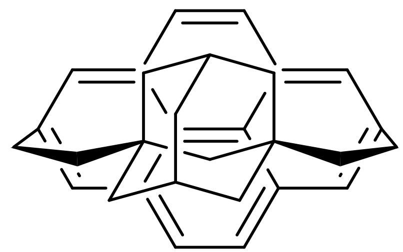
Studies on the synthesis of

[2](1,3)adamantano[2](2,7)pyrenophane



10.06.2011

Stefanie Pleik

Outline

- Canadian research group (Dr. Graham Bodwell) – Research Hot Spot
- Current research interests
- Cyclophanes
    - 1,*n*-Dioxa[*n*](2,7)pyrenophanes
    - [*n*](2,7)Pyrenophanes
    - 1,1,8,8-Tetramethyl[8](2,11)teropyrenophane
    - 1,8-Pyrenylene-Ethylene Macrocycles
- Experimental
    - [2](1,3)adamantano[2](2,7)pyrenophane

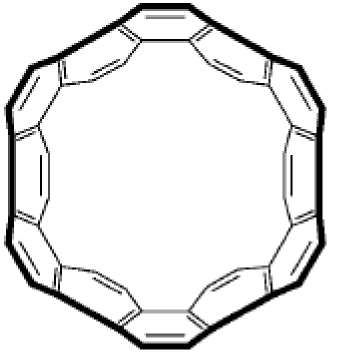
The Canadian research group

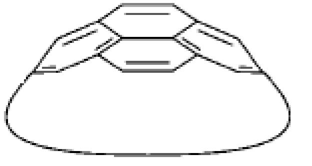
Dr. Graham Bodwell:

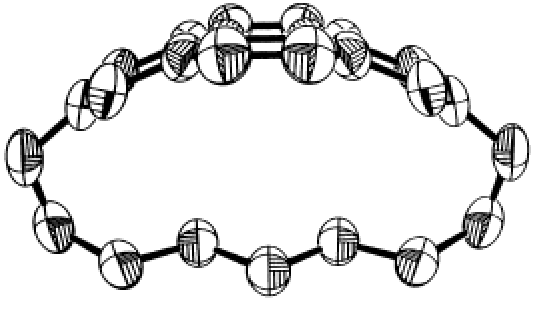
- 1962: was born in **UK**
- 1971: moved to **Canada**
- 1979: finished high school
- 1984: **University of Victoria**
- 1986: **Braunschweig** (supervisor Prof. Dr. Hopf)
- **Oxford University** (group of Dr. Steven Davies): asymmetric synthesis
- 1992: assistant professor at **MUN** (full professor 2001)

Current research interests

- Cyclophanes
- Novel aromatic compounds
- New materials
- Diels-Alder-Chemistry
- Synthetic methodology & synthesis of natural products





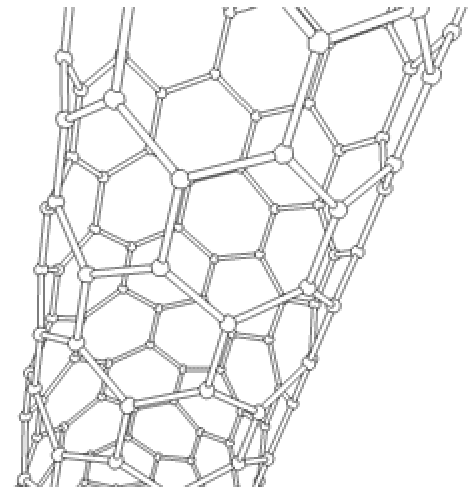


Cyclophanes

Motivation:

- Interplay of π-electron delocalization and strain

→ 1,*n*-Dioxa[*n*](2,7)pyrenophanes (2003)
→ [*n*](2,7)Pyrenophanes (2008)
→ 1,1,8,8-Tetramethyl[8](2,11)teropyrenophane (2009)



Application:

- Single wall carbon nanotubes

Recent publication:

- 1,8-Pyrenylene-Ethylene Macrocycles (*Org. Lett.*, **2011**, *13*, 2240-2243)

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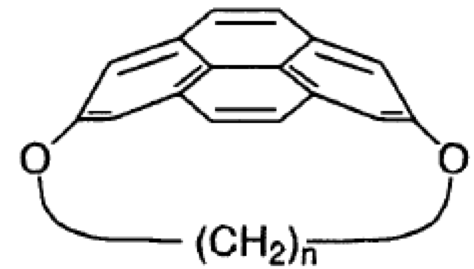
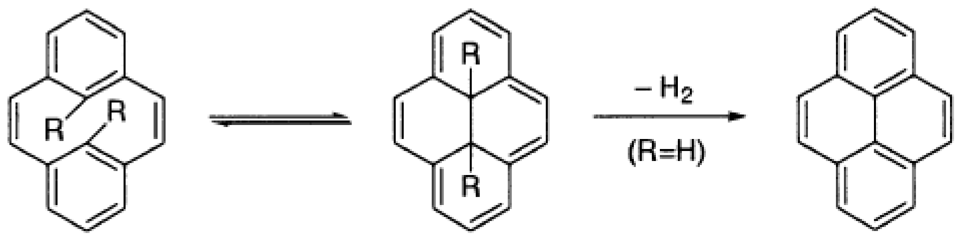
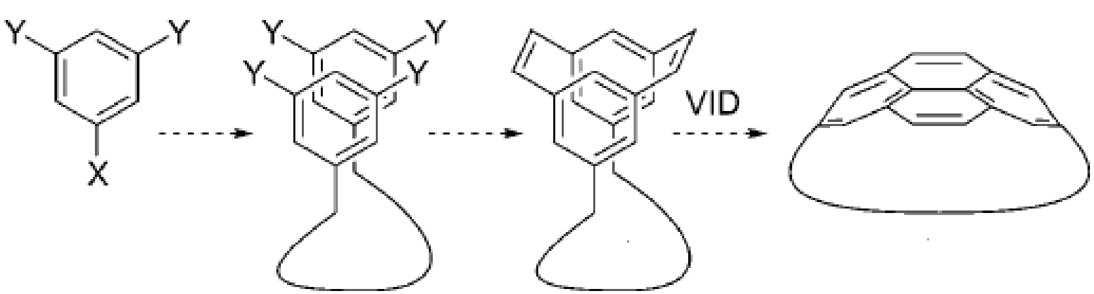
1,n-Dioxa[n](2,7)pyrenophanes

„How does bending affect cyclic π-electron delocalization?‘

- Pyrenes from metacyclophanedienes
- VID (valence isomerization/dehydrogenation)







- 1,*n*-Dioxa[*n*](2,7)pyrenophanes (*n*=7-12)
- Distorted bend angle
- Slightly diminished aromaticity

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G. J. Bodwell, J N. Bridson, M. K. Cyrański, J. W. J. Kennedy, T. M. Krygowski, M. R. Mannion, D. O. Miller, *J. Org. Chem.*, **2003**, *68*, 2089-2098
Mitchell, R. H.; Boekelheide, V. *J. Am. Chem. Soc.* **1970**, *92*, 3510-3512

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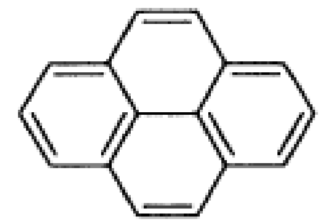
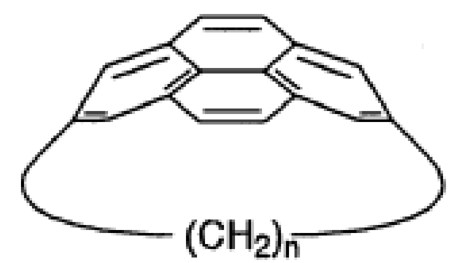
[*n*](2,7)Pyrenophanes

- [*n*](2,7)Pyrenophanes (*n*=6-12)
- **nonplanarity** of the pyrene moiety depends on the number of CH_2-groups in the aliphatic bridge
- Influences the **strain energy** and the **π-electron delocalization**
- Most distorted pyrene unit (α=39,7°): [6](2,7)pyrenophan
- Relative aromatic stabilization energy (**ΔASE**)

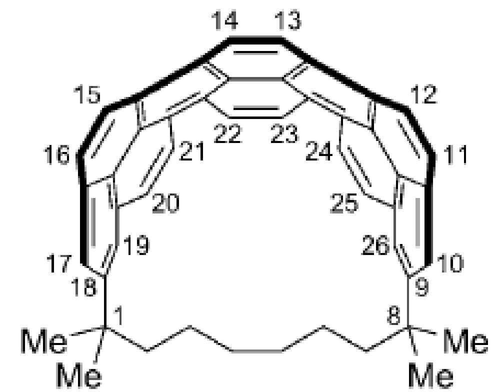


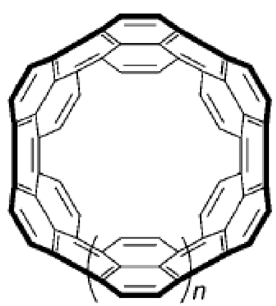


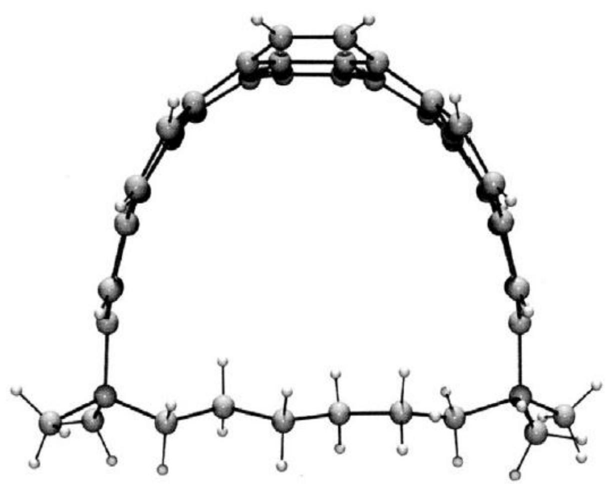
M. A. Dobrowolski, M. K. Cyrański, B. L. Merner,
G. J. Bodwell, J. I. Wu, P. v. R. Schleyer, *J. Org. Chem.*, **2008**, *73*, 8001-8009

1,1,8,8-Tetramethyl[8](2,11)teropyrenophane

- Half of an aromatic belt
- Segment of an Single-Walled Carbon Nanotube (SWNT)
- „Vögtle belts“ (short armchair SWCNTs)



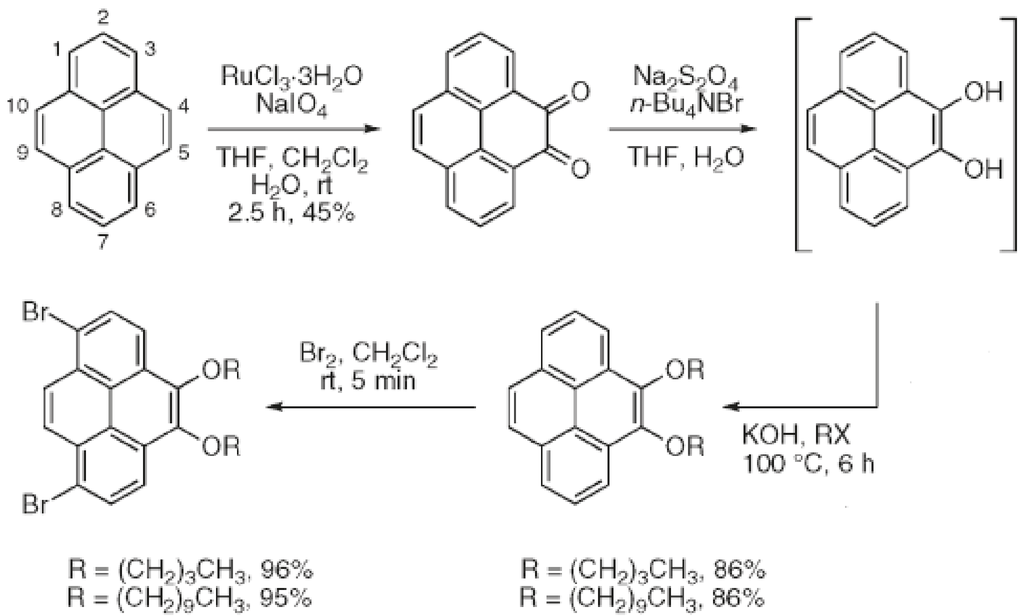


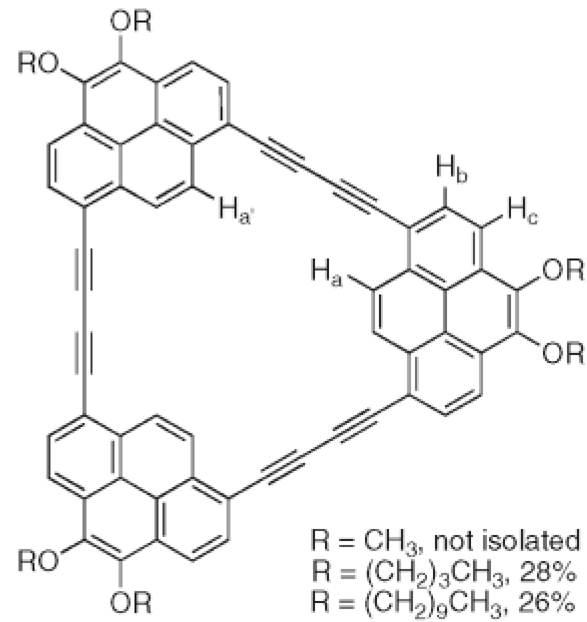


B. L. Merner, L. N. Dawe, G. J. Bodwell, *Angew. Chem. Int. Ed.*, **2009**, *48*, 5487-5491; F. Vögtle, *Top. Curr. Chem.*,**1983**, *115*, 157 – 159

1,8-Pyrenylene-Ethynylene Macrocycles

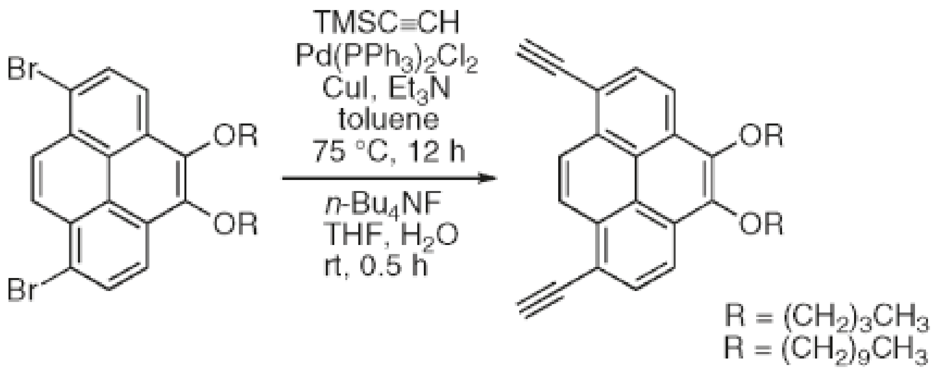
- starting from pyrene
- substitution at 4 and 5 positions to hinder the 3 and 6 position → completely regioselective synthesis

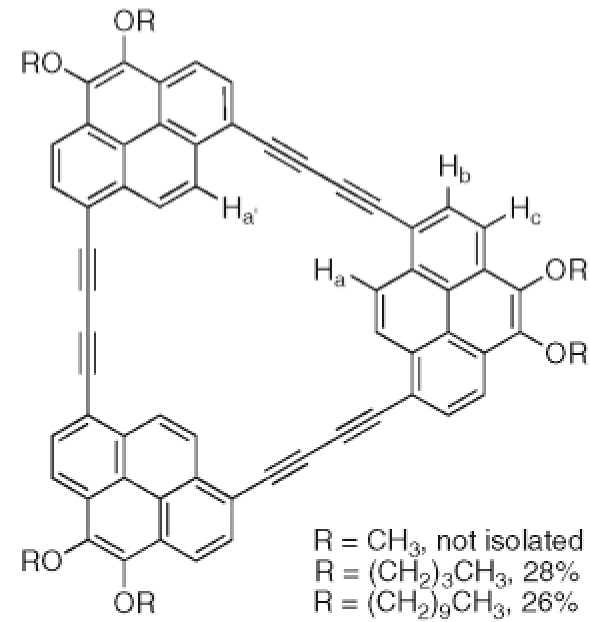




G. Venkataramana, P. Dongare, L. N. Dawe, D. W. Thompson, Y. Zhao, G. J. Bodwell, *Org. Lett.*, **2011**, *13*, 2240-2243

1,8-Pyrenylene-Ethynylene Macrocycles





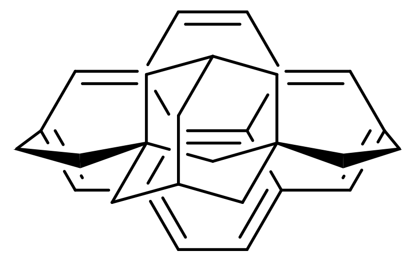
- Sonogashira/deprotection sequence
- Yield: 83-86%
- 1,8-Diethynylpyrenes → cyclic trimers
- using oxidative coupling protocol

G. Venkataramana, P. Dongare, L. N. Dawe, D. W. Thompson, Y. Zhao, G. J. Bodwell, *Org. Lett.*, **2011**, *13*, 2240-2243

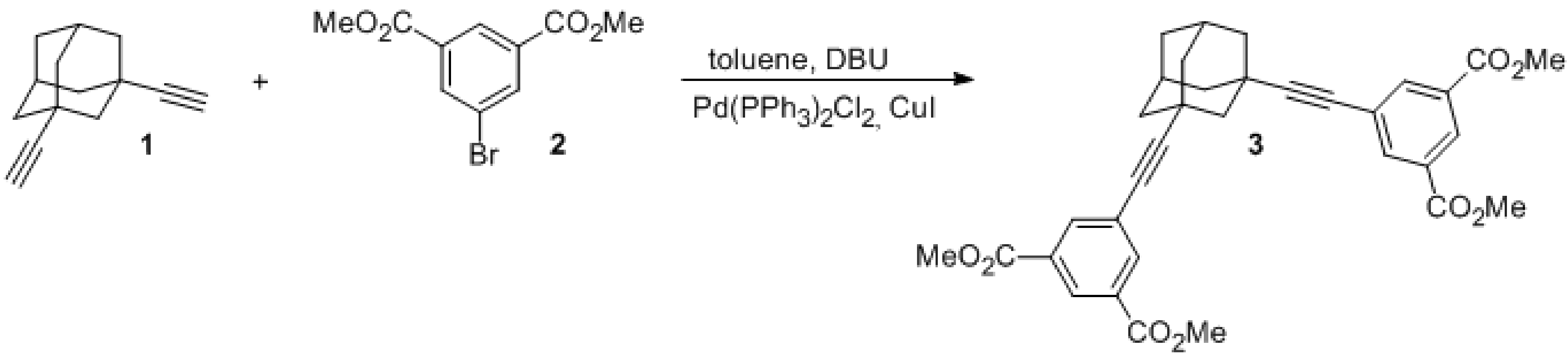
[2](1,3)adamantano[2](2,7)pyrenophane

General route:

1. Sonogashira cross coupling
2. Hydrogenation
3. Reduction
4. Bromination
5. Cyclization (Na_2S/Al_2O_3 coupling)
6. Steven‘s rearrangement
7. Hofmann elimination



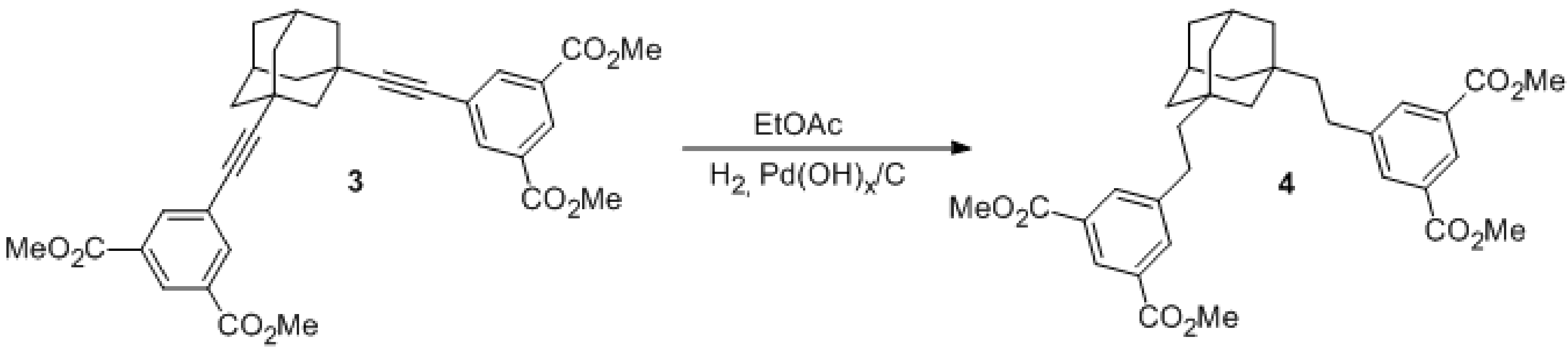
Sonogashira cross coupling



- Pd-catalyzed (5 mol%)
- Cocatalyst copper iodide (10 mol%)
- Problem: O_2-supported dimerization of the diyne
- Yield: **65%** after column (approach 2mmol)

K. Sonogashira, Y. Tohda, N. Hagihara, *Tetrahedron Lett.*, **1975**, 4467-4470

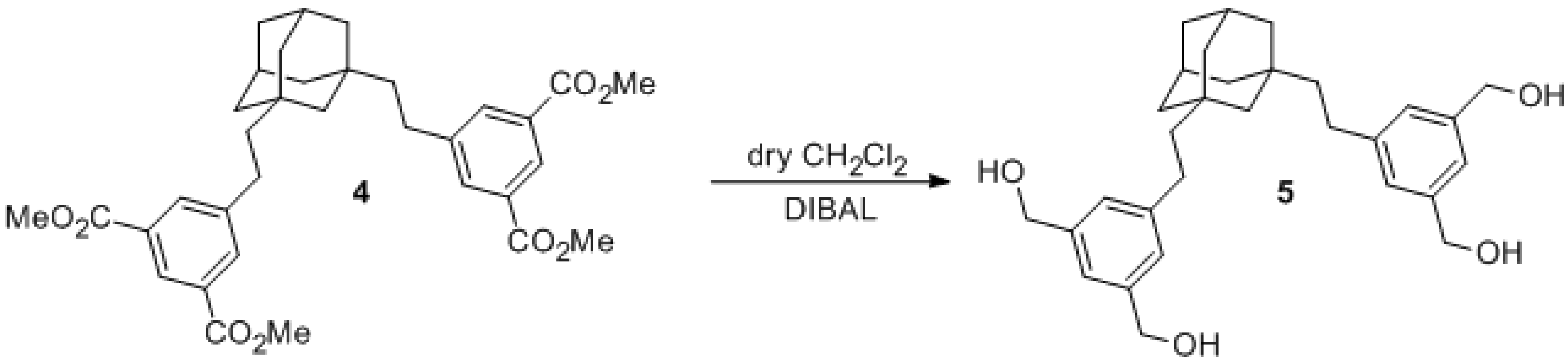
Hydrogenation



- Pearlman‘s catalyst
- Reaction finished after 1h
- Cannot be detected by TLC
- Yield: **78%**

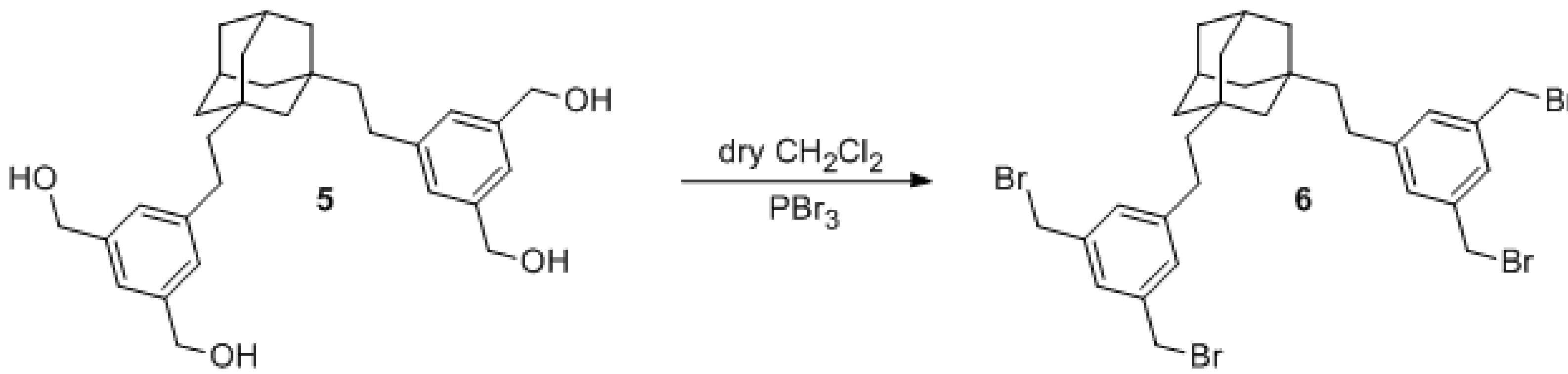
W. M. Pearlman, *Tetrahedron Lett.*, ***1967***, 1663-1664

Reduction



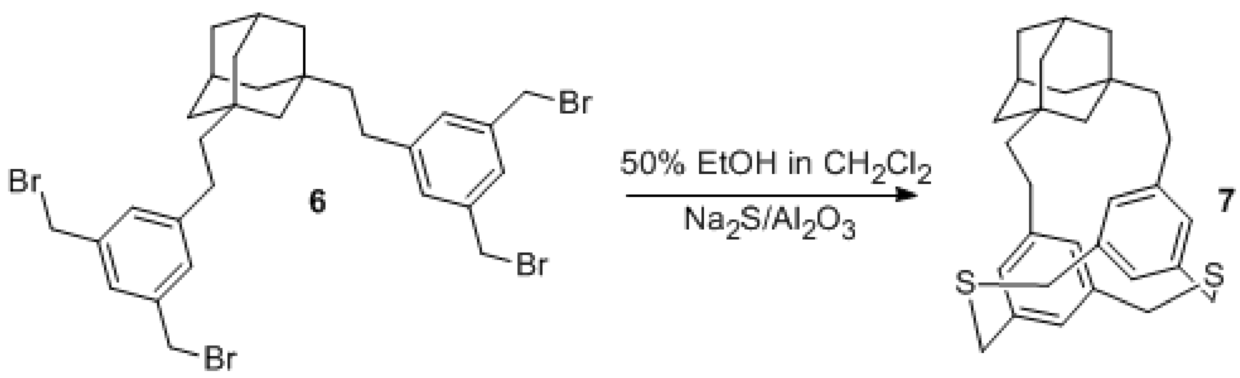
- 17 equivalents DIBAL
- Stirred for 10 minutes
- No purification by column chromatography
- Yield: **100%**

Bromination



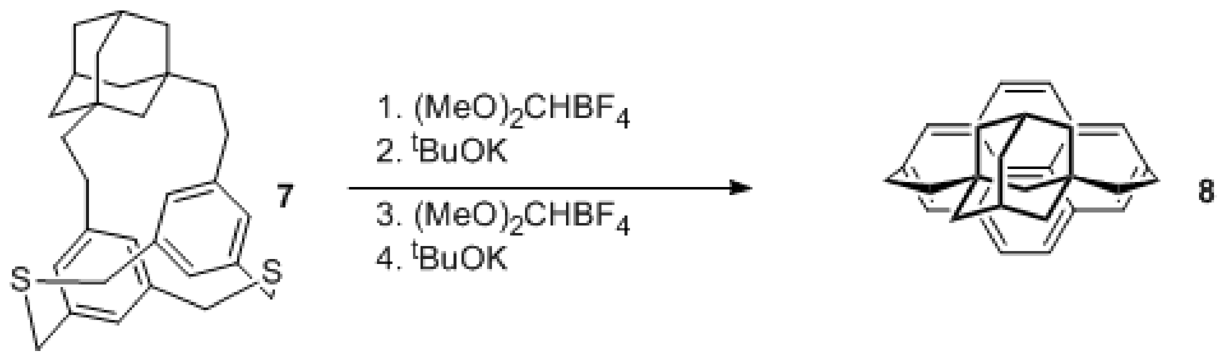
- 2 equivalents PBr_3
- Stirred for 10 minutes
- Yield: **39%** (surprising)

Cyclization with Na_2S/ Al_2O_3



- 4,5 equivalents Na_2S/ Al_2O_3
- Stirred overnight
- 2 more equivalents Na_2S/ Al_2O_3
- Yield: **50%**

Steven‘s rearrangement followed by Hofmann elimination



- 3 equivalents Borch reagent (1.)
- Stirred for 1 h
- 4,5 equivalents ^{t}BuOK (2.)
- Stirred overnight
- 3,3 equivalents Borch reagent (3.)
- 4,7 equivalents ^{t}BuOK (4.)
- Yield: **10%** (7 mg)

T. S. Stevens, *J. Chem. Soc.*, **1928**, 3193
A. W. v. Hofmann, *Annalen der Chemie und Pharmazie*, **1851**, *78*, 253-286

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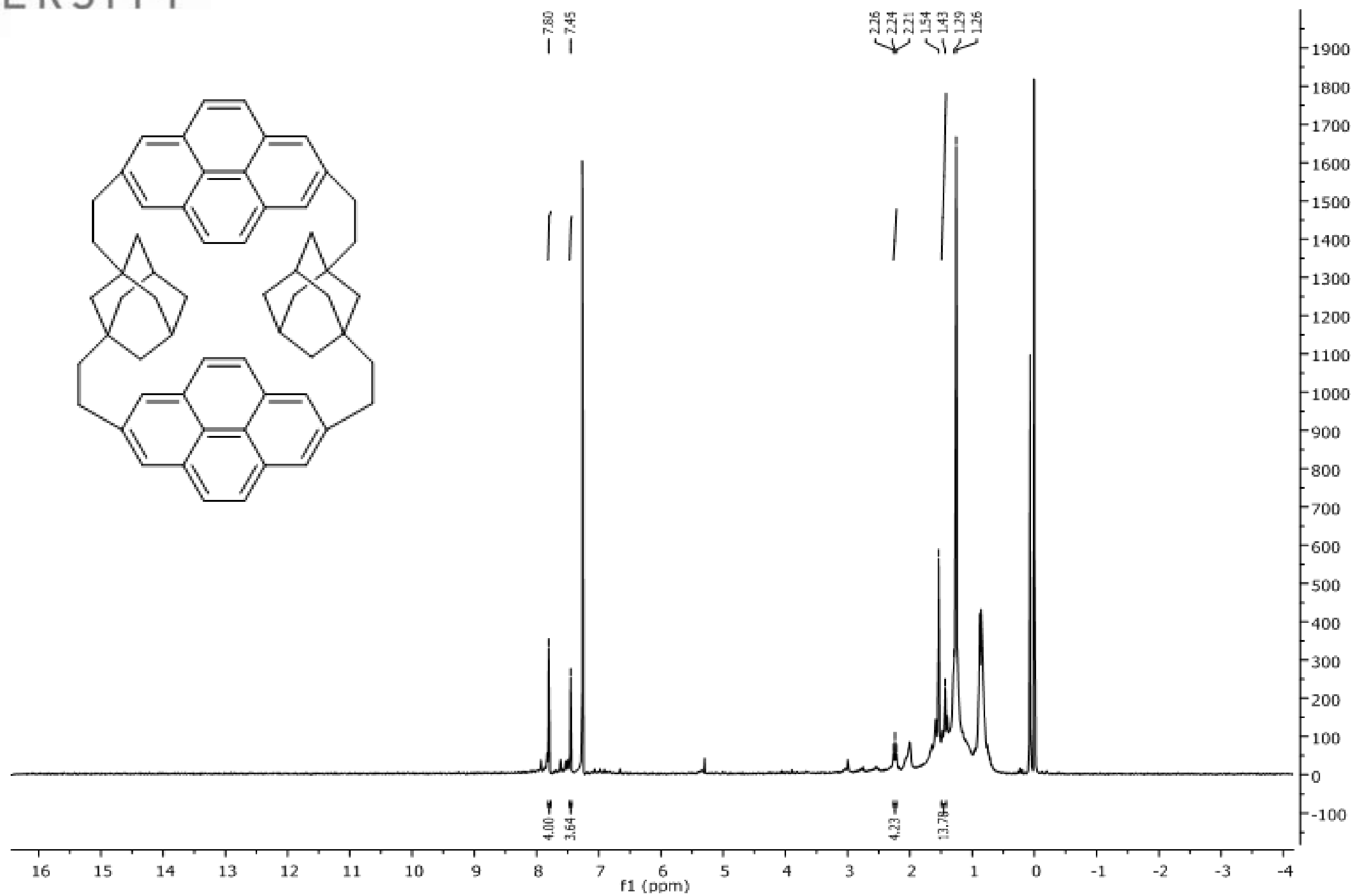
Characterization - NMR



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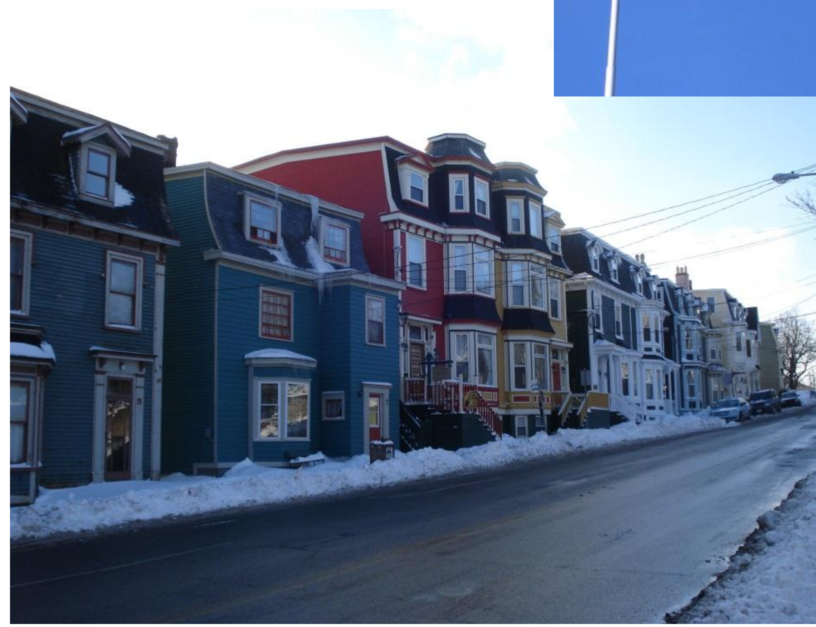

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