

Presentation to CNM college & career high school

Tyler E. Stevens

Some background- journey to become a scientist

- From Albuquerque
- High school interests
 - Music, science
- University of New Mexico
 - What to study?
 - Music? Pre-med?



Generally need science
degree- biochemistry

Biochemistry as a path to med school

Why Study Biochemistry?

Undergraduate Education ▾

Undergraduate Program

How to Succeed

Course of Study

Research and Honors

Career Planning

Graduate Studies

Undergraduate Program Description

Biochemistry is an undergraduate major degree option in the UNM College of Arts & Sciences, making it one of the only undergraduate biochemistry programs in the nation housed in a School of Medicine. It trains pre-med, pre-pharmacy and pre-dental students, as well as students enrolled in the Combined BA/MD Program and students interested in MS and PhD degrees in the discipline.

Although the biochemistry major is offered by the College of Arts & Sciences, the Department of Biochemistry and Molecular Biology is organizationally and physically part of the School of Medicine, located just across Lomas Boulevard from UNM's main campus. Some courses are offered on the main campus, while more advanced courses and senior research are conducted in two modern, excellently equipped buildings in the medical school complex.

Both BA and BS degrees are available. Students seeking to major in Biochemistry must first be accepted into the College of Arts & Sciences.

The Biochemistry degree meets or exceeds all of the curricular recommendations from both the American Chemical Society and the American Society of Biochemistry and Molecular Biology. The program is also consistent with current national recommendations for 21st century educational practices.

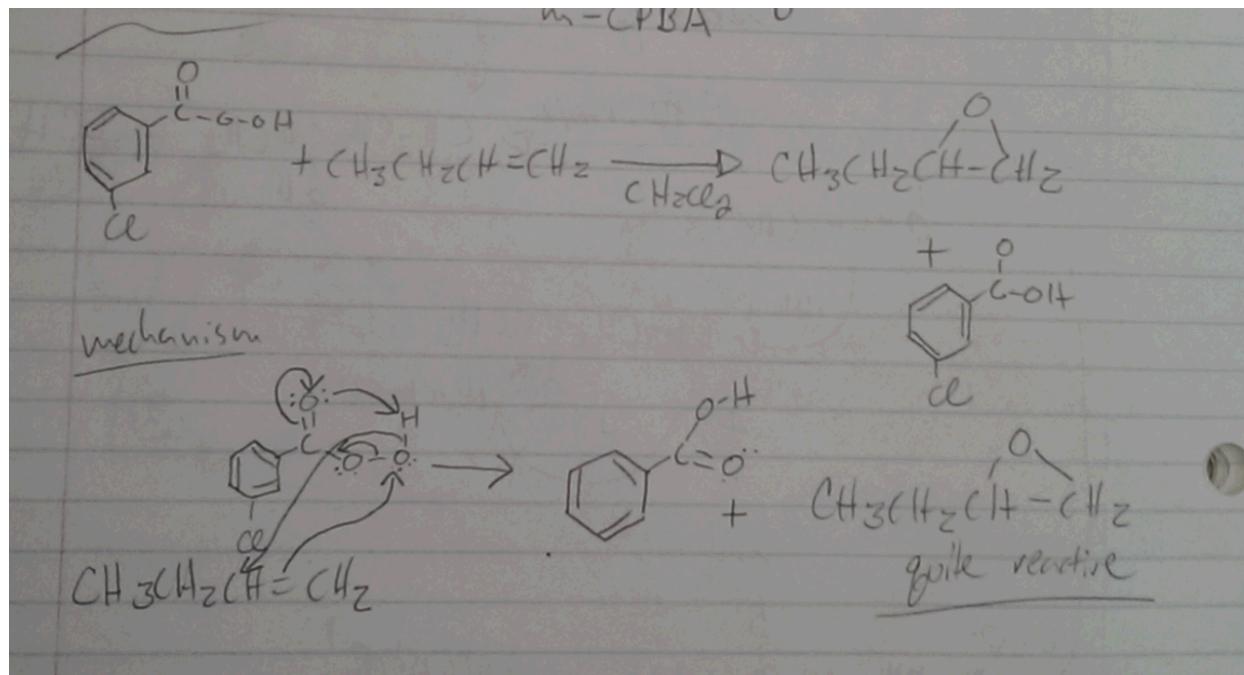
Admission Requirements

- Read the [College of Arts and Sciences and Biochemistry Major Undergraduate Admission Requirements](#)
- [Elective choices for a Biochemistry Degree](#)

Chemistry research

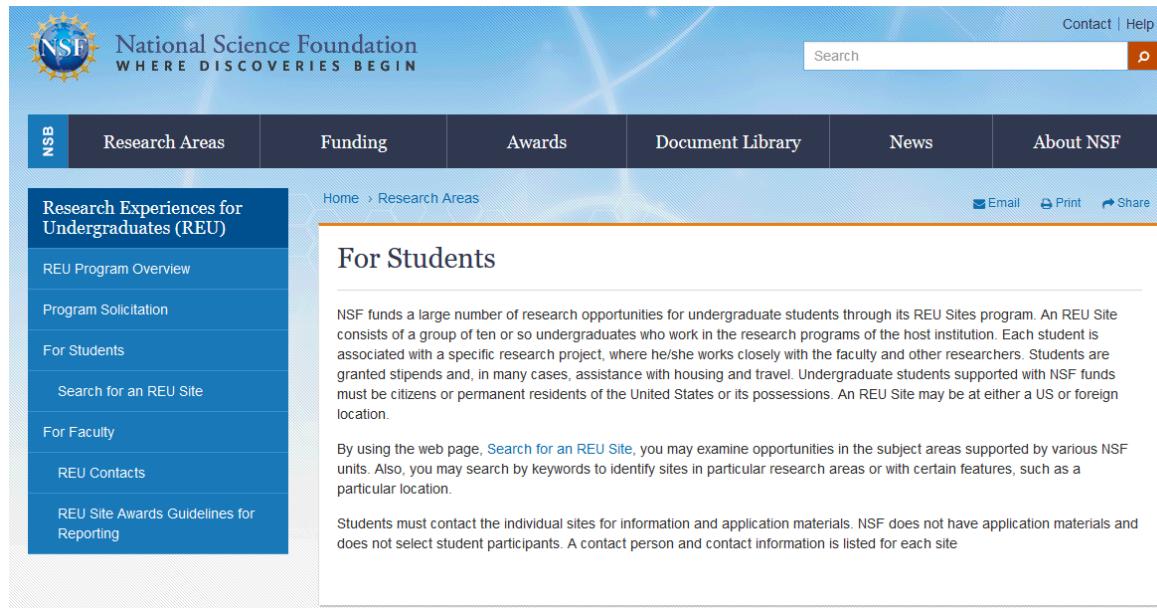
Biochemistry- many pre-requisite courses in chemistry and biology

Chemistry was exciting (after gen chem!)
Reaction mechanisms



Undergraduate research possibilities

- Many options
 - At school of study
 - REU
 - Internship



The screenshot shows the NSF website with a blue header. The header includes the NSF logo, the text "National Science Foundation WHERE DISCOVERIES BEGIN", a search bar, and links for "Contact | Help". Below the header is a dark blue navigation bar with links for "NSB", "Research Areas", "Funding", "Awards", "Document Library", "News", and "About NSF". The main content area has a light blue background. On the left, there is a sidebar with a blue background containing links for "Research Experiences for Undergraduates (REU)", "REU Program Overview", "Program Solicitation", "For Students", "Search for an REU Site", "For Faculty", "REU Contacts", and "REU Site Awards Guidelines for Reporting". The main content area has a white background and contains the following text:

For Students

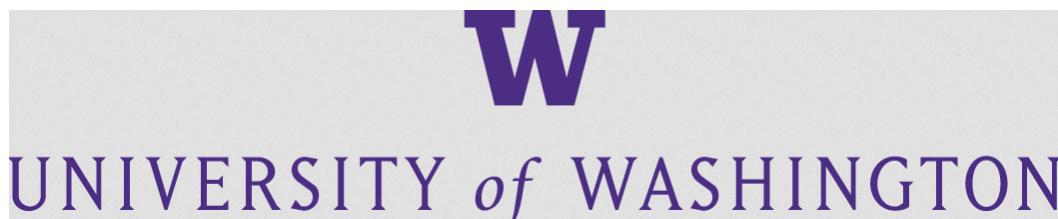
NSF funds a large number of research opportunities for undergraduate students through its REU Sites program. An REU Site consists of a group of ten or so undergraduates who work in the research programs of the host institution. Each student is associated with a specific research project, where he/she works closely with the faculty and other researchers. Students are granted stipends and, in many cases, assistance with housing and travel. Undergraduate students supported with NSF funds must be citizens or permanent residents of the United States or its possessions. An REU Site may be at either a US or foreign location.

By using the web page, [Search for an REU Site](#), you may examine opportunities in the subject areas supported by various NSF units. Also, you may search by keywords to identify sites in particular research areas or with certain features, such as a particular location.

Students must contact the individual sites for information and application materials. NSF does not have application materials and does not select student participants. A contact person and contact information is listed for each site.

What next?

- Graduate School
 - Great option, but where to go?
 - I applied to four schools:



University of Washington was best fit for me

UNIVERSITY of WASHINGTON

DEPARTMENT OF CHEMISTRY

UNIVERSITY of WASHINGTON

Chemistry

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Karen I. Goldberg

Faculty by Research Area

- [Analytical Chemistry](#)
- [Biological Chemistry](#)
- [Catalysis / Synthesis](#)
- [Inorganic Chemistry](#)
- [Materials, Polymers and Nanoscience](#)
- [Organic Chemistry](#)
- [Physical Chemistry / Chemical Physics](#)
- [Theoretical Chemistry](#)

Description of Research Areas

- [Centers & Institutes](#)

Professor and Nicole A. Board Endowed Chair in Chemistry

Director, Center for Enabling New Technologies through Catalysis

Ph.D. University of California at Berkeley, 1988

(Organometallic and Inorganic Chemistry)

(206) 616-2973

Email: goldberg@chem.washington.edu

[Goldberg group website](#)

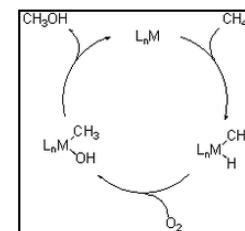
[Center for Enabling New Technologies through Catalysis website](#)



Research Interests

One of the most important applications of organometallic chemistry has been the use of organotransition metal catalysts in the commercial production of chemicals, pharmaceuticals and organic materials. The reaction steps in the catalytic cycles are typically general, or so called fundamental reactions in organometallic chemistry, such as oxidative addition, reductive elimination, migratory insertion and beta-hydride elimination. Understanding the mechanisms of these basic reaction steps is key to the improvement of current catalysts and to the design of new catalytic systems. The Goldberg group focuses on developing detailed mechanistic understanding of these fundamental reactions with the goal of creating catalysts for desirable and challenging transformations.

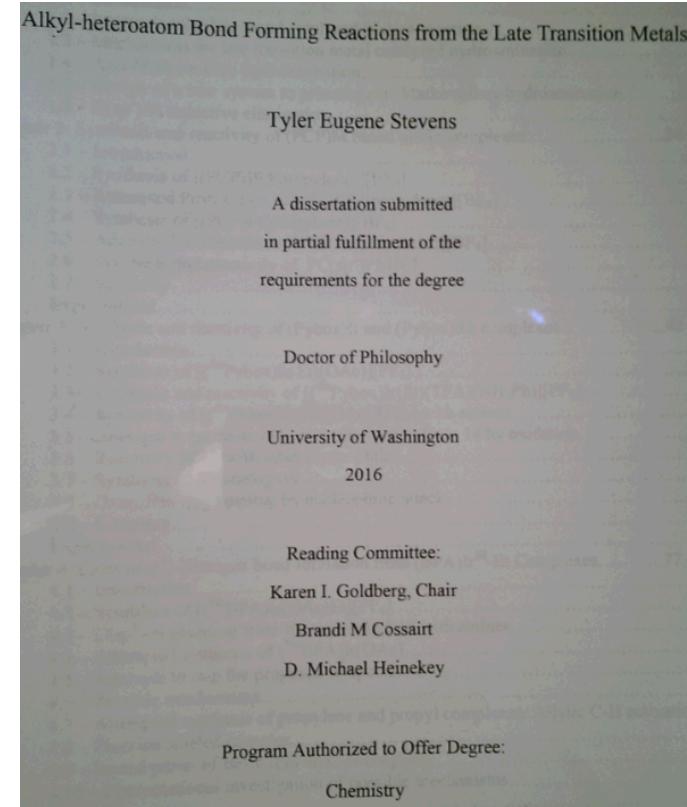
As an example, in one particular project in the group, the reaction steps that could be involved in the selective oxidation of alkanes to alcohols are being studied. Shown below is an idealized catalytic cycle for converting methane to methanol – oxidative addition of the C-H bond forms a metal alkyl hydride, insertion of oxygen into the metal hydride bond forms a metal alkyl hydroxide species, and finally C-O reductive elimination forms the alcohol product and regenerates the catalyst. Understanding how each step proceeds, what type of MLn fragment (geometry and ligand set) is needed, and what type of solvent system will promote that reaction step provides insight and direction to efforts to rationally design catalysts that will carry out such transformations. Some other transformations for which we are trying to develop catalysts are anti-Markovnikov hydration and hydroamination of olefins, oxidation of olefins with molecular oxygen and the release of hydrogen from amine boranes and other viable hydrogen storage materials.



Ph.D. students working on projects in the Goldberg group are trained in syntheses, characterization and mechanistic analysis using a variety of experimental, spectroscopic and analytical methods. These include the manipulation of air-sensitive compounds by Schlenk and vacuum line techniques, high field multinuclear NMR, IR and UV-visible spectrometry, mass spectrometry, and x-ray crystallography.

Graduate school experience

- Depends on school, but most are similar
 - UW Chemistry
 - 6 classes + research (4-5+ years)
 - 2 oral exams, each 2+ hours with 4-5 professors
 - Dissertation, Defense
- Generally TA or RA



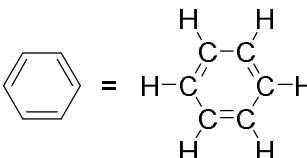
Graduate school experience

- Not all work...



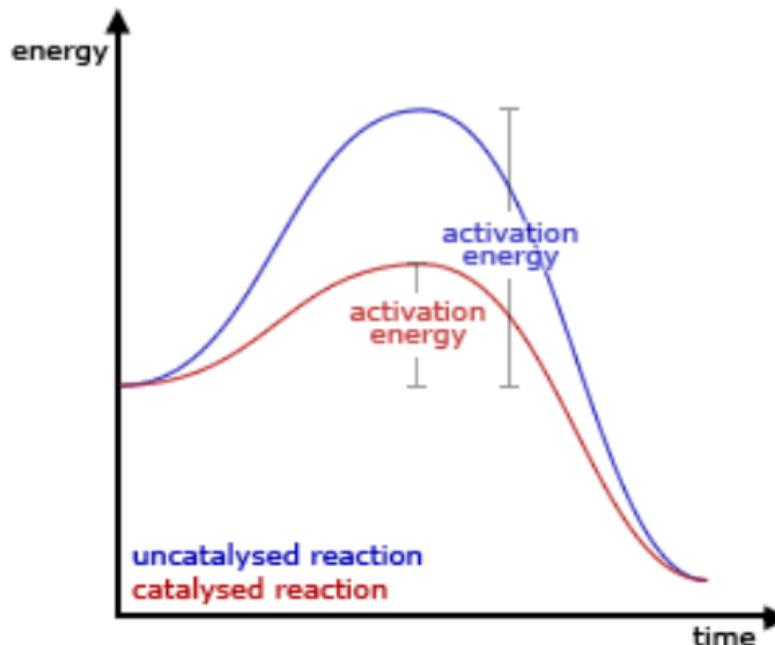
Organometallic (OM) chemistry

Periodic Table of the Elements



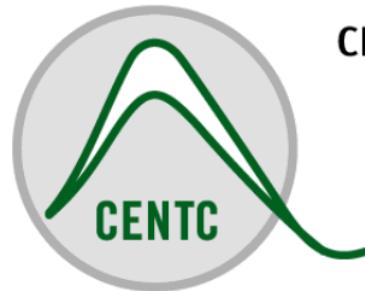
- Must have at least one metal-carbon bond

Application of OM complexes: Catalysis



http://ch302.cm.utexas.edu/images302/Catalyst_effect.pn

g



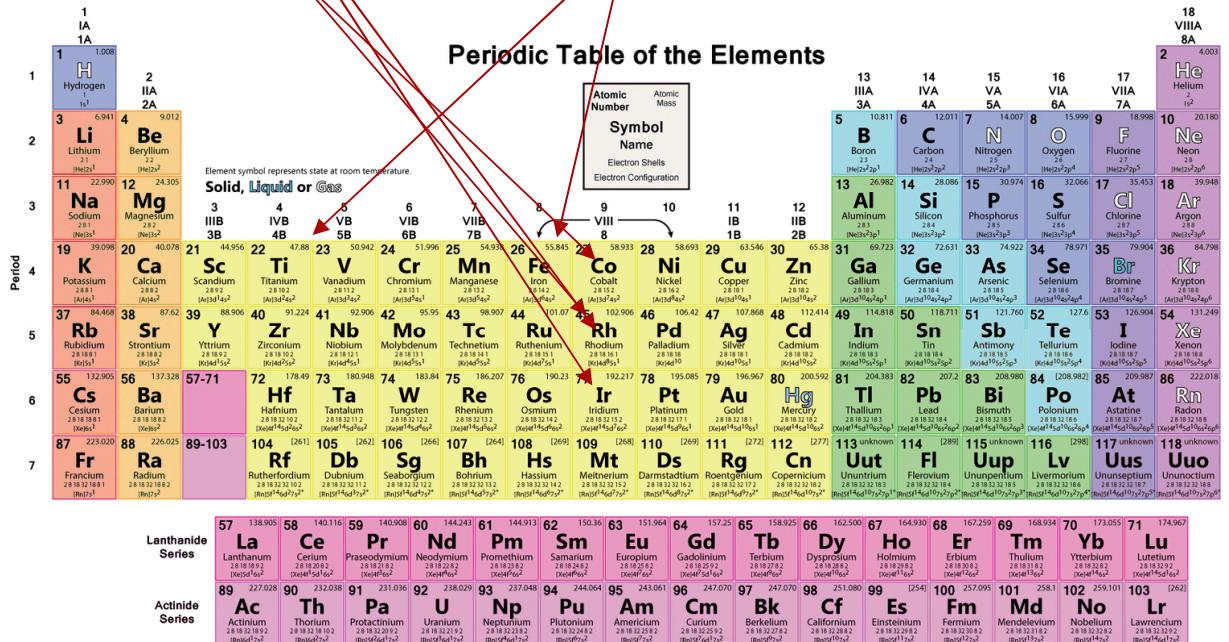
**CENTER FOR ENABLING
NEW TECHNOLOGIES
THROUGH CATALYSIS**

*A NSF CENTER FOR
CHEMICAL INNOVATION*

Industrial uses of catalysts

- Both **homogeneous** and **heterogeneous** catalysts are used (same phase) (different phase)
- Acetic acid
- Oxo process
- Haber-Bosch
- Olefin polymerization

Periodic Table of the Elements

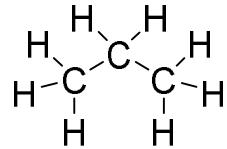


The table includes the following information for each element:

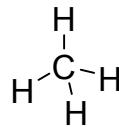
- Atomic Number**: The element's position in the periodic table.
- Symbol**: The standard one-letter symbol for the element.
- Name**: The element's name.
- Atomic Mass**: The element's mass number.
- Electron Shells**: The number of shells and the number of electrons in each shell.
- Electron Configuration**: The specific orbital arrangement of electrons.
- Element symbol represents state at room temperature**: A note indicating the physical state of the element at 25°C.
- Solid, Liquid or Gas**: A classification of the element's state.

Some challenges for OM chemistry

- Hydrocarbons- many uses



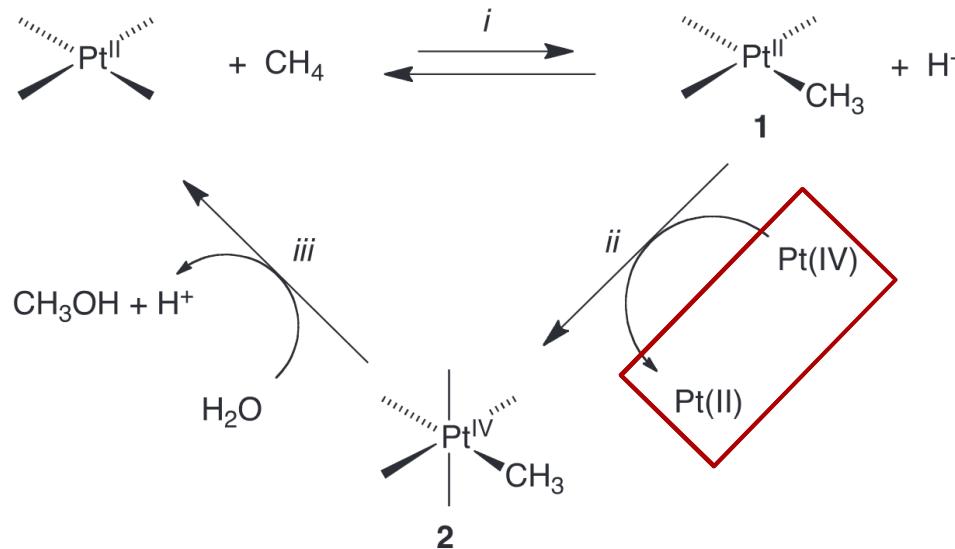
- What happens when we can't easily use them (i.e. methane)?



Converting methane into something that we can use is challenging

- C-H bonds are strong!
- What if we could selectively break the bond?

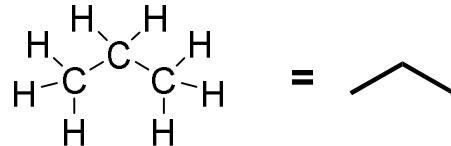
The "Shilov Cycle"



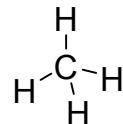
Labinger & Bercaw *JOMC* 2015, 793, 47.

Some challenges for OM chemistry

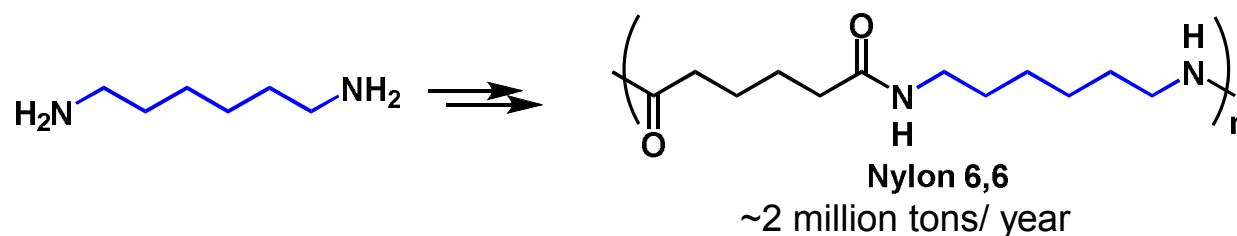
- Hydrocarbons- many uses



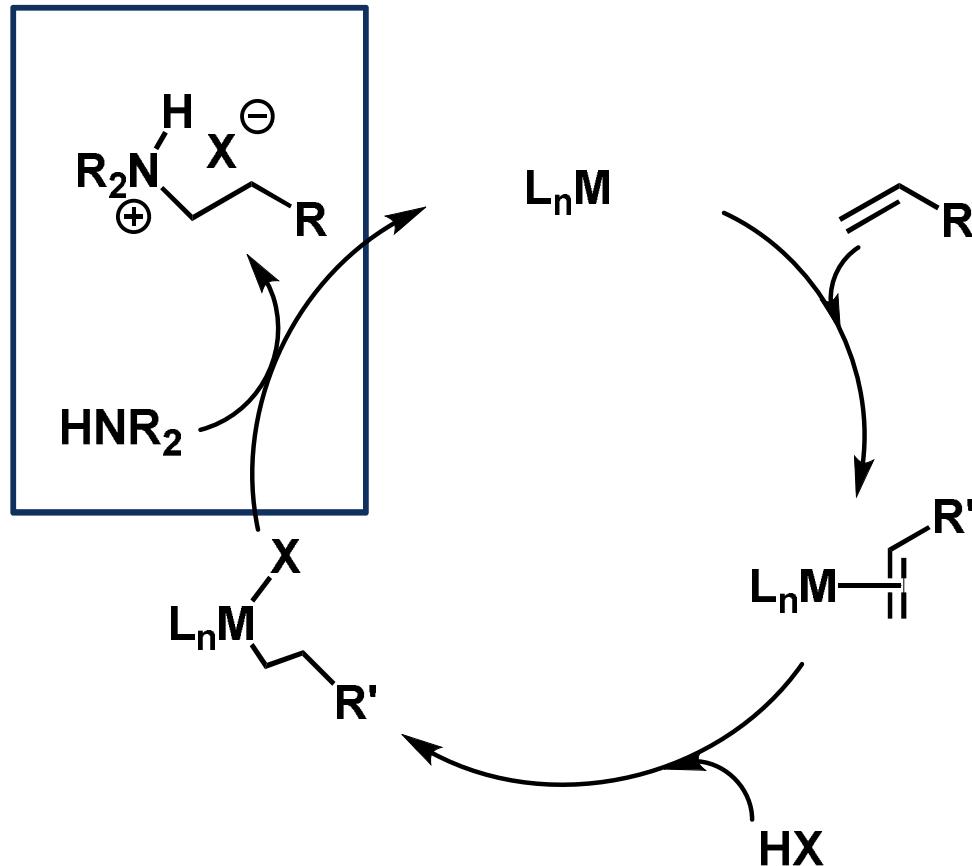
- What happens when we can't easily use them (i.e. methane)?



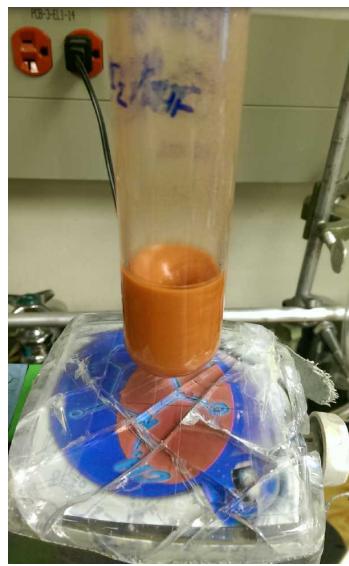
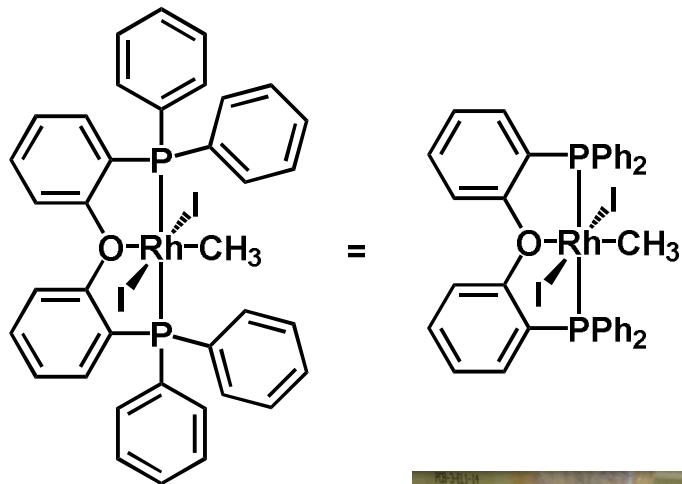
- Or if many steps are required to synthesize?



Can we develop a catalyst to produce alkylamines?

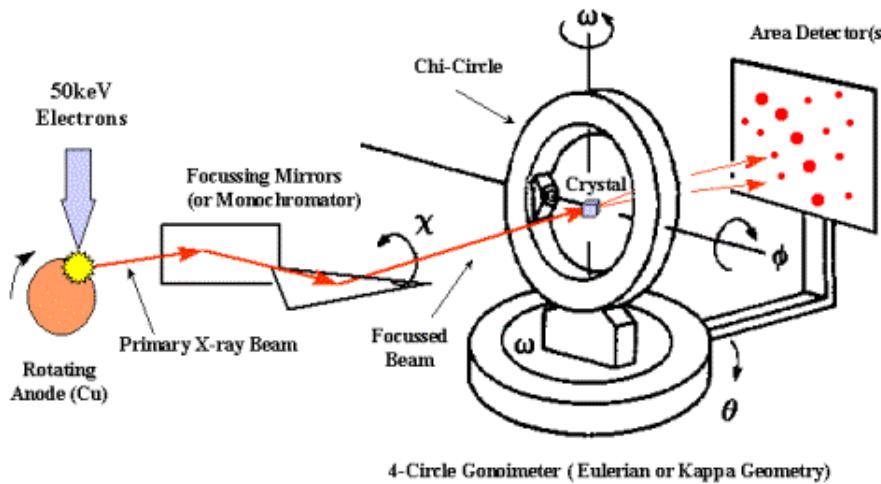
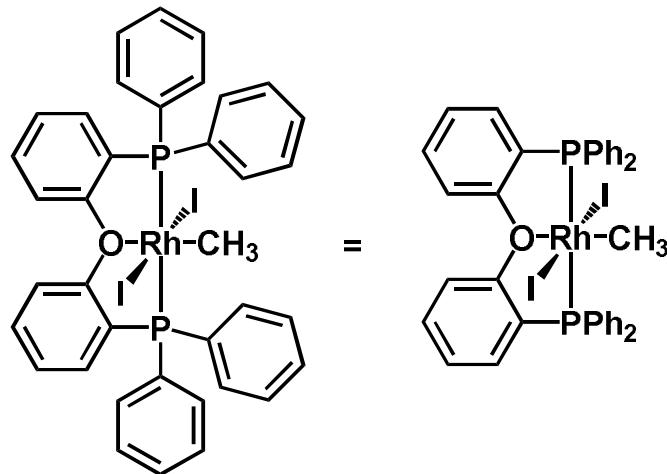


Synthesis of model complexes

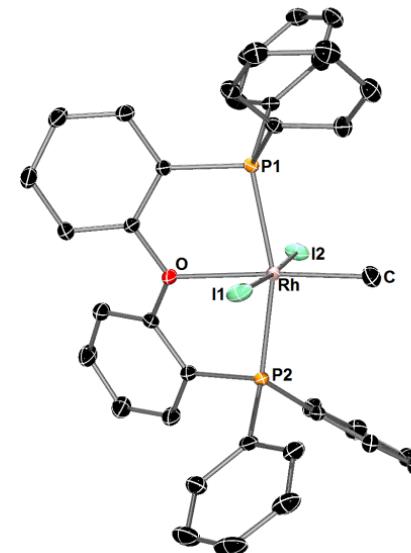



9	10
VIII	
8	
27	28
Co Cobalt 58.933	Ni Nickel 58.693
45	46
Rh Rhodium 102.906	Pd Palladium 106.42
77	78
Ir Iridium 192.22	Pt Platinum 195.08

Characterization of new complexes



http://pruffle.mit.edu/atomiccontrol/education/xray/xray_diff_files/image006.gif



Nuclear Magnetic Resonance (NMR)

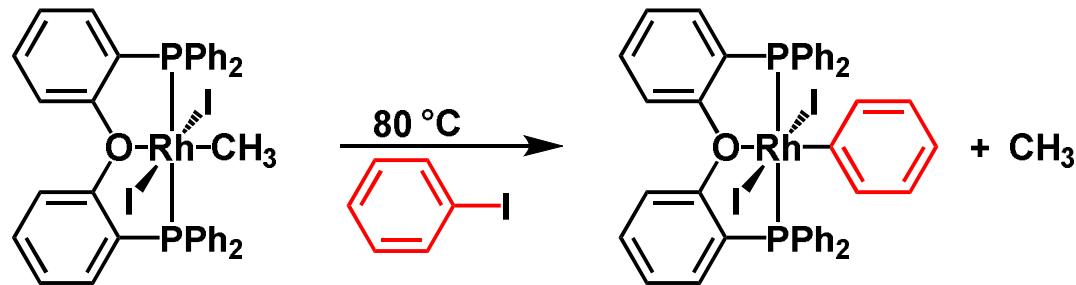


Image source: Bruker

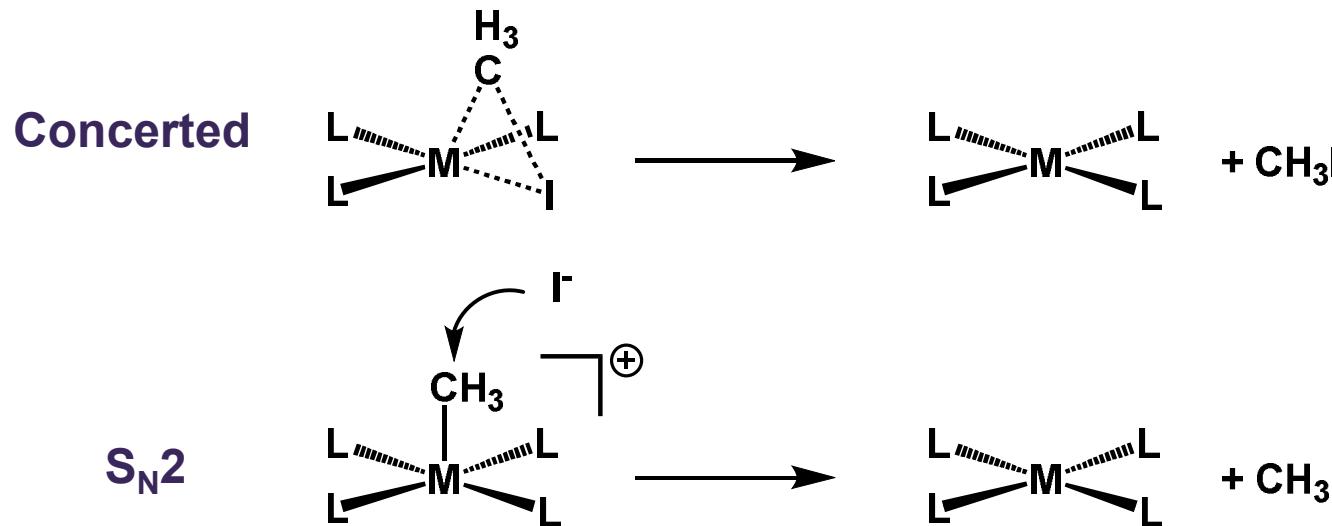


Image source: Philips

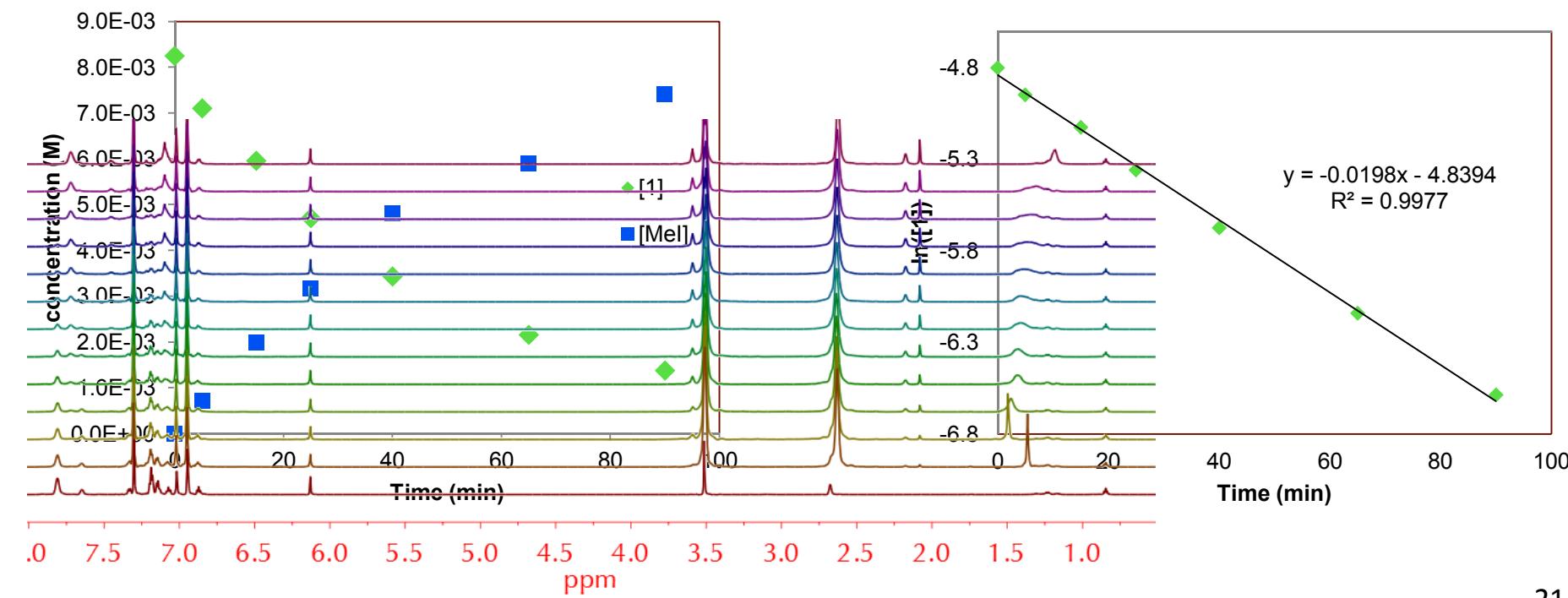
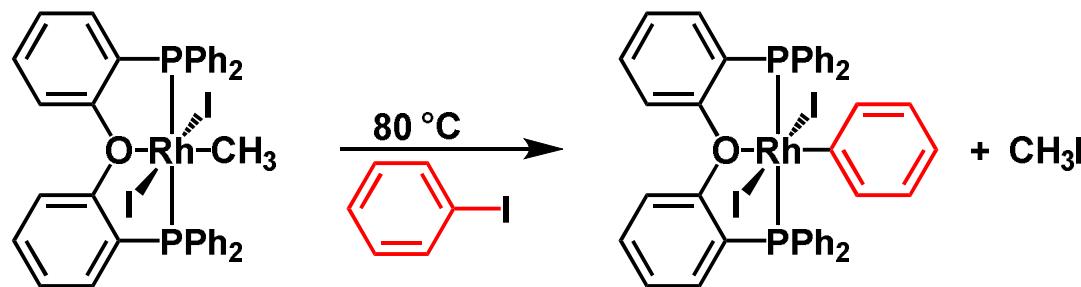
What happens if we heat?



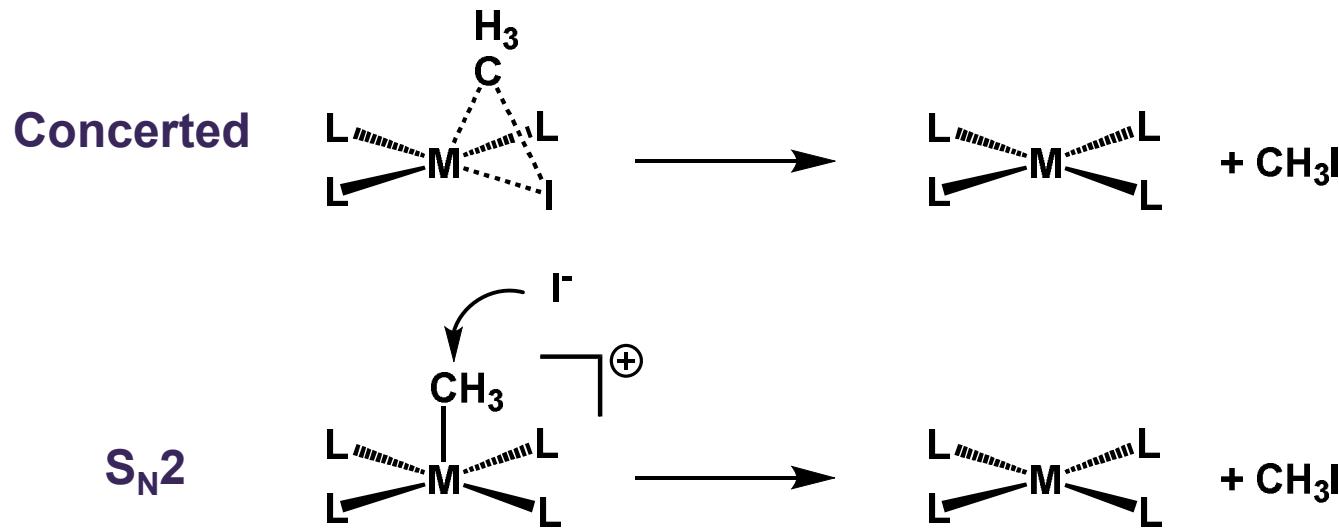
- How does this happen (mechanism)?



Reaction progress



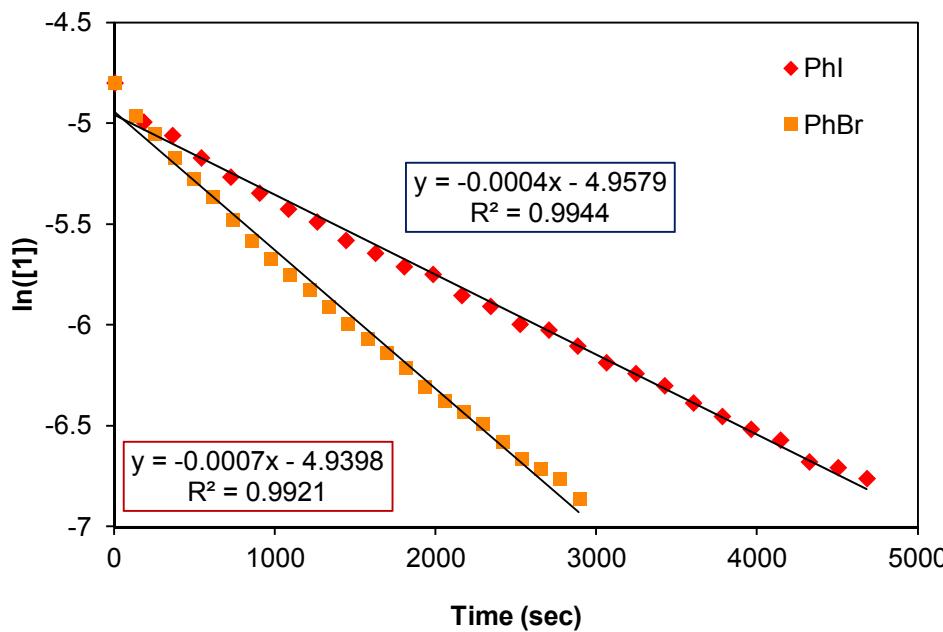
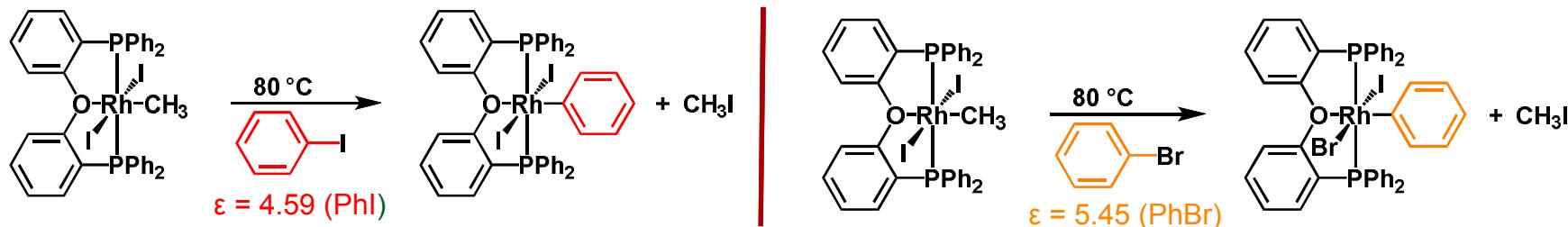
1st order reaction



- Need more experiments to rule out mechanisms

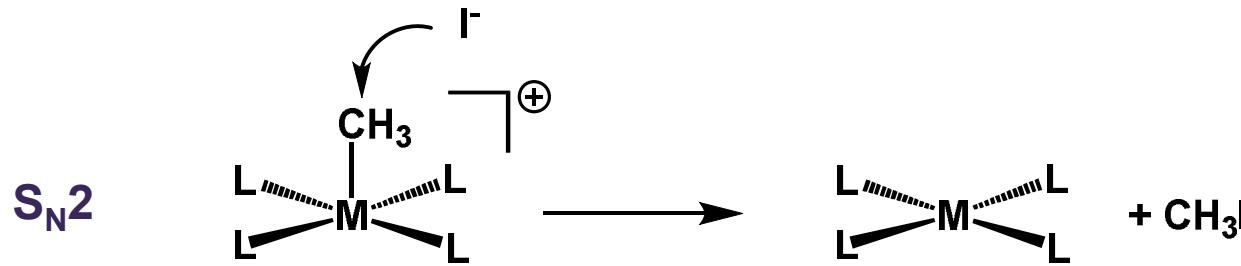
Vary conditions- one at a time

- Formation of charged species should be more favored in more polar solvent
- Polarity should not have significant effect on concerted pathway

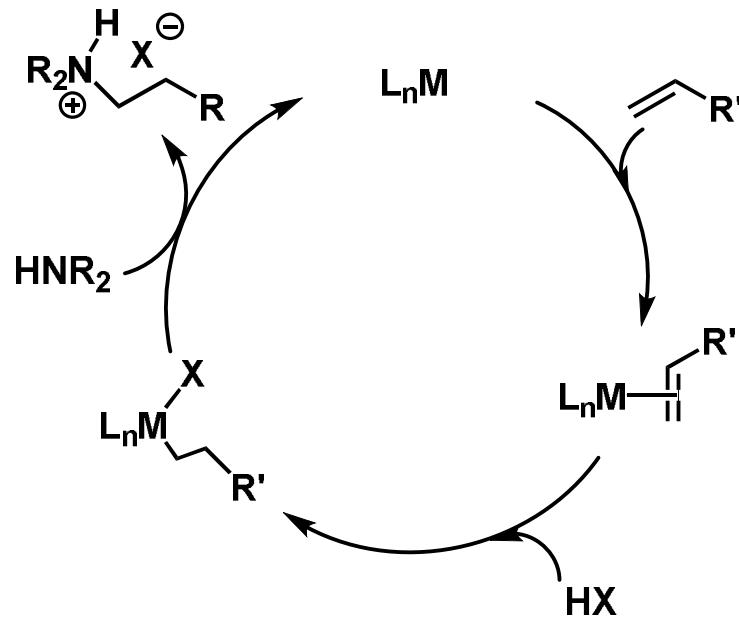


- $k_{\text{obs}} = 4.0 \pm 0.1 \times 10^{-4} \text{ s}^{-1}$ (PhI)
- $k_{\text{obs}} = 6.6 \pm 0.1 \times 10^{-4} \text{ s}^{-1}$ (PhBr)
- k_{obs} is 1.7x faster in PhBr

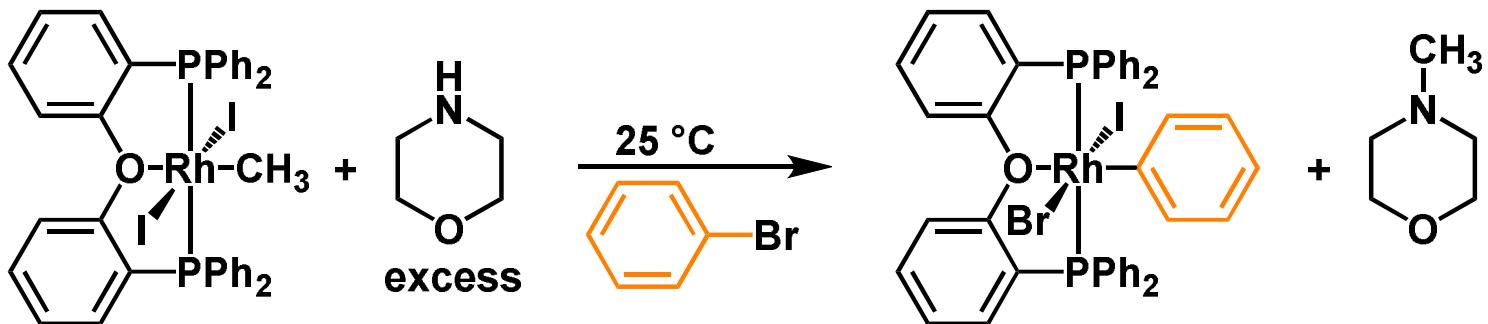
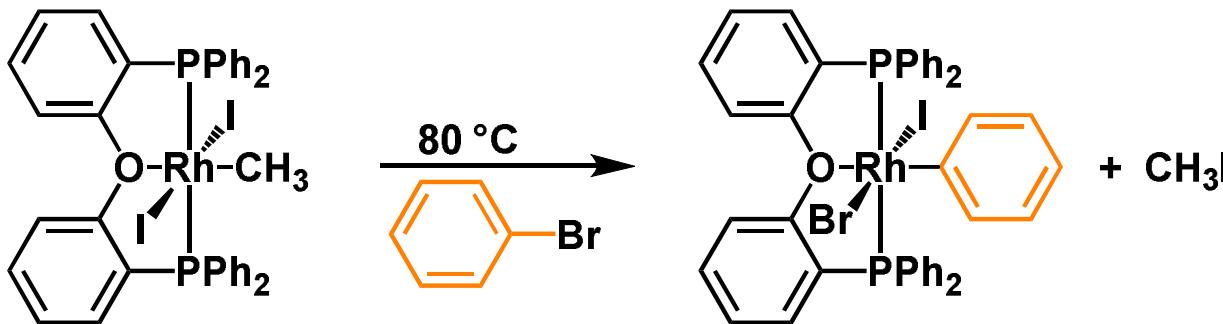
After many more experiments...



- Two path mechanism (second path not shown)



Reaction with amines results in C-N bond formation



What do we do with the results?

Communication

Direct Formation of Carbon(sp³)–Heteroatom Bonds from Rh^{III} To Produce Methyl Iodide, Thioethers, and Alkylamines

Tyler E. Stevens, Karena A. Smoll, and Karen I. Goldberg*

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J. Am. Chem. Soc. 2017, 139 (23), pp 7725–7728

DOI: 10.1021/jacs.7b04169

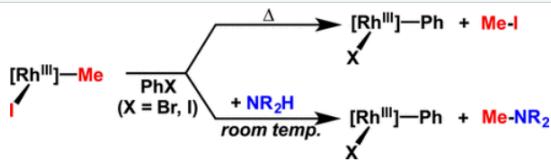
Publication Date (Web): June 2, 2017

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goldberg@chem.washington.edu

Abstract



Thermolysis of the Rh^{III}–Me complex (DPEphos)RhMeI₂ (**1**) results in reductive elimination of MeI. Mechanistic studies are consistent with S_N2 attack by I[–] at the Rh^{III}–Me group via two separate competing paths. Addition of sulfur and nitrogen nucleophiles allows effective competition and formation of C(sp³)–S and C(sp³)–N coupled products in high yields. C(sp³)–N bond formation is second-order in amine, consistent with amine substitution of iodide at the metal followed by nucleophilic attack at carbon by a second amine.

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Direct Formation of Carbon(sp³)–Heteroatom Bonds from Rh^{III} To Produce Methyl Iodide, Thioethers, and Alkylamines

Tyler E. Stevens, Karena A. Smoll, and Karen I. Goldberg*

Department of Chemistry, University of Washington, Box 351700, Seattle, Washington 98195, United States

Supporting Information

ABSTRACT: Thermolysis of the Rh^{III}–Me complex (DPEphos)RhMeI₂ (**1**) results in reductive elimination of MeI. Mechanistic studies are consistent with S_N2 attack by I[–] at the Rh^{III}–Me group via two separate competing paths. Addition of sulfur and nitrogen nucleophiles allows effective competition and formation of C(sp³)–S and C(sp³)–N coupled products in high yields. C(sp³)–N bond formation is second-order in amine, consistent with amine substitution of iodide at the metal followed by nucleophilic attack at carbon by a second amine.

to an unprecedented path involving coordination of the amine to the metal center followed by C–N bond formation via external attack at the Rh–Me group by a second amine equivalent.

The Rh^{III}–Me complex (DPEphos)RhMeI₂ (**1**) was prepared in high yield by addition of excess MeI to (DPEphos)Rh₂Cl₆ Complex **1** in THF-*d*₁ exhibits a doublet at 13.2 ppm ($J_{\text{Rh}-\text{p}} = 103.8$ Hz) in the ³¹P NMR spectrum. The methyl group bound to Rh gives rise to a doublet of triplets in the ¹H NMR spectrum at 2.22 ppm ($J_{\text{Rh}-\text{H}} = 4.9$ Hz, $J_{\text{H}-\text{H}} = 2.6$ Hz). The solid-state structure of **1** (Figure S1) shows octahedral geometry about Rh with meridional DPEphos and trans iodide ligands. The Rh–Me (2.0769(19) Å) and Rh–I (2.6633(4) Å and 2.6379(4) Å) bond lengths are similar to those reported for other Rh^{III} octahedral bisphosphine complexes.^{32,37}

Thermolysis of **1** in iodobenzene at 80 °C resulted in quantitative formation of MeI and a new Rh species. The ³¹P NMR resonance of the new Rh product appeared only slightly downfield at 15.4 ppm with a similar $J_{\text{Rh}-\text{p}}$ coupling constant (106.4 Hz). On this basis, we speculated that it was also a Rh^{II} complex, and given that the reaction was performed in iodobenzene, we proposed that the product was (DPEphos)RhPh(I)₂ (**2**). Overlay of the ¹H NMR aromatic resonances made characterization of the product challenging, and attempts to obtain crystals were unsuccessful. To establish the identity of the Rh product, it was thermolyzed in *p*-bromotoluene. The ³¹P NMR chemical shift and $J_{\text{Rh}-\text{p}}$ coupling constant of the corresponding product (18.6 ppm, $J_{\text{Rh}-\text{p}} = 105.5$ Hz) were similar to those of the product from thermolysis in iodobenzene. However, the ¹H NMR spectrum contained an upfield singlet (2.18 ppm, 3H), consistent with a bound *p*-tolyl moiety. Furthermore, the solid-state structure (Figure S2) confirmed that the solvent had added to rhodium, yielding (DPEphos)Rh(tolyl)I₂ (**3**). The production of tolyl complex **3** by thermolysis of **1** in *p*-bromotoluene substantiates the proposed formation of phenyl complex **2** by thermolysis of **1** in iodobenzene. Thus, the overall thermolysis reaction involves the formation of a C(sp³)–I bond with the reductive elimination of MeI and the cleavage of a C(sp³)–X bond with the oxidative addition of aryl halide.

On the basis of literature precedent for mechanisms of reductive elimination, six potential pathways for MeI elimination from **1** are proposed in Scheme 1. Routes C₁–C₃ involve concerted formation of the C(sp³)–I bond. In path C₁, MeI is eliminated directly from the six-coordinate complex **1**. In path C₂, the formation of a five-coordinate species prior to concerted C–I coupling is proposed, with the DPEphos ligand changing

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Reductive elimination, a fundamental organometallic process,¹ is the product release step in numerous catalytic processes.² Reactions that form carbon–heteroatom (C–X) bonds via reductive elimination are particularly valuable, as new functionality is introduced into the product. For example, arylamines are formed by C(sp³)–N reductive elimination from Pd⁰ in the product release step in Buchwald–Hartwig cross-coupling reactions.³ Strikingly less prevalent in both catalytic and stoichiometric reactions are reductive eliminations involving alkyl groups to form C(sp³)–X bonds⁴ and in particular C(sp³)–N bonds.^{5,6} Access to such couplings to form C(sp³)–N bonds would be a tremendous asset in rational design efforts for catalytic systems. For example, a C(sp³)–N bond-forming reaction could be used to produce alkylamines via olefin hydroamination or direct alkane oxidation.

In the few reported examples of C(sp³)–X coupling reactions (X = N, O, S, halide), high-valent metal centers such as Rh^{III}₂^{6a–m} and Pt^{IV}^{3b–d,4a–h} are primarily employed. Recently, examples of C(sp³)–N reductive elimination from Pd⁰ and Ni^{IV} have also been observed.^{4e,f} However, sulfonamides were employed for these reactions, and C(sp³)–N reductive elimination to produce alkylamines has rarely been documented.^{4d} Both concerted reductive elimination and S_N2-type mechanisms have been proposed for C(sp³)–X coupling reactions,^{3,4} with both pathways occurring through coordinately unsaturated metal centers. We now report a well-characterized example of C(sp³)–I reductive elimination from Rh^{III} along with mechanistic studies that indicate the involvement of two competing pathways of S_N2 attack in the presence of excess iodide. Similar competitive behavior has not previously been observed in reductive elimination reactions, and the presence of the second pathway provides access to incorporation of external nucleophiles. This second pathway allows for the formation of C(sp³)–S and C(sp³)–N bonds at room temperature. Furthermore, mechanistic studies of the C(sp³)–N coupling point

Received: April 24, 2017
Published: June 2, 2017

7725

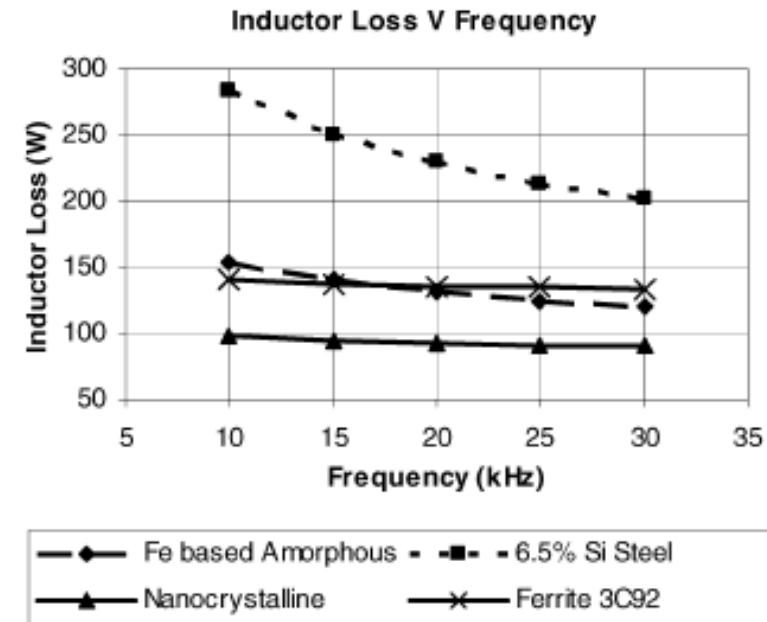
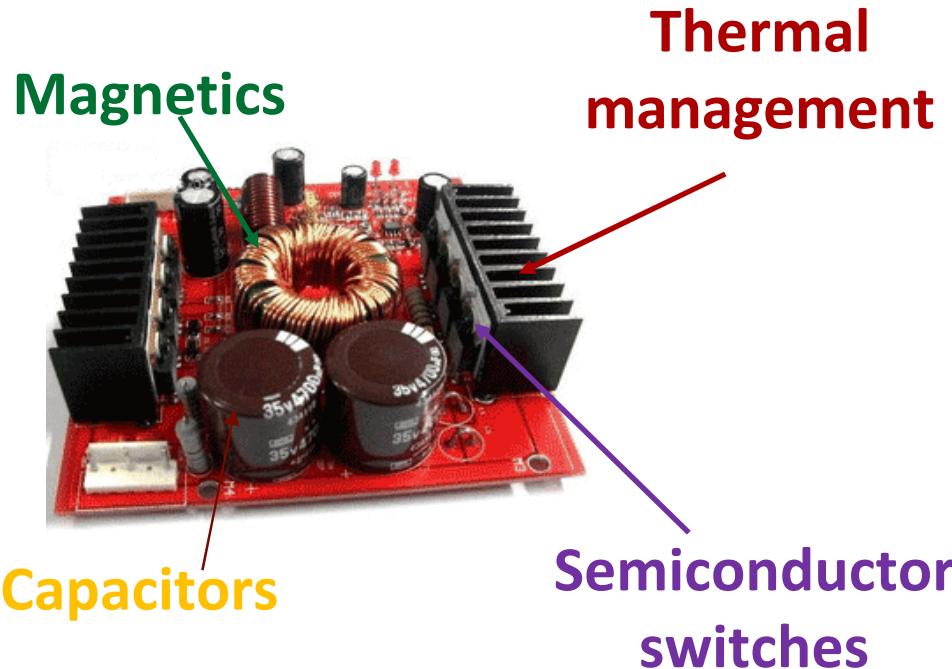
DOI: 10.1021/jacs.7b04169
J. Am. Chem. Soc. 2017, 139, 7725–7728

Transition to inorganic materials

Periodic Table of the Elements																										
Period	1		2		3		4		5		6		7		8		9									
	IA	1A	IIA	2A	IIIB	3B	IVB	4B	VB	5B	VIIB	7B	VIIIB	8B	VIII	9	10									
1	1 H Hydrogen 1s1	2 He Boron 2s2 [He]2s2	3 Li Lithium 2s1 [He]2s1	4 Be Beryllium 2s2 [He]2s2	5 B Boron 2s2 [He]2s2	6 C Carbon 2s2 [He]2s2	7 N Nitrogen 2s2 [He]2s2	8 O Oxygen 2s2 [He]2s2	9 F Fluorine 2s2 [He]2s2	10 Ne Neon 2s2 [He]2s2	11 Na Sodium 2s1 [Ne]3s1	12 Mg Magnesium 2s2 [Ne]3s2	13 Al Aluminum 2s2 [Ne]3s2	14 Si Silicon 2s2 [Ne]3s2	15 P Phosphorus 2s3 [Ne]3s3	16 S Sulfur 2s3 [Ne]3s3	17 Cl Chlorine 2s3 [Ne]3s3	18 Ar Argon 2s3 [Ne]3s3								
2	11 Na Sodium 2s1 [Ne]3s1	12 Mg Magnesium 2s2 [Ne]3s2	13 Al Aluminum 2s2 [Ne]3s2	14 Si Silicon 2s2 [Ne]3s2	15 P Phosphorus 2s3 [Ne]3s3	16 S Sulfur 2s3 [Ne]3s3	17 Cl Chlorine 2s3 [Ne]3s3	18 Ar Argon 2s3 [Ne]3s3	19 K Potassium 2s1 3s1 [Ar]3s1	20 Ca Calcium 2s2 3s2 [Ar]3s2	21 Sc Scandium 2s2 3d1 [Ar]3d1	22 Ti Titanium 2s2 3d2 [Ar]3d2	23 V Vanadium 2s2 3d3 [Ar]3d3	24 Cr Chromium 2s2 3d5 [Ar]3d5	25 Mn Manganese 2s2 3d5 4s1 [Ar]3d5 4s1	26 Fe Iron 2s2 3d6 [Ar]3d6	27 Co Cobalt 2s2 3d7 [Ar]3d7	28 Ni Nickel 2s2 3d8 [Ar]3d8	29 Cu Copper 2s2 3d10 [Ar]3d10	30 Zn Zinc 2s2 3d10 [Ar]3d10	31 Ga Gallium 2s2 3d10 4s1 [Ar]3d10 4s1	32 Ge Germanium 2s2 3d10 4s2 [Ar]3d10 4s2	33 As Arsenic 2s2 3d10 4s2 4p3 [Ar]3d10 4s2 4p3	34 Se Selenium 2s2 3d10 4s2 4p5 [Ar]3d10 4s2 4p5	35 Br Bromine 2s2 3d10 4s2 4p6 [Ar]3d10 4s2 4p6	36 Kr Krypton 2s2 3d10 4s2 4p6 [Ar]3d10 4s2 4p6
3	37 Rb Rubidium 2s1 3d1 4s1 [K]3d1 4s1	38 Sr Strontium 2s1 3d2 4s2 [K]3d2 4s2	39 Y Yttrium 2s1 3d9 4s2 [K]3d9 4s2	40 Zr Zirconium 2s2 3d1 4s2 [K]3d1 4s2	41 Nb Niobium 2s2 3d4 4s2 [K]3d4 4s2	42 Mo Molybdenum 2s2 3d5 4s2 [K]3d5 4s2	43 Tc Technetium 2s2 3d5 4s1 [K]3d5 4s1	44 Ru Ruthenium 2s2 3d6 4s1 [K]3d6 4s1	45 Rh Rhodium 2s2 3d7 4s1 [K]3d7 4s1	46 Pd Palladium 2s2 3d8 4s1 [K]3d8 4s1	47 Ag Silver 2s2 3d10 4s1 [K]3d10 4s1	48 Cd Cadmium 2s2 3d10 4s2 [K]3d10 4s2	49 In Indium 2s2 3d10 4s2 4p1 [K]3d10 4s2 4p1	50 Sn Tin 2s2 3d10 4s2 4p5 [K]3d10 4s2 4p5	51 Sb Antimony 2s2 3d10 4s2 4p5 [K]3d10 4s2 4p5	52 Te Tellurium 2s2 3d10 4s2 4p6 [K]3d10 4s2 4p6	53 I Iodine 2s2 3d10 4s2 4p6 [K]3d10 4s2 4p6	54 Xe Xenon 2s2 3d10 4s2 4p6 [K]3d10 4s2 4p6								
4	55 Cs Cesium 2s1 3d1 4s2 4p6 [Ba]3d1 4s2 4p6	56 Ba Barium 2s1 3d2 4s2 [Ba]3d2 4s2	57-71	72 Hf Hafnium 2s1 3d2 4s2 [Ta]3d2 4s2	73 Ta Tantalum 2s1 3d3 4s2 [Ta]3d3 4s2	74 W Tungsten 2s1 3d4 4s2 [Ta]3d4 4s2	75 Re Rhenium 2s1 3d5 4s2 [Ta]3d5 4s2	76 Os Osmium 2s1 3d6 4s2 [Ta]3d6 4s2	77 Ir Iridium 2s1 3d7 4s2 [Ta]3d7 4s2	78 Pt Platinum 2s1 3d8 4s2 [Ta]3d8 4s2	79 Au Gold 2s1 3d10 4s2 [Ta]3d10 4s2	80 Hg Mercury 2s1 3d10 4s2 4p6 [Hg]3d10 4s2 4p6	81 Tl Thallium 2s1 3d10 4s2 4p6 [Tl]3d10 4s2 4p6	82 Bi Bismuth 2s1 3d10 4s2 4p6 [Bi]3d10 4s2 4p6	83 Po Polonium 2s1 3d10 4s2 4p6 [Po]3d10 4s2 4p6	84 At Astatine 2s1 3d10 4s2 4p6 [At]3d10 4s2 4p6	85 Rn Radon 2s1 3d10 4s2 4p6 [Rn]3d10 4s2 4p6									
5	87 Fr Francium 2s1 3d1 4s2 4p6 [Rn]3d1 4s2 4p6	88 Ra Radium 2s1 3d1 4s2 4p6 [Rn]3d1 4s2 4p6	89-103	104 Rf Rutherfordium 2s1 3d1 4s2 4p6 [Rn]3d1 4s2 4p6	105 Db Dubnium 2s1 3d1 4s2 4p6 [Rn]3d1 4s2 4p6	106 Sg Seaborgium 2s1 3d1 4s2 4p6 [Rn]3d1 4s2 4p6	107 Bh Bohrium 2s1 3d1 4s2 4p6 [Rn]3d1 4s2 4p6	108 Hs Hassium 2s1 3d1 4s2 4p6 [Rn]3d1 4s2 4p6	109 Mt Meitnerium 2s1 3d1 4s2 4p6 [Rn]3d1 4s2 4p6	110 Ds Darmstadtium 2s1 3d1 4s2 4p6 [Rn]3d1 4s2 4p6	111 Rg Roentgenium 2s1 3d1 4s2 4p6 [Rn]3d1 4s2 4p6	112 Cn Copernicium 2s1 3d1 4s2 4p6 [Rn]3d1 4s2 4p6	113 Uut Ununtrium 2s1 3d1 4s2 4p6 [Rn]3d1 4s2 4p6	114 Fl Flerovium 2s1 3d1 4s2 4p6 [Rn]3d1 4s2 4p6	115 Uup Ununpentium 2s1 3d1 4s2 4p6 [Rn]3d1 4s2 4p6	116 Lv Livermorium 2s1 3d1 4s2 4p6 [Rn]3d1 4s2 4p6	117 Uus Ununseptium 2s1 3d1 4s2 4p6 [Rn]3d1 4s2 4p6	118 Uuo Ununoctium 2s1 3d1 4s2 4p6 [Rn]3d1 4s2 4p6								
6	Lanthanide Series																									
7	Actinide Series																									

Iron nitride

Magnetic components are large!

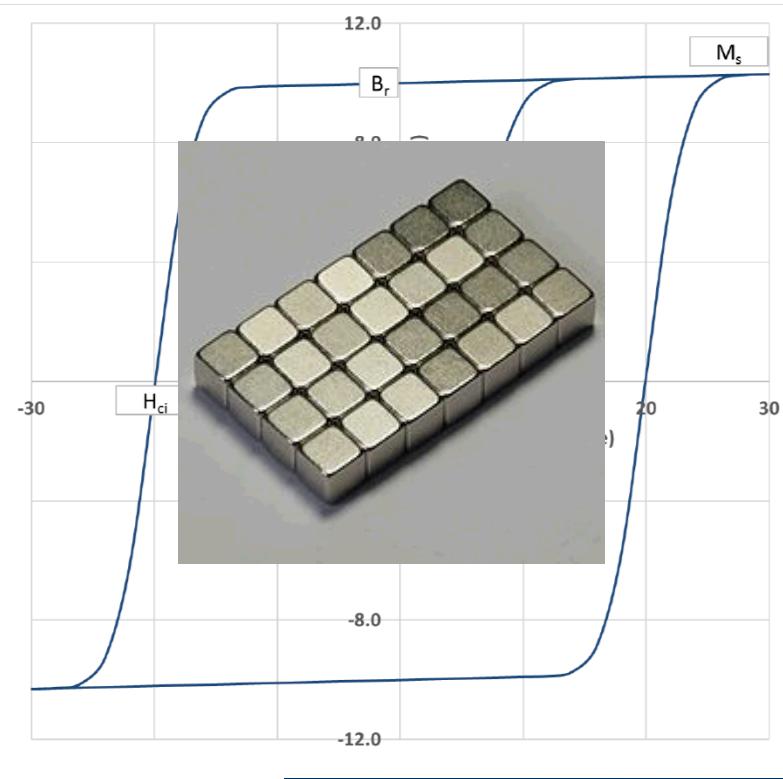


B.J. Lyons, J.G. Hayes, M.G. Egan, Magnetic Material Comparisons for High-Current Inductors in Low-Medium Frequency DC-DC Converters, *IEEE, 2007*, 71.

- New soft magnetic materials could enable smaller/ more portable power electronics

What is a soft magnet???

Hard (permanent)magnet

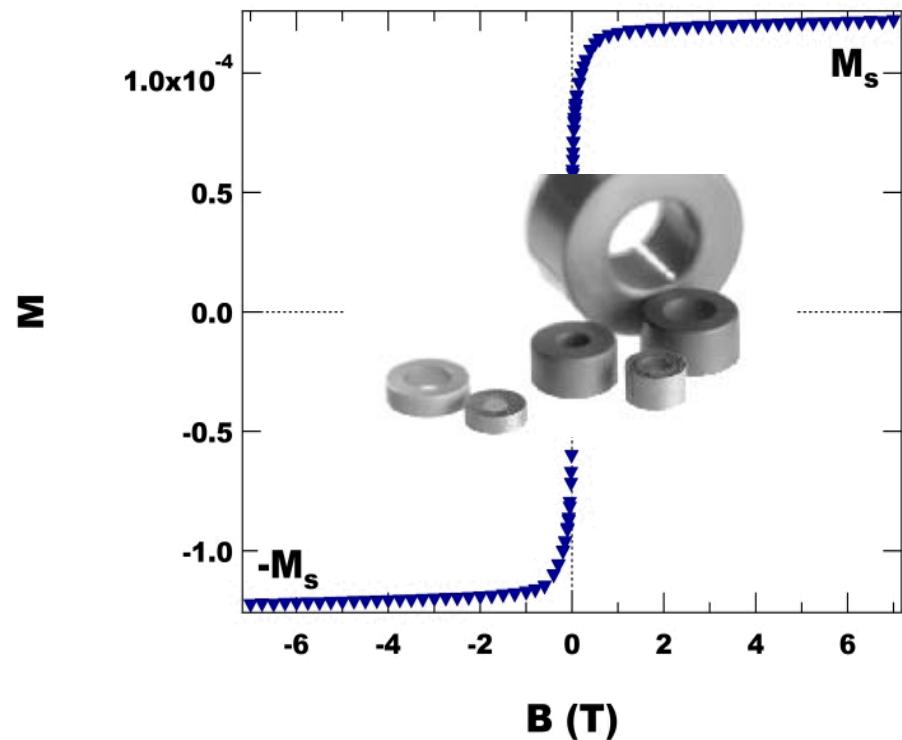


Spontaneous Materials

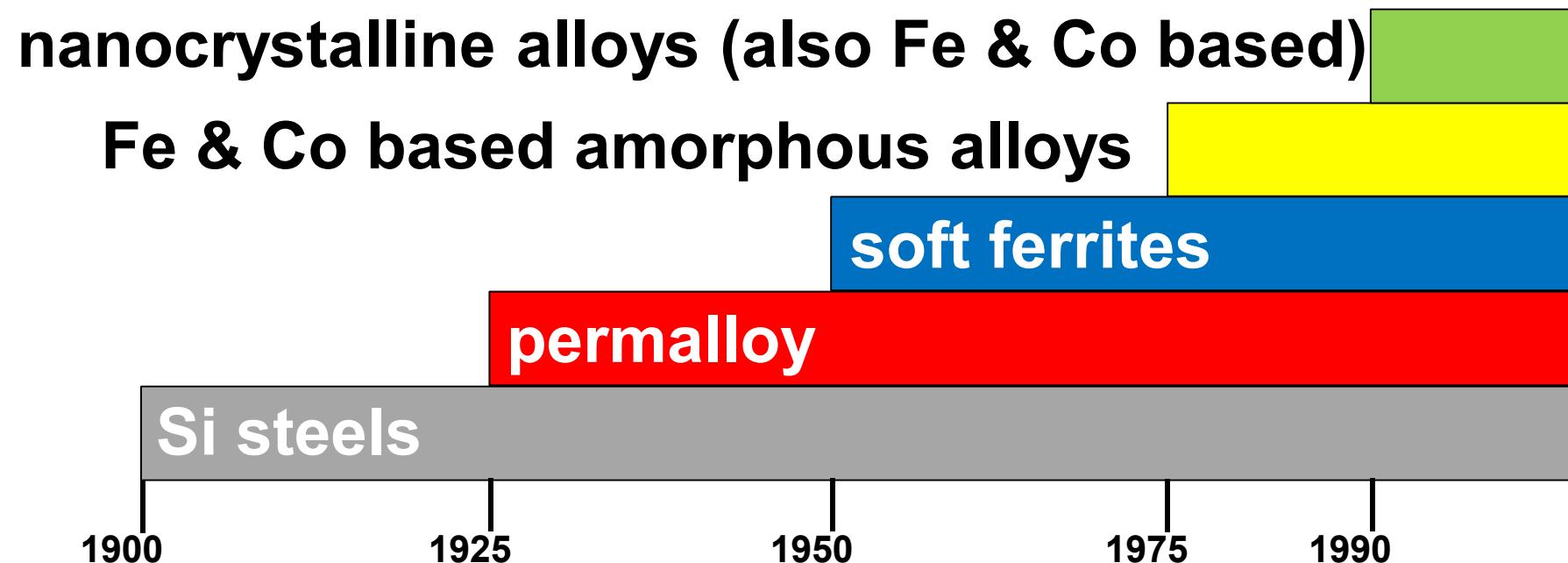
M_s = saturation magnetization, B_r = magnetic remanence

H_c = coercivity, μ = permeability

Soft magnet



Development of soft magnetic materials



Adapted from: L.A. Dobrzański, M. Drak, B. Ziębowicz, Materials with specific magnetic properties, *Journal of Achievements in Materials and Manufacturing Eng.* 2006, 17, 37.

γ' -Fe₄N meets all of the requirements



Magnetic Material	J_s (T)	$\rho(\mu\Omega\cdot m)$	Cost
VITROPERM (Vacuumschmelze)	1.20	1.15	High
Metglas 2605SC	1.60	1.37	High
Ferrite (Ferroxcube)	0.52	5×10^6	Low
Si steel	1.87	0.05	Low
γ' -Fe ₄ N	1.89	> 200	Low

Possible careers for an OM chemist

- Universities
 - Professor, research assistant, lecturer, etc.
- Industry
- National Labs & other govt. agencies

Questions???

