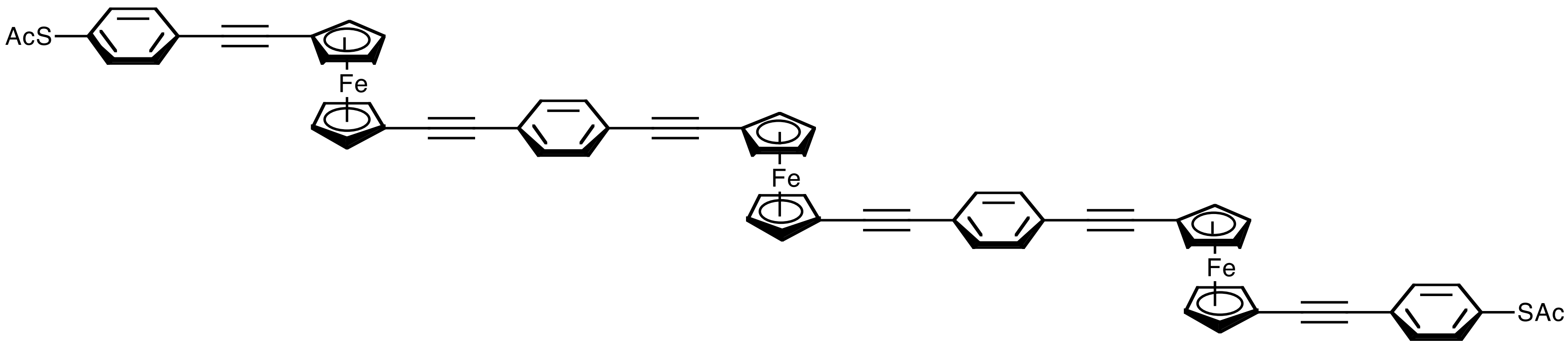
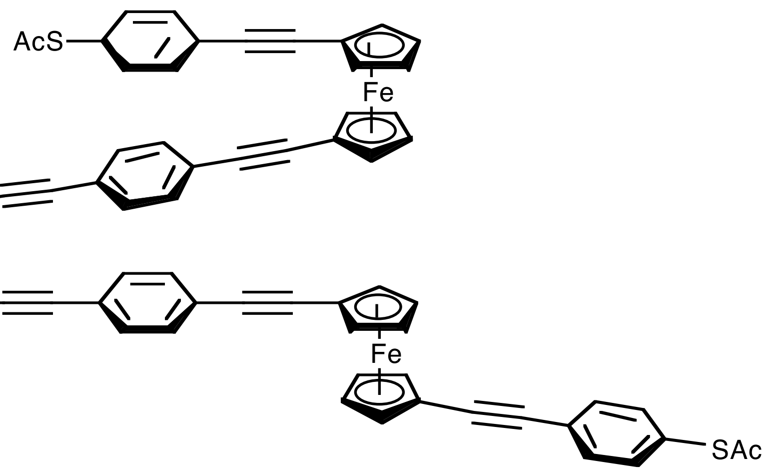


Figure 4.18 Schematic of a molecular device controller where a gate electrode could modulate the overlap in a molecule by preferring the more planar zwitterionic form.

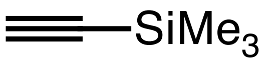
J. M. Tour, Molecular Electronics: Commercial Insights, Chemistry, Devices, Architecture and Programming, World Scientific, New Jersey 2003.

Our Idea: 3D and Length Adjustable Molecular Wires

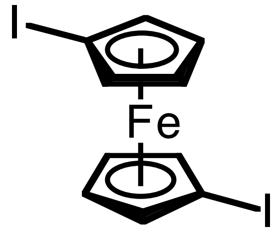




Our Building Blocks



Donation from Wacker Chemie



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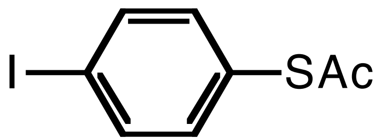

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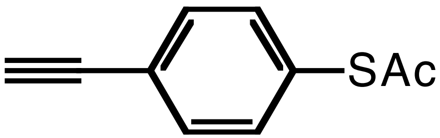

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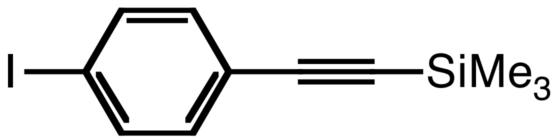
D. T. Gryko, C. Clausen, K. M. Roth, N. Dontha, D. F. Bocian, W. G. Kuhr, J. S. Lindsey, *J. Org. Chem.* **2000**, , 7345-7355.



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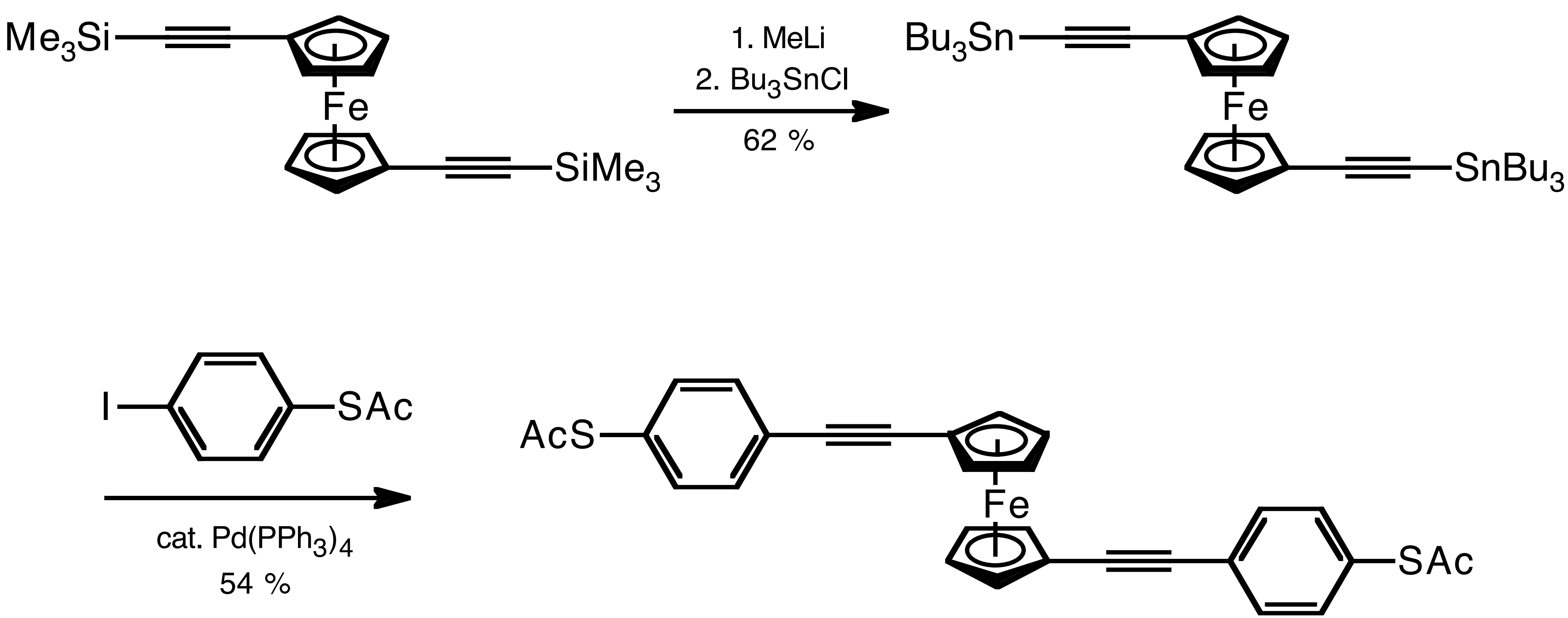
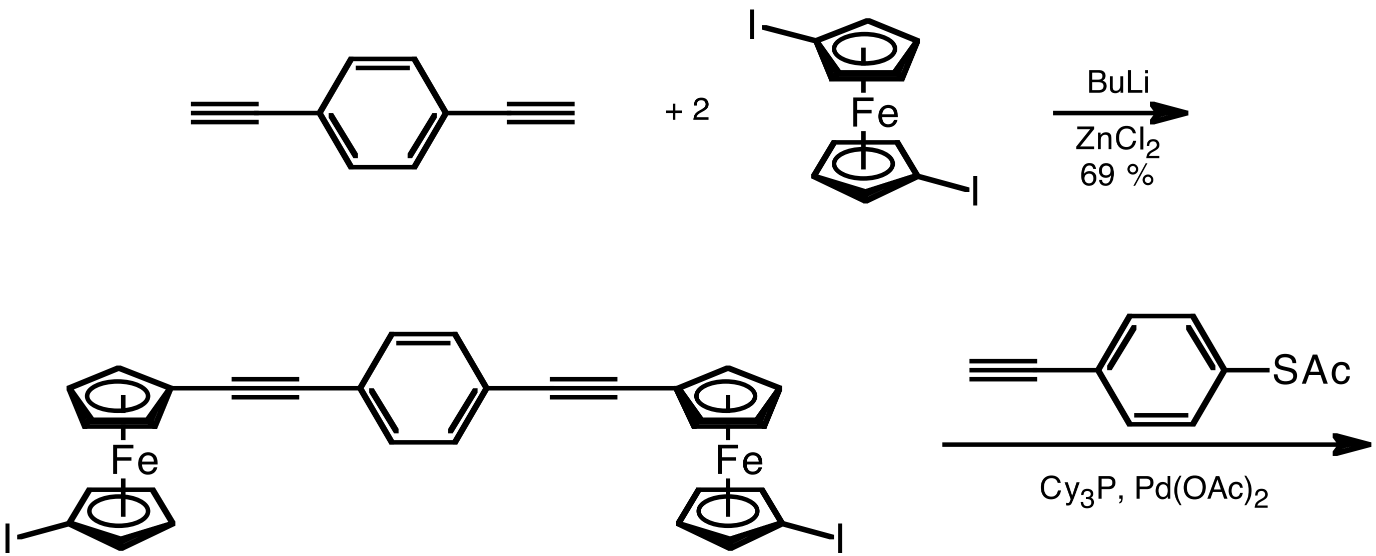
Synthesis of the First Hinge Molecular Wire

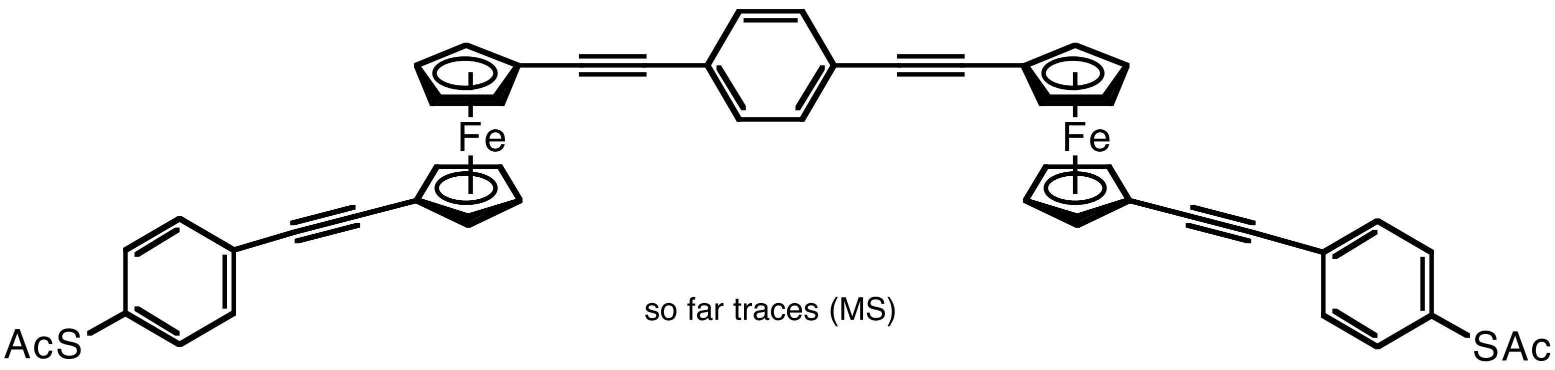


M. Vollmann, H. Butenschön, *C. R. Chimie* **2005**, *8*, 1282-1285.

En Route to the Second Hinge

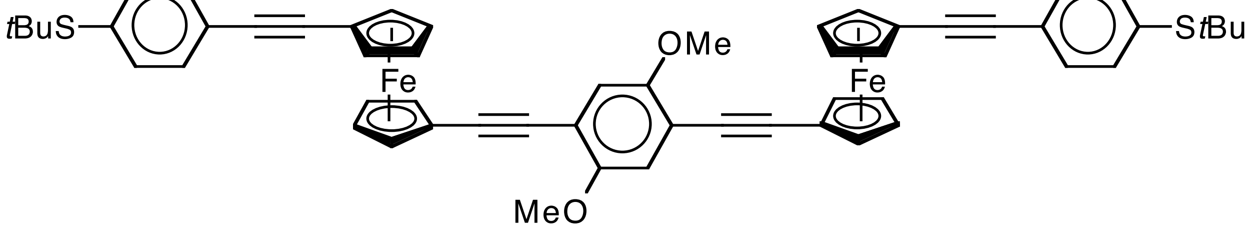


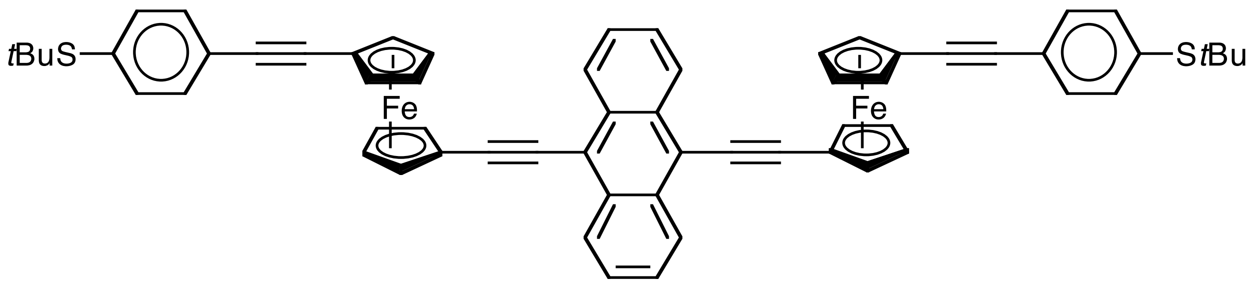
S. L. Ingham, M. S. Khan, J. Lewis, N. J. Long, P. R. Raithby,
J. Organomet. Chem. **1994**, *470*, 153-159. (57 % yield)



so far traces (MS)

New Molecular Wires





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Dipl.-Chem. Marc Vollmann
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Funding

Deutsche Forschungsgemeinschaft
(SPP 1243: Quantum Transport on the Molecular Scale)

Volkswagen**Stiftung**
(Schwerpunkt Einzelmoleküle)