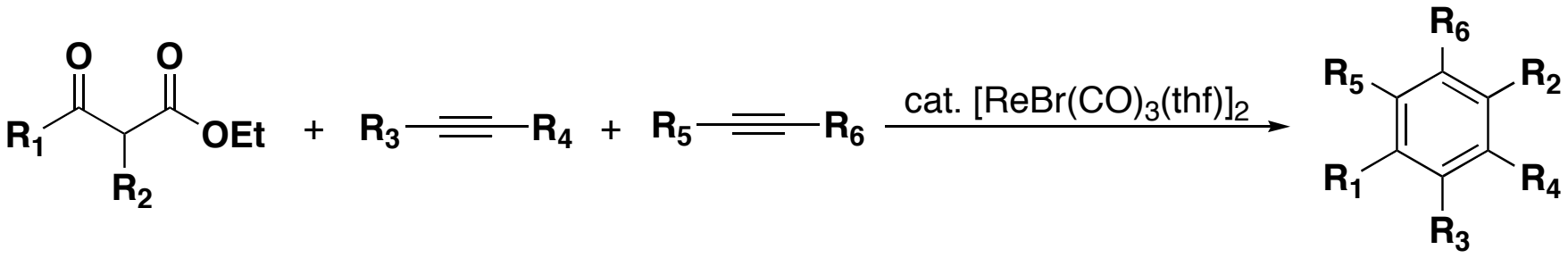
Rhenium-Catalyzed Synthesis of Multisubstituted Aromatic Compounds via C-C Single-Bond Cleavage

Kuninobu, Y.; Takata, H.; Kawata, A.; Takai, K. *Org. Lett.* ASAP



Current Literature

Kalyani Patil

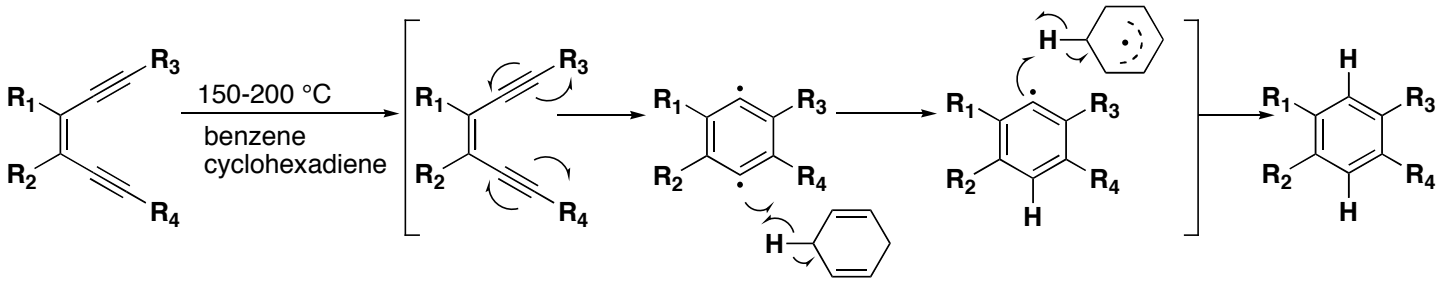
6/28/08

Outline

- Synthesis of Substituted Aromatic Compounds
- Rhenium Catalyzed Reactions
- Rhenium Catalyzed C-H Activation - Takai Group
- Title Paper
- Summary

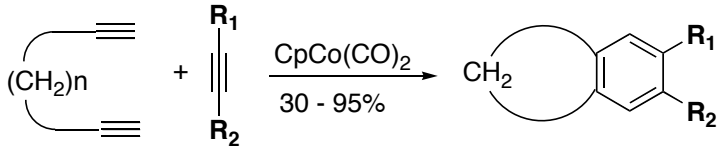
Synthesis of Substituted Aromatic Compounds

Bergman cyclization

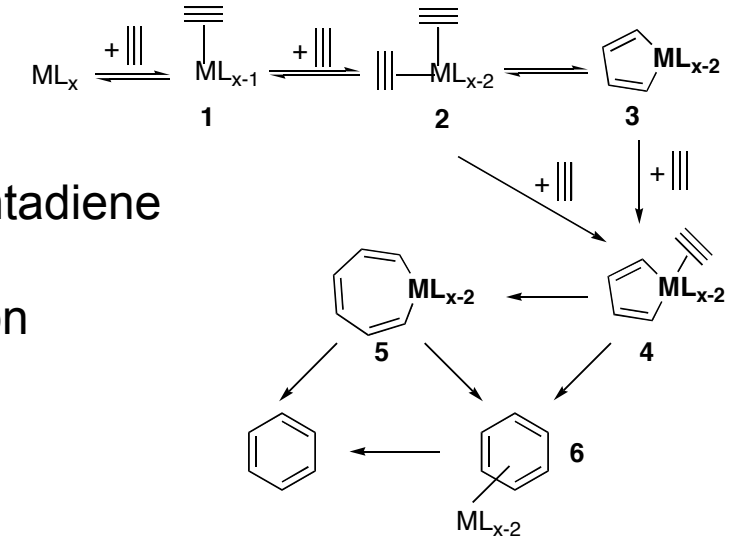


Bergman et. al. *J. Am. Chem. Soc.* **1972**, *94*, 660

Trimerization of acetylenes



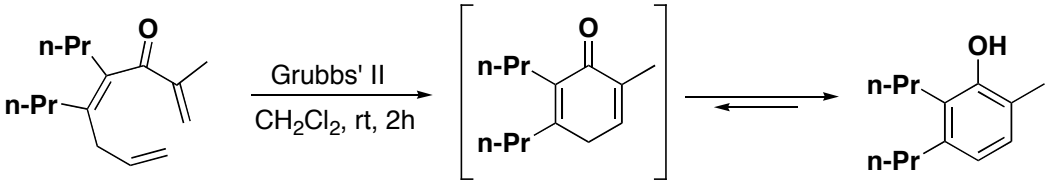
Vollhardt *Angew. Chem. Int. Ed.* **1984**, *23*, 539



- Oxidative coupling to give metallacyclopentadiene
- Alkyne insertion or Diels-Alder type addition

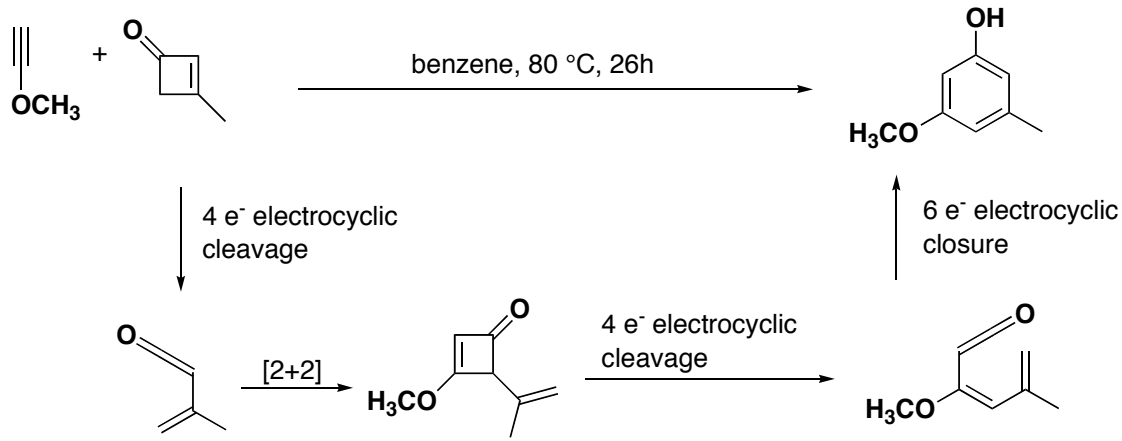
Synthesis of Substituted Aromatic Compounds

Ring-closing metathesis



Imamoto et. al. *J. Am. Chem. Soc.* **2005**, *127*, 10470

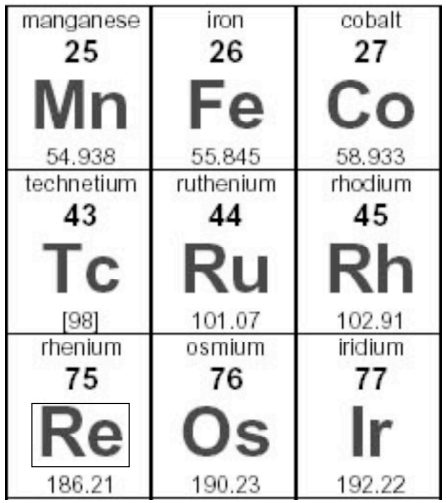
Annulation of vinylketenes with acetylenes



Danheiser et. al. *J.Org. Chem.* **1984**, *49*, 1672

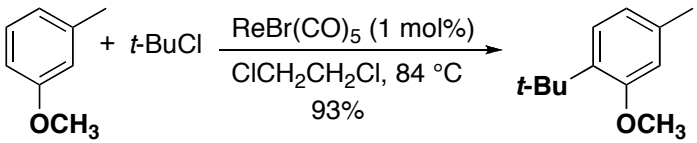
Properties of Rhenium

- Grayish white metal, last naturally occurring element to be discovered
- Discovered in 1925 by Dr. Walter Noddack and Dr. Ida Tacke Noddack
- Electronic configuration: [Xe] $4f^{14}$ $5d^{5}$ $6s^{2}$
- Oxidation states: -3, -1, 0, +1 to +7
- Lower electronegativity than Ru and Rh



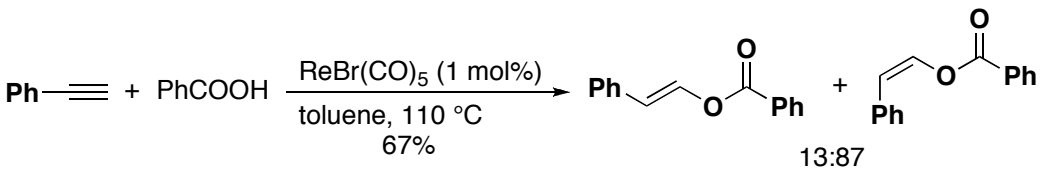
Rhenium Catalyzed Reactions

Friedel-Crafts alkylation



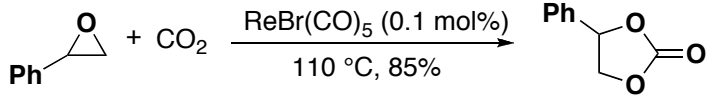
Sonoda et. al. *Bull. Chem. Soc. Jpn.* **2000**, *73*, 2779

Anti-Markovnikov addition of carboxylic acids to terminal alkynes



Hua et. al. *J. Org. Chem.* **2004**, *69*, 5782

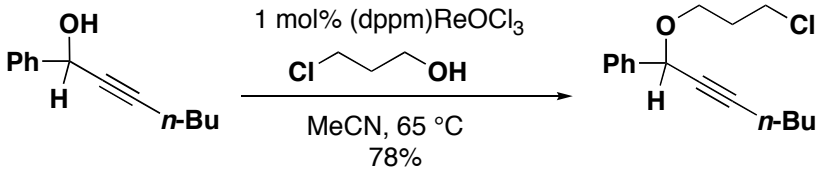
Coupling of epoxides with CO_2



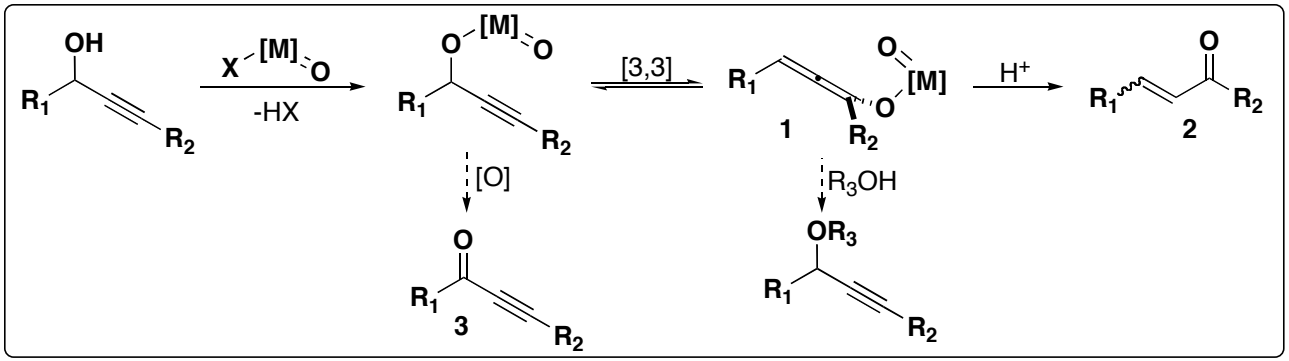
Hua et. al. *J. Org. Chem.* **2005**, *70*, 381

Rhenium Catalyzed Reactions - Toste Group

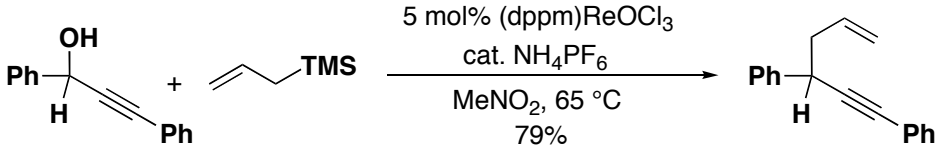
Etherification of propargylic alcohols



Toste et. al. *J. Am. Chem. Soc.* **2003**, *125*, 6076



Synthesis of 1,5-Enynes

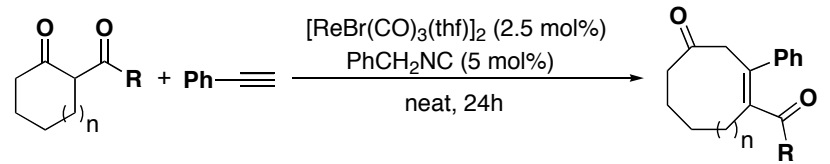


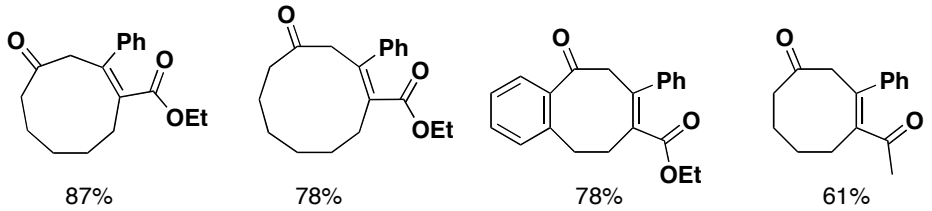
Toste et. al. *J. Am. Chem. Soc.* **2003**, *125*, 15760

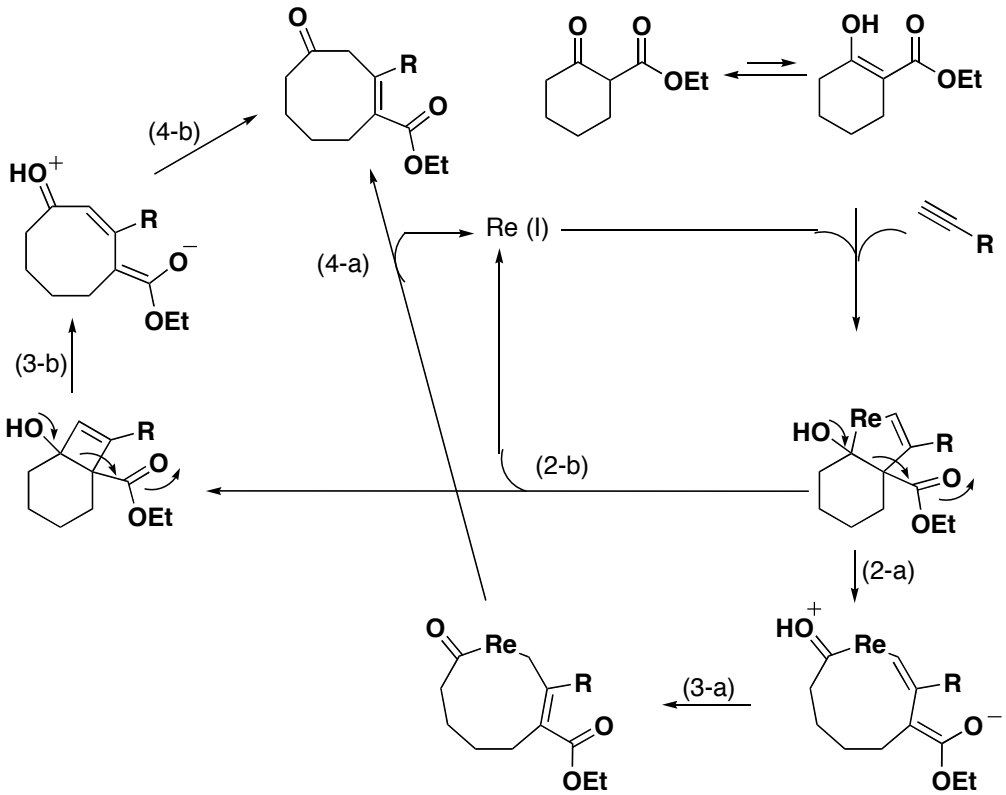
Rhenium Catalyzed Ring Expansion - Takai Group

Construction of medium size rings

Insertion of terminal alkynes into C-C next to the carbonyl group





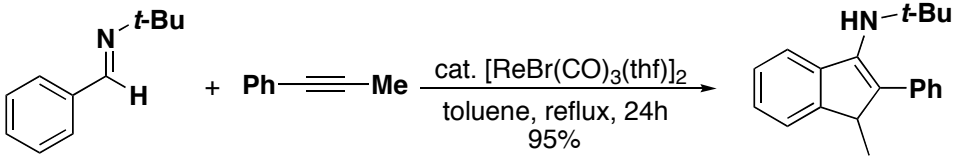


- Rhenacyclopentene intermediate
- Retro-aldol reaction/isomerization
- Reductive elimination

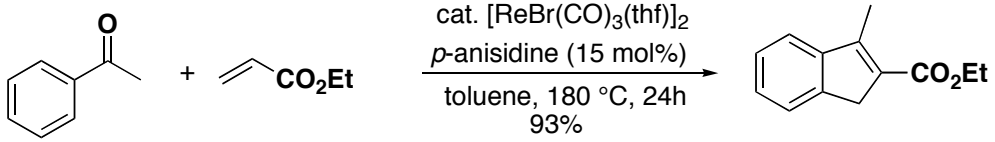
Takai et. al. *J. Am. Chem. Soc.***2006**, *128*, 12376

Rhenium Catalyzed C-H Activation - Takai Group

Formation of indene derivatives

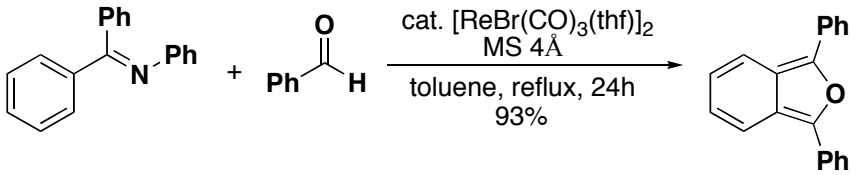


Takai et. al. *J. Am. Chem. Soc.* **2005**, *127*, 13498



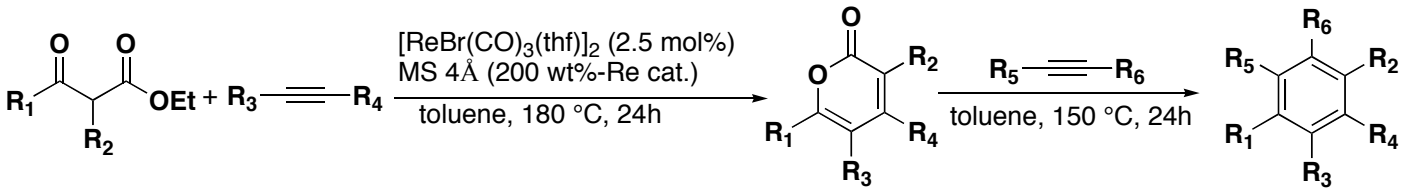
Takai et. al. *Angew. Chem. Int. Ed.* **2006**, *45*, 2766

Synthesis of isobenzofuran

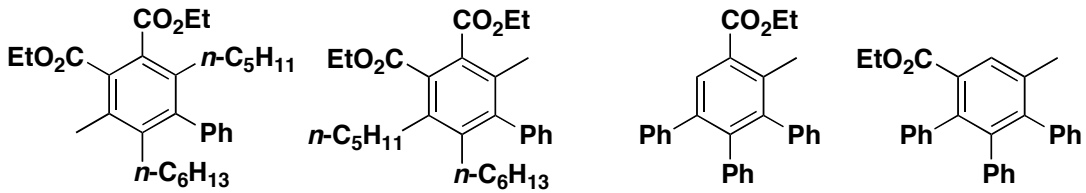


Takai et. al.*J. Am. Chem. Soc.* **2006**, *128*, 12376

Title Paper



Entry	R_1	R_2	R_3	R_4	R_5	R_6	Yield (%)
1.	Me	Me	Ph	Ph	CO_2Et	CO_2Et	83
2.	Ph	Me	Ph	Ph	CO_2Et	CO_2Et	64
3.	Me	H	Ph	Ph	CO_2Et	CO_2Et	84
4.	Me	Me	Me	Ph	CO_2Et	CO_2Et	91
5.	Me	Me	H	Ph	CO_2Et	CO_2Et	87
6.	Me	Me	H	*n*-$C_{10}H_{21}$	CO_2Et	CO_2Et	72
7.	Me	*n*-C_5H_{11}	*n*-C_6H_{13}	Ph	CO_2Et	CO_2Et	85, **A**:**B** = 96:4
8.	*n*-C_5H_{11}	Me	*n*-C_6H_{13}	Ph	CO_2Et	CO_2Et	83, **A**:**B** = 6:94
9.	Me	Me	Ph	Ph	CO_2Et	H	83
10.	Ph	Me	Ph	Ph	CO_2Et	H	77, **C**:**D** = 39:61



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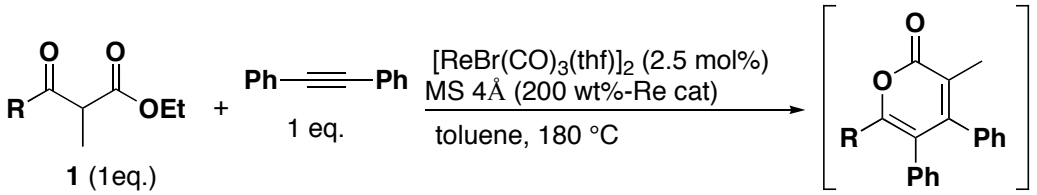
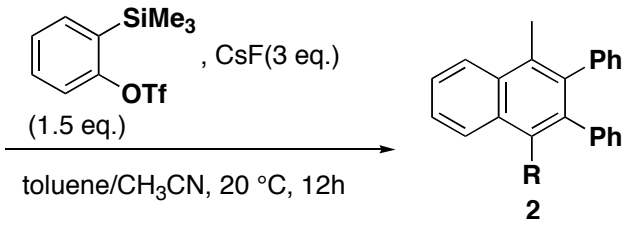
Title Paper

DA w/ Benzyne

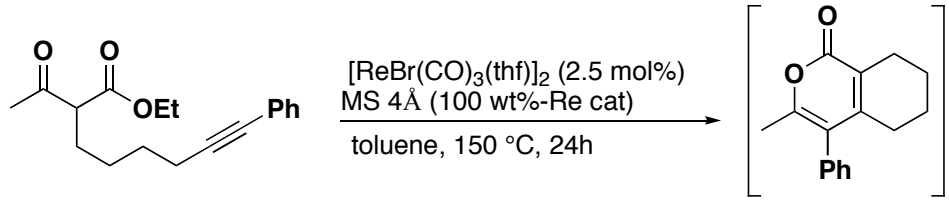


Benzyne generated in situ to synthesize naphthalene derivatives

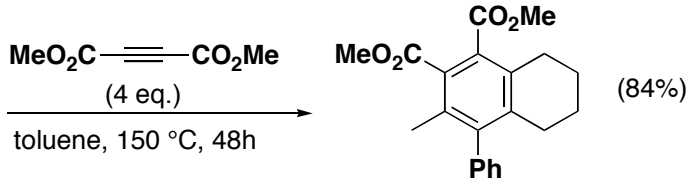


R	time (h)	yield (%)
Me (**1a**)	24	92 (**2a**)
Ph (**1b**)	48	96 (**2b**)

Intramolecular Reaction



Synthesis of tetrahydronaphthalene derivatives



(84%)

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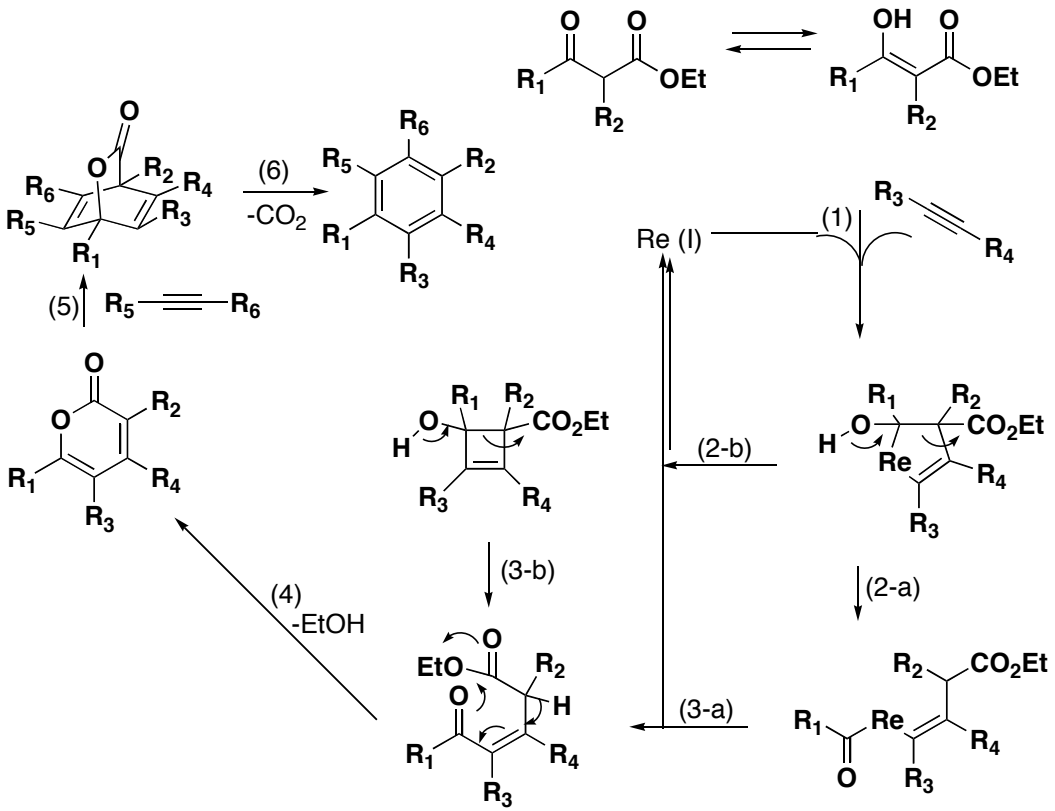
Title Paper: Proposed Mechanism



- Rhenacyclopentene intermediate
- Retro-aldol reaction/reductive elimination
- Isomerization of the alkene/cyclization
- DA reaction/decarboxylation

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Summary

- Synthesis of Multisubstituted Aromatic Compounds in Good Yields
- Products are Obtained in High Regioselectivity
- Aliphatic and Aromatic Acetylenes employed Prior to DA Reaction