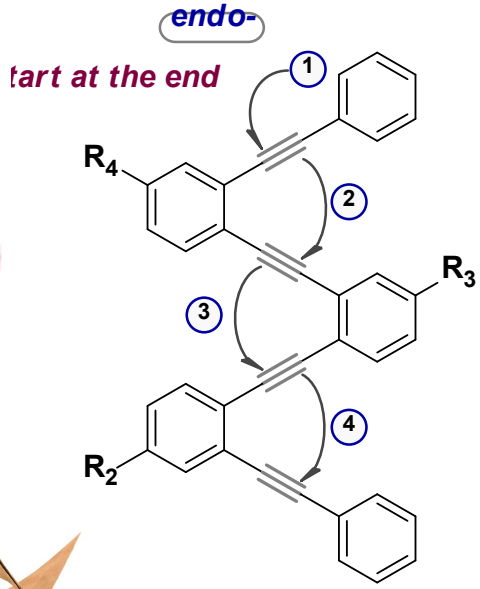
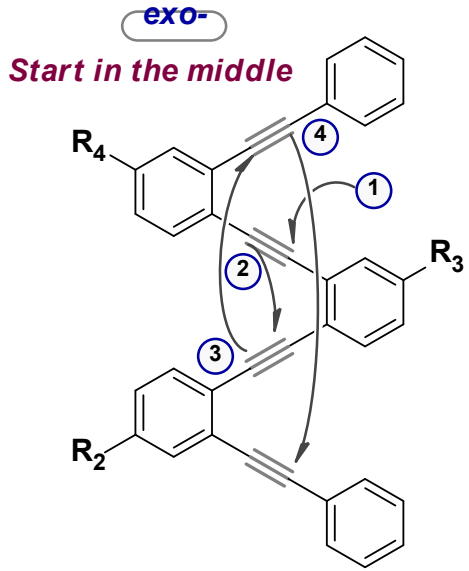
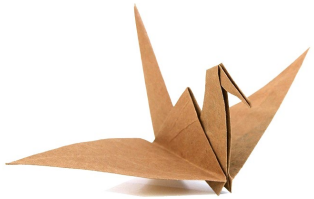
How to Become Famous (with Organic Chemistry)

Alternative Folding Patterns:







2 + ? = 4

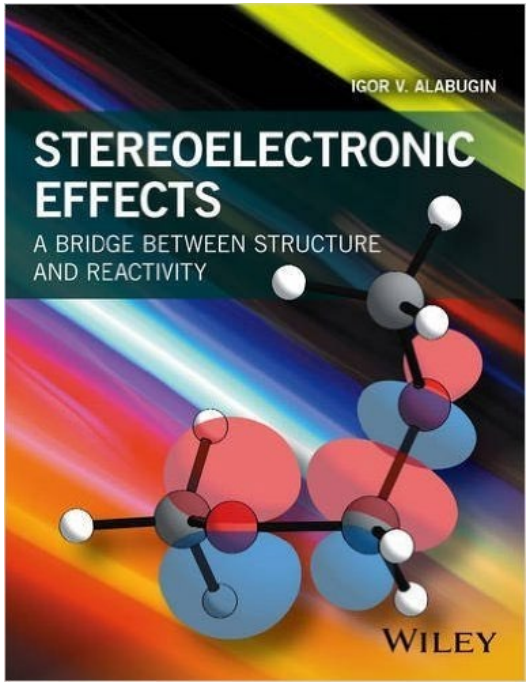
Igor Alabugin,
Florida State University,

July 23, 2024

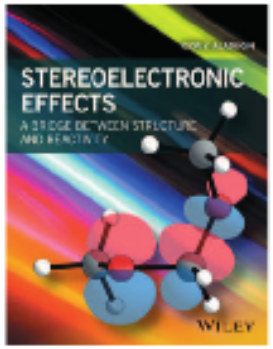
The main questions of chemistry:

How to make a bond?

How to break a bond?



GDCh **Books**



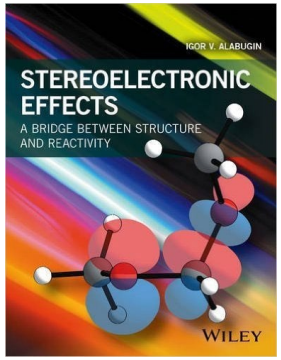
Stereoelectronic Effects
A Bridge between Structure and Reactivity
By Igor V. Alabugin. John Wiley and Sons, Hoboken 2016. 392 pp., softcover

Stereoelectronic Effects

Obviously, a profound knowledge of structures, energies, and reactivities of chemical compounds is essential for every chemist, and stereoelectronic effects have a significant influence on these factors. In this book, Igor Alabugin, a widely acknowledged expert in this field, gives an up-to-date and comprehensive overview of this topic with a strong focus on organic chemistry. The relevance of these stabilizing effects,

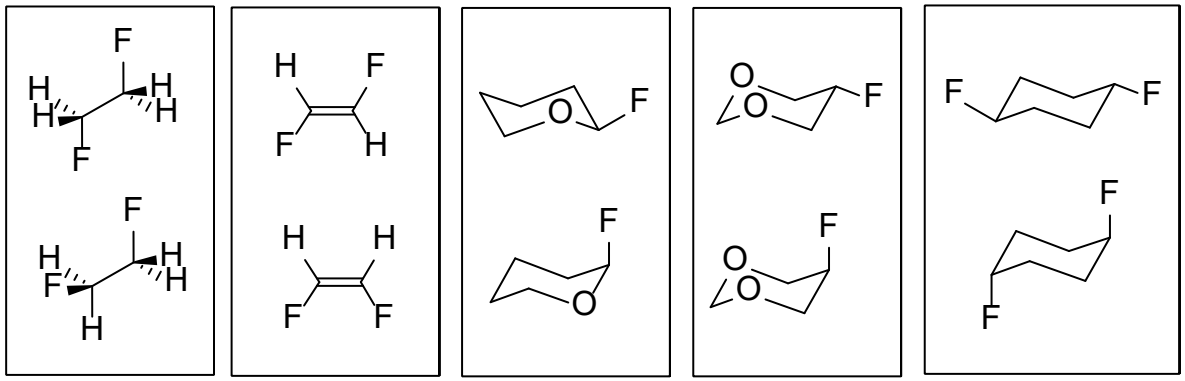
"This book is highly recommended to every chemist and particularly to every student…" *Angew. Chem. Int. Ed*. **2017**, *56*, 2.

How not to be wrong

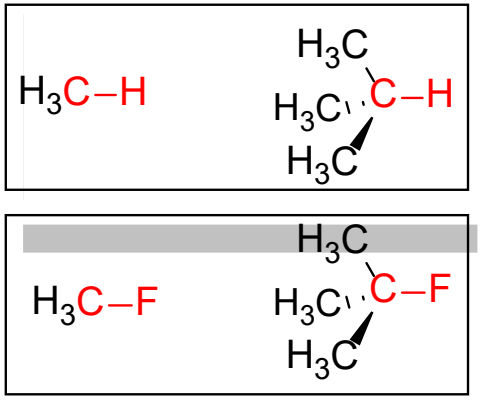


Let's take a quiz!

Circle the more stable structure in these pairs

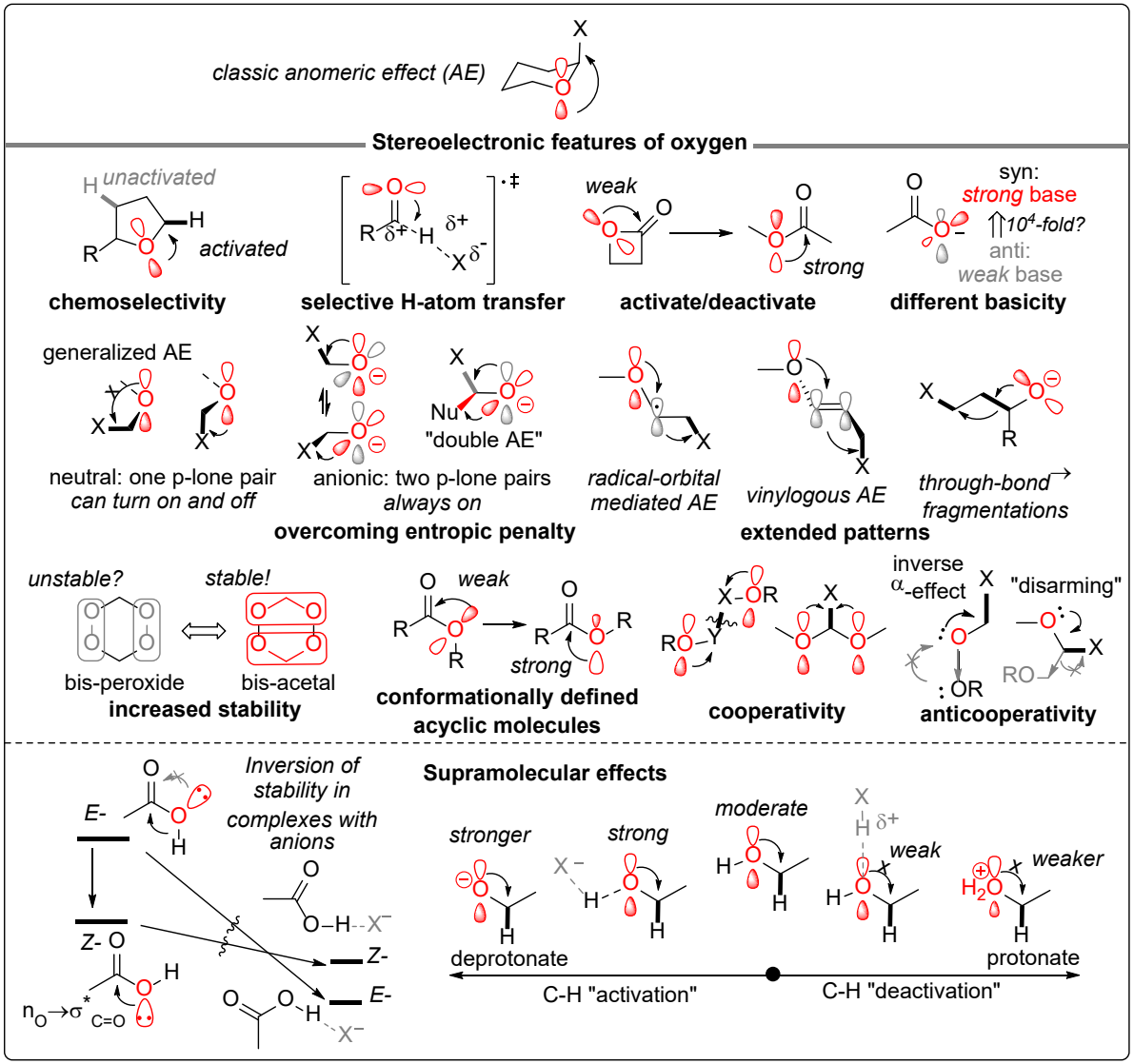


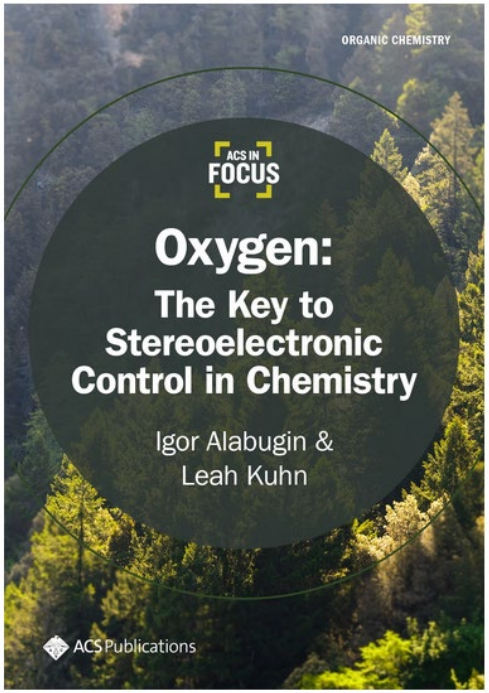
Circle the stronger bond in the two pairs



Everything you need to know about oxygen in organic molecules

Leah Kuhn



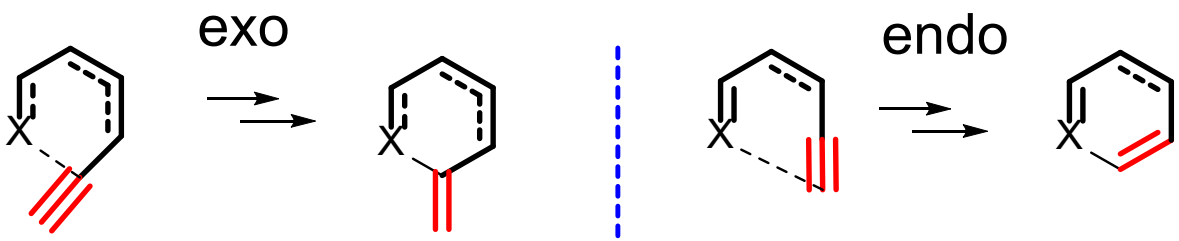


Back-to-back 2021 papers in Chem. Soc. Reviews (impact factor =55):

1. Anomeric Effect, Hyperconjugation and Electrostatics: Lessons from Complexity in a Classic Stereoelectronic Phenomenon.
2. Stereoelectronic Power of Oxygen in Control of Chemical Reactivity: the Anomeric Effect is not Alone

Choosing the right path for alkyne cyclizations

solved



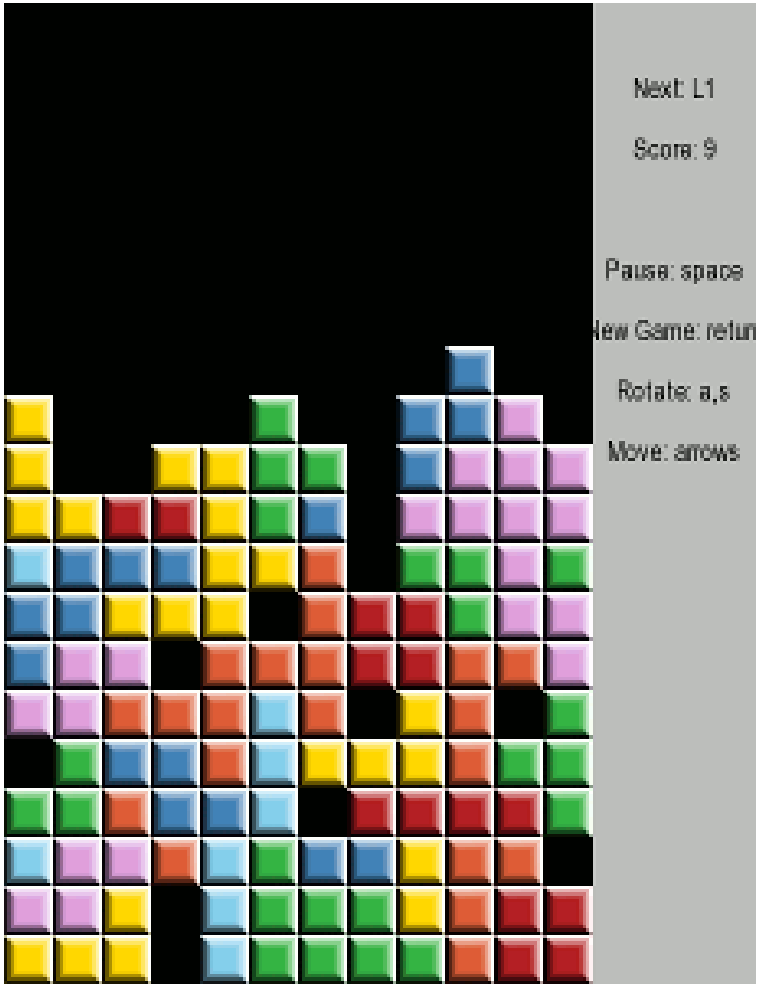
Stereoelectronic analysis supports exo-selectivity for radical cyclizations

For "endo" cyclizations, stereoelectronic requirements need to be reversed (e.g., "LUMO umpolung" in EPNCs etc)

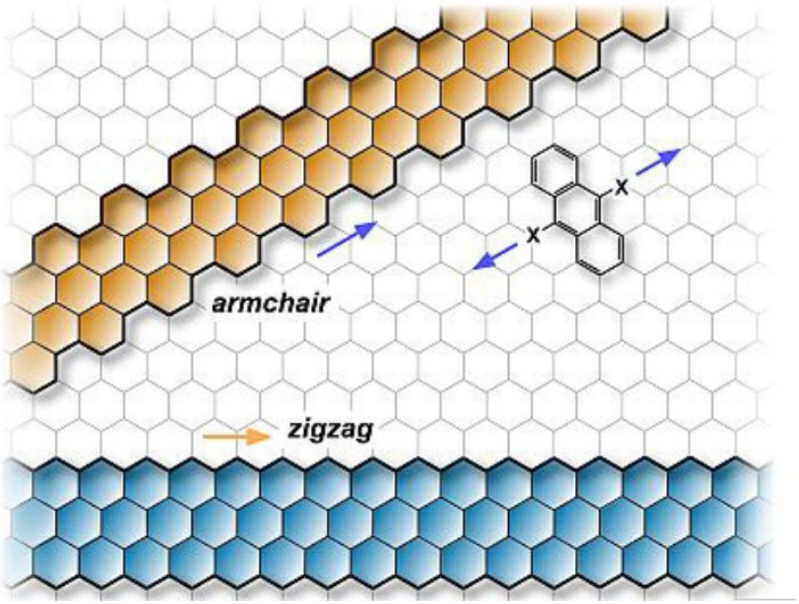
Kerry Gilmore, University of Connecticut (2020 ACS Green Chemistry Award)

TITLE	CITED BY	YEAR
Cyclizations of alkynes: revisiting Baldwin's rules for ring closure K Gilmore, IV Alabugin Chemical Reviews 111 (11), 6513-6556	554	2011
Rules for anionic and radical ring closure of alkynes IV Alabugin, K Gilmore, M Manoharan Journal of the American chemical society 133 (32), 12608-12623	181	2011
Finding the right path: Baldwin "Rules for Ring Closure" and stereoelectronic control of cyclizations IV Alabugin, K Gilmore Chemical Communications 49 (96), 11246-11250	171	2013

Playing Molecular Tetris - mostly with hexagons



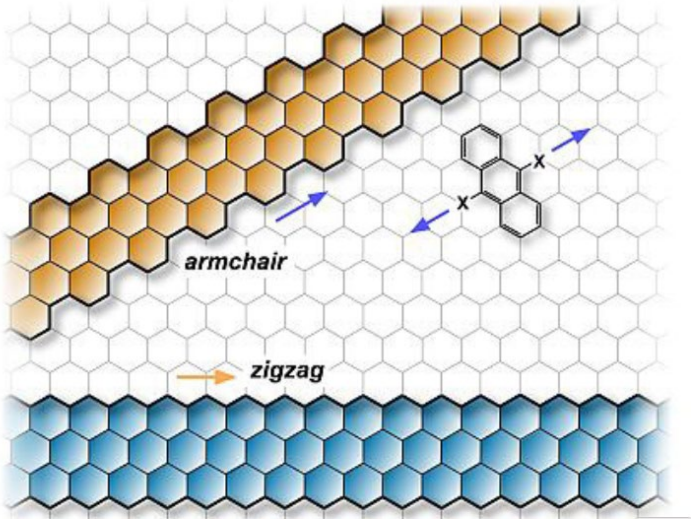
Cyclic molecules can force desired electron delocalization patterns: by organizing space, we can organize energy



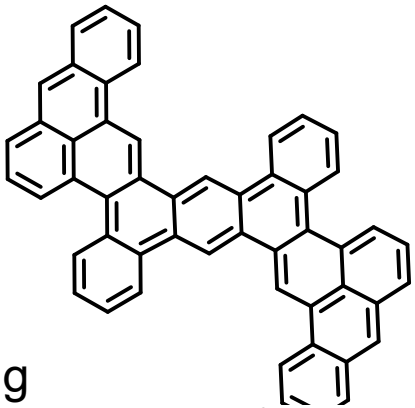
Müllen, Fasel and coworkers.
Nature, 531, 489–492, **2016**

There is more than one way to “cut” graphene into interesting substructures. This can be useful as long as we can make these substructures with precise control of shapes and sizes

What can we make with hexagons?

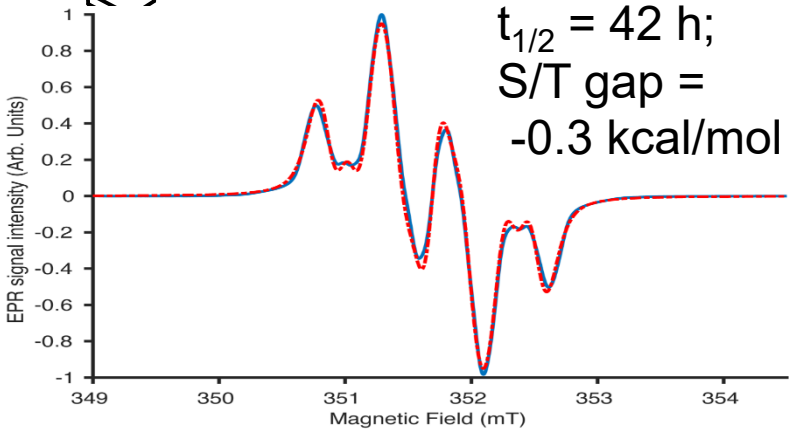


No need to go far to find something unusual



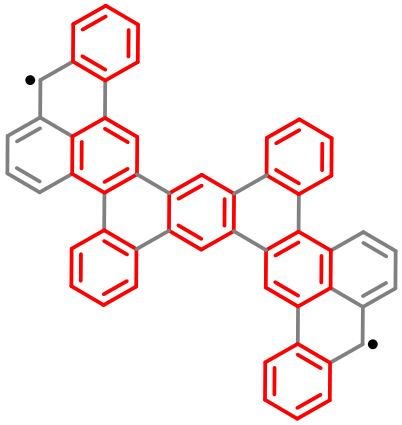
Has no NMR signals

… but shows an EPR signal



$t_{1/2}$ = 42 h;
S/T gap =
-0.3 kcal/mol

Beginning of new technologies – as long as we can make these structures with precise control of shapes and sizes



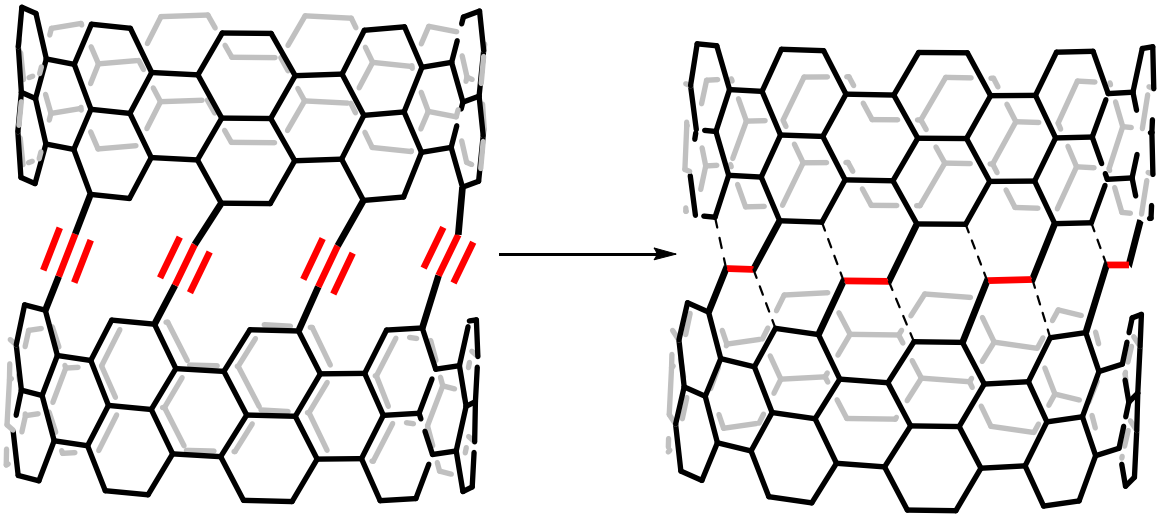
Febin Kuriakose

Michael Commodore

Kuriose, Commodore et al. *J. Amer. Chem. Soc*. **2022**, 23448. https://pubs.acs.org/doi/10.1021/jacs.2c09637

Radicals and alkynes – a perfect combination?

Neutral reactive intermediates + carbon-rich high-energy functionality = fewer problems with overoxidation/ fewer hydrogens to remove

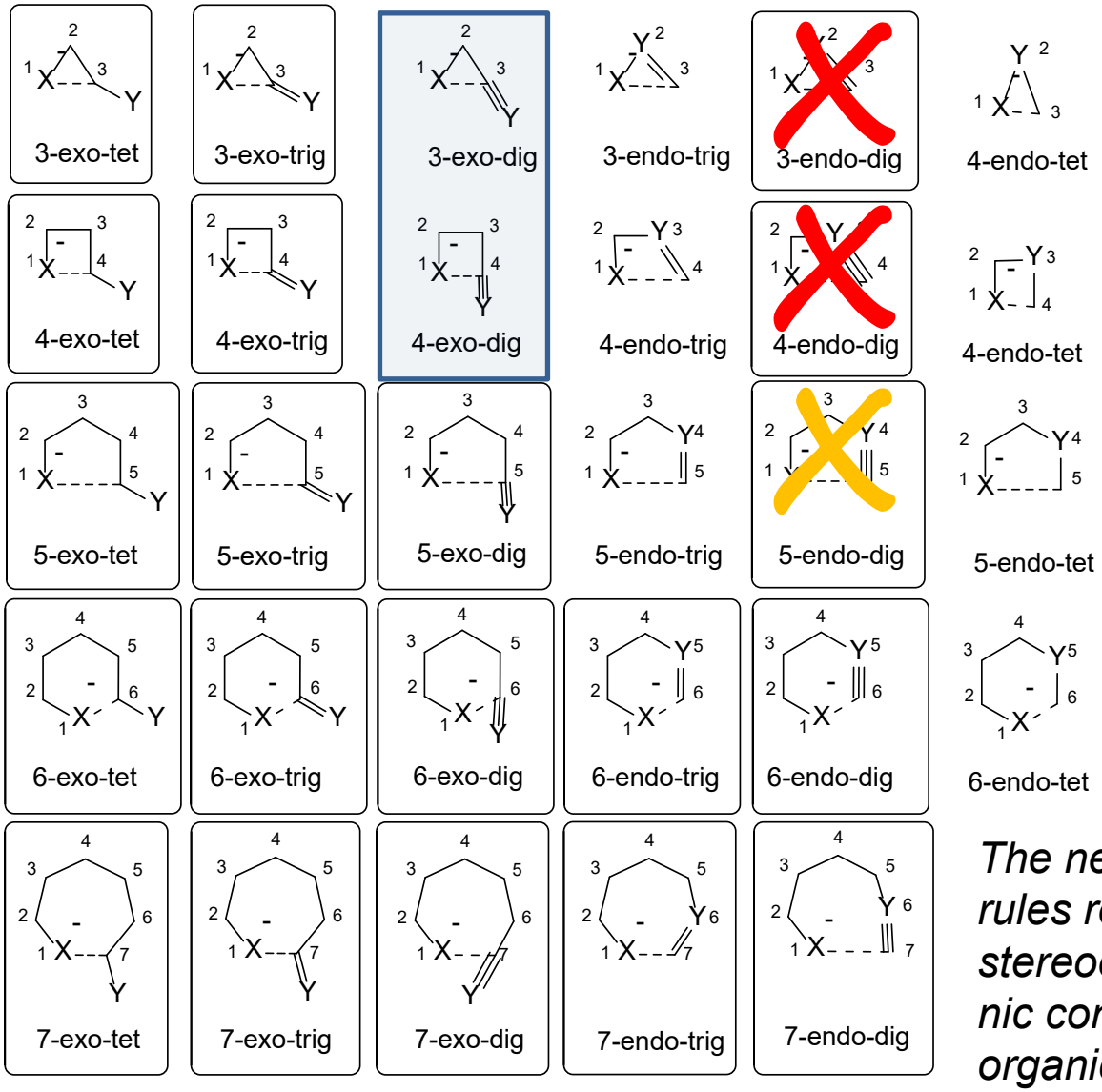


Two challenges –

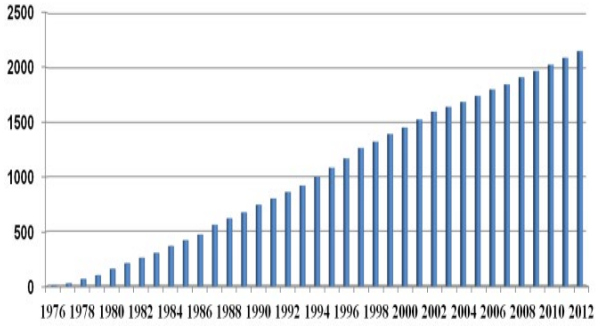
1) understanding how alkynes can be used to form a cycle
2) understanding how radicals can be used efficiently and selectively in alkyne reactions

Mohamed, Mondal, Guerrera, Eaton, Albrecht-Schmitt, Shatruk, Alabugin, *ACIE,* **2016**, *55*, 12054

Refined cyclization rules (Baldwin rules)

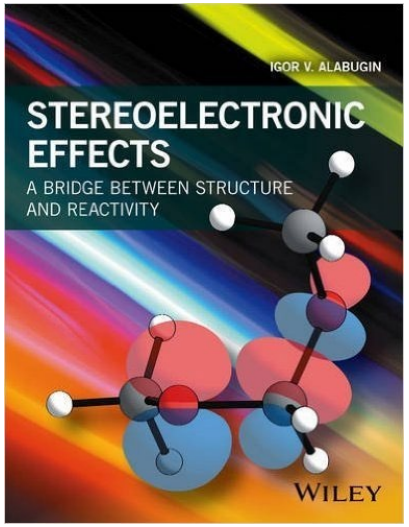


Citations for the "Rules for Ring Closure" (1976-2012) – *the most cited paper in the first 40 years of ChemComm*



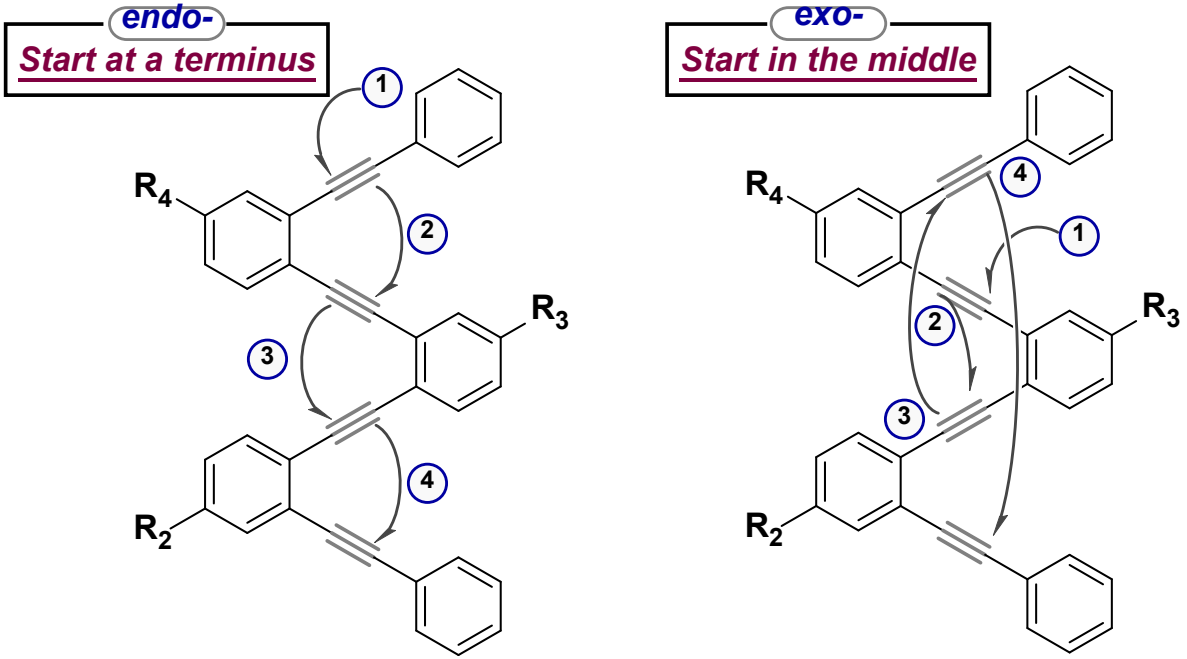
Baldwin, *Chem. Commun.* **1976**, 734

The new rules reflect stereoelectronic control of organic reactivity



Let's add aromatic spacers to oligoalkynes

Alternative Folding Patterns:



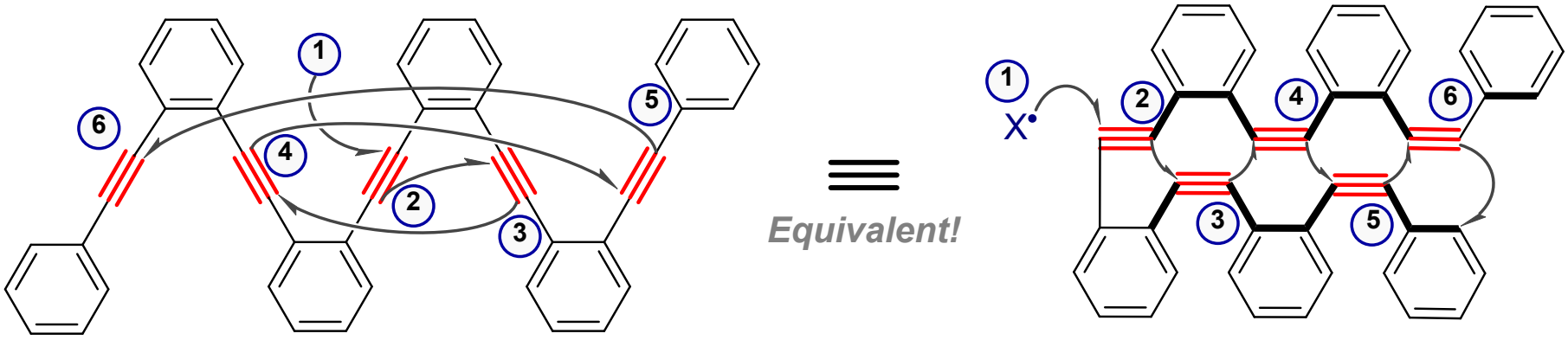
Which of the two "alkyne origami" patterns to choose?

Topogically:
endo is preferred

Stereoelectronically:
Exo is preferred

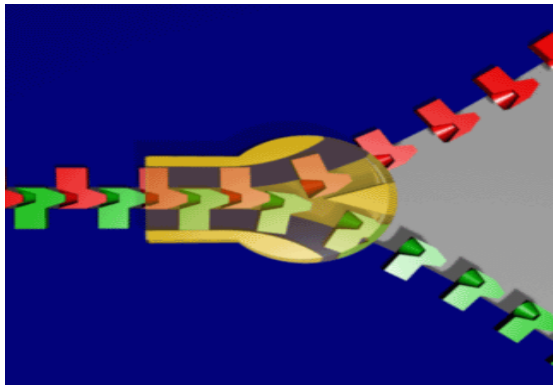
“To bend or not to bend”: Simplifying the analysis of alkyne folding

The “all-exo” cascade

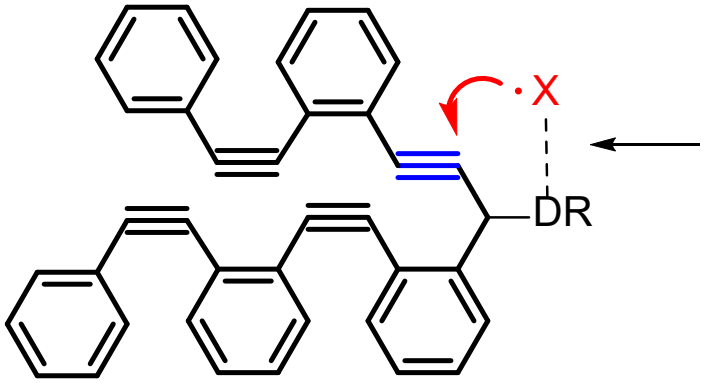


The "bent alkyne" representation simplifies analysis of oligoalkyne folding into an aromatic ribbon

Can we make a polyacetylene chain between two rows of benzenes with this radical “polymerization”?



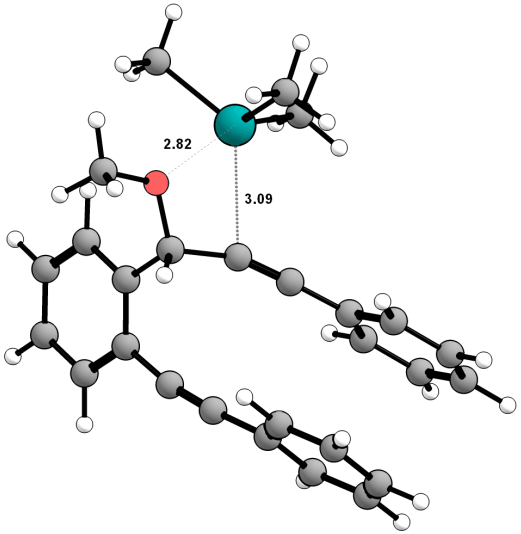
"Directing groups" for intermolecular control of reactivity?



What is the right combination that will create a transient but effective supramolecular X…DR "bond"?

DR= directing group

Gabriel dos Passos Gomes



O…Sn interaction

K. Pati, **G. Gomes**, T. Harris, A. Hughes, H. Phan, T. Banerjee, K. Hanson, I. Alabugin, *J. Am. Chem. Soc.*, **2015**, 1165.

How many papers will you publish in grad school?

- S. Umedu, **G. P. Gomes**, M. Sakae, T. Yoshinaga, K. Matsumoto, T. Iwata, I. Alabugin, M. Shindo "Regioselective One-pot Synthesis of Triptycenes via Triple-Cycloadditions of Arynes to Ynolates" *Angew. Chem. Int. Ed.*, **2016**, *56*, 1298 (featured on: • *Synfacts* **2017**, *13 (03)*, 253 "Three Benzynes and the Ynolate", doi: 10.1055/s-0036-1590046)
- S. Z. Vatsadze, Y. Loginova, **G. P. Gomes**, I. V. Alabugin "Stereoelectronic Chameleons: The Reversal of Donor-Acceptor Properties of Common Functional Groups by a Geometric Change" *Chem. Eur. J.*, **2016**, *23*, 3225 (*Frontspiece of Chemistry – A European Journal*, doi: 10.1002/chem.201781461)
- K. Pati, **G. P. Gomes**, I. V. Alabugin "Combining Traceless Directing Groups with Hybridization Control of Radical Reactivity: from Skipped Enynes to Defect-Free Hexagonal Frameworks" *Angew. Chem. Int. Ed.*, **2016**, *55*, 11633
- T. Harris, **G. P. Gomes**, R. Clark, I. V. Alabugin, "Domino Fragmentations in Traceless Directing Groups of Radical Cascades: Evidence for the Formation of Alkoxy Radicals via C-O Scission" *J. Org. Chem.*, **2016**, *81 (14)*, 6007 (featured on: • *sciencing.net*)
- K. Pati, **G. P. Gomes**, T. Harris, I. V. Alabugin "Fused Catechol Ethers from Gold (I)-Catalyzed Intramolecular Reaction of Propargyl Ethers with Acetals" *Org. Lett.*, **2016**, *18 (5)*, 928
- **G. P. Gomes**, V. A. Vil', A. Terent'ev and I. V. Alabugin, "Stereoelectronic Source of the Anomalous Stability of Bis-peroxides", *Chem. Sci.*, **2015**, *6*, 6783 (featured on: • *Chemistry World*; • NBO's features website; • chem.fsu.edu/News)
- K. Pati, **G. P. Gomes**, T. Harris, A. Hughes, H. Phan, T. Banerjee, K. Hanson, I. V. Alabugin "Traceless Directing Groups in Radical Cascades: From Oligoalkynes to Fused Helicenes without Tethered Initiators" *J. Am. Chem. Soc.*, **2015**, *137*, 1165
- I. V. Alabugin, S. Bresch, **G. P. Gomes** "Orbital Hybridization: A Key Electronic Factor in Control of Structure And Reactivity" *J. Phys. Org. Chem.*, **2014**, *28*, 147 (one of the *most accessed* papers on: • *JPOC* between 10/2015-09/2016 & 02/2016-08/2017 • department's most read paper on *ResearchGate* in October–November 2017; featured on: • *amphoteros.com*)

How many papers will you publish in grad school?

- **11.** S. Umedu, **G. P. Gomes**, M. Sakae, T. Yoshinaga, K. Matsumoto, T. Iwata, I. Alabugin, M. Shindo "Regioselective One-pot Synthesis of Triptycenes via Triple-Cycloadditions of Arynes to Ynolates" *Angew. Chem. Int. Ed.*, **2016**, *56*, 1298 (featured on: • *Synfacts* **2017**, *13 (03)*, 253 "Three Benzynes and the Ynolate", doi: 10.1055/s-0036-1590046)
- **10.** S. Z. Vatsadze, Y. Loginova, **G. P. Gomes**, I. V. Alabugin "Stereoelectronic Chameleons: The Reversal of Donor-Acceptor Properties of Common Functional Groups by a Geometric Change" *Chem. Eur. J.*, **2016**, *23*, 3225 (*Frontspiece of Chemistry – A European Journal*, doi: 10.1002/chem.201781461)
- **9.** K. Pati, **G. P. Gomes**, I. V. Alabugin "Combining Traceless Directing Groups with Hybridization Control of Radical Reactivity: from Skipped Enynes to Defect-Free Hexagonal Frameworks" *Angew. Chem. Int. Ed.*, **2016**, *55*, 11633
- **8.** T. Harris, **G. P. Gomes**, R. Clark, I. V. Alabugin, "Domino Fragmentations in Traceless Directing Groups of Radical Cascades: Evidence for the Formation of Alkoxy Radicals via C-O Scission" *J. Org. Chem.*, **2016**, *81 (14)*, 6007 (featured on: • *sciencing.net*)
- **6.** K. Pati, **G. P. Gomes**, T. Harris, I. V. Alabugin "Fused Catechol Ethers from Gold (I)-Catalyzed Intramolecular Reaction of Propargyl Ethers with Acetals" *Org. Lett.*, **2016**, *18 (5)*, 928
- **5.** **G. P. Gomes**, V. A. Vil', A. Terent'ev and I. V. Alabugin, "Stereoelectronic Source of the Anomalous Stability of Bis-peroxides", *Chem. Sci.*, **2015**, *6*, 6783 (featured on: • *Chemistry World*; • NBO's features website; • chem.fsu.edu/News)
- **2.** K. Pati, **G. P. Gomes**, T. Harris, A. Hughes, H. Phan, T. Banerjee, K. Hanson, I. V. Alabugin "Traceless Directing Groups in Radical Cascades: From Oligoalkynes to Fused Helicenes without Tethered Initiators" *J. Am. Chem. Soc.*, **2015**, *137*, 1165
- **1.** I. V. Alabugin, S. Bresch, **G. P. Gomes** "Orbital Hybridization: A Key Electronic Factor in Control of Structure And Reactivity" *J. Phys. Org. Chem.*, **2014**, *28*, 147 (one of the *most accessed* papers on: • *JPOC* between 10/2015-09/2016 & 02/2016-08/2017 • department's most read paper on *ResearchGate* in October–November 2017; featured on: • *amphoteros.com*)

How many papers will you publish in grad school?

- **25. G. P. Gomes** & I. V. Alabugin "Stereoelectronic Effects: Analysis by Computational and Theoretical Methods", chapter 15 for the book "Applied Theoretical Organic Chemistry" Editor: Prof. Dean Tantillo (UC-Irvine), **2018**.
- **23.** N. P. Tsvetkov, E. Gonzalez-Rodriguez, A. Hughes, **G. P. Gomes**, F. D. White, I. V. Alabugin "Radical Alkyne Peri-annulations for Synthesis of Functionalized Phenalenes, Benzanthrenes, and Olympicene", *Angew. Chem. Int. Ed.,* **2018**, *in print*, doi: 10.1002/anie.201712783 (• *Top 5% of ACIE's output*. Featured on *FSU News*, *reproduced on:* • *phys.org;* • *nsf.gov/news;* • *sciencedaily.com;* • *EurekAlert!*)
- **22.** V. A. Vil', **G. P. Gomes**, O. V. Bityukov, M. A. Syroeshkin, K. A. Lyssenko, G. I. Nikishin, I. V. Alabugin. A. O. Terent'ev "Interrupted Baeyer-Villiger Rearrangement: Building A Stereoelectronic Trap for the Criegee Intermediate", *Angew. Chem. Int. Ed.,* **2018**, *in print*, doi: 10.1002/anie.201712651. (• *Top 5% of ACIE's output*. Featured on: • *Chemical & Engineering News*)
- **20.** C. J. Evoniuk, **G. P. Gomes,** S. Hill, F. Satoshi, I. V. Alabugin "Coupling C-H activation, N-H deprotonation and Oxidation: metal-free C(sp^3)-H aminations with unprotected anilines" *J. Am. Chem. Soc.*, **2017**, *139 (45),* 16210 (featured on: • *Synfacts* **2018**, *14 (02),* 144 "Expanded N-Heterocycles through C(sp^3)–H Amination"; • in the top 20 most-read *JACS* papers in Oct-Nov 2017)
- **19.** T. Harris, **G. P. Gomes**, R. Clark, S. Ayad, V. V. Lobodin, K. Hanson, I. V. Alabugin "Twisted chiral cyclodecynes and remote activation of click reactivity" *Chem*, **2017**, *3 (4),* 629 (• *video-summary of the paper.* Featured on: • *FSU News*)
- **18.** N. H. Park, **G. P. Gomes**, M. Fevre, G. O. Jones, I. V. Alabugin, J. L. Hedrick, "Organocatalyzed Synthesis of Fluorinated Poly(aryl thioethers)" *Nature Communications*, **2017**, *8,* 166; (a collaboration *with IBM Research, San Jose*, *CA*. Featured on: • *Plastic News*; • *Synfacts* **2017**, *13 (10),* 1035 "Salt-Free Polymerization Yields Fluorinated Poly(aryl thioether)s")
- **17.** E. Juaristi, **G. P. Gomes**, A. O. Terent'ev, R. Notario, I. V. Alabugin "Stereoelectronic Interactions as a Probe for the Existence of the Intramolecular α-Effect", *J. Am. Chem. Soc.*, **2017**, *139 (31),* 10799
- **15. G. P. Gomes**[§]**,** C. J. Evoniuk[§], M. Ly, I. V. Alabugin "Changing the path of least resistance, or access to *endo*-dig products *via* a sequence of three *exo*-trig transition states: electronic effects in homoallyic ring expansion cascades of alkenyl isonitriles" *Org. Biom. Chem.*, **2017**, *15,* 4135
- **13. G. P. Gomes**[§], Y. A. Yaremenko[§], P. S. Radulov, R. A. Novikov, V. V. Chernyshev, A. A. Korlyukov, G. I. Nikishin, A. O. Terent'ev, I. V. Alabugin "Stereoelectronic Control in the Ozone-Free Synthesis of Ozonides" *Angew. Chem. Int. Ed.*, **2017**, *56,* 4955
- **12. G. P. Gomes** & I. V. Alabugin "Drawing Catalytic Power from Charge Separation: Stereoelectronic and Zwitterionic Assistance in the Au(I)-Catalyzed Bergman Cyclization" *J. Am. Chem. Soc.*, **2017**, *139 (9),* 3406

Less than four years since starting his PhD

How many papers will you publish in grad school?

32-42…Were also published (one more is under review)

31. A. Hughes, **G. P. Gomes**, I. V. Alabugin, Stereoelectronic Influence of a "Spectator" Propargylic Substituent Can Override Aromaticity Effects in Radical Peri-cyclizations on Route to Expanded Polyaromatics, *J. Org. Chem*., **2019**, *84*, 1853

30. CO_2 or SO_2: Should it stay or should it go? Gomes, G.; Wimmer, A.; Smith, J.; König, B.; Alabugin, I.V. *J. Org. Chem.*, **2019**, *84*, 6232-6243.

29. V. A. Vil', **G. P. Gomes**, M. V. Ekimova, K. A. Lyssenko, G. I. Nikishin, I. V. Alabugin, A. O. Terent'ev "From transient Bayer-Villiger (Criegee) intermediate to stable peroxides: BF3-catalyzed synthesis of β-hydroperoxy-β-peroxylactones from five different types of substrates", *J. Org. Chem.*, **2018**, *83,* 13427–13445

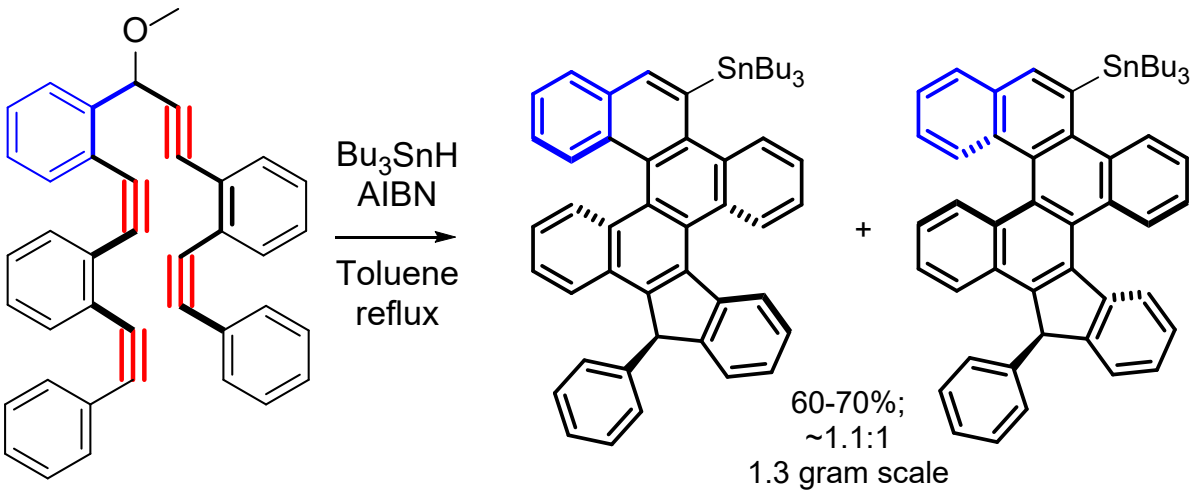
28. G. P. Gomes, Y. Loginova, S. Z. Vatsadze, I. V. Alabugin "Isocyanides as Stereoelectronic Chameleons: The Donor-Acceptor Dichotomy in Radical Additions", *J. Am. Chem. Soc.* **2018***, 140,* 14272-14288.

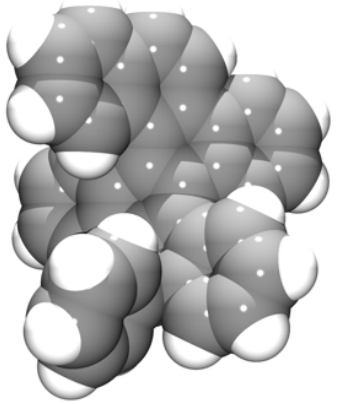
27. G. P. Gomes, A. E. Morrison, G. B. Dudley, I. V. Alabugin "Optimizing amine-mediated alkyne-allene isomerization to improve benzannulation cascades: synergy between theory and experiments", *Eur. J. Org. Chem.*, **2019**, *512-518*.

26. I. V. Alabugin**, G. P. Gomes**, M. Abdo, "Hyperconjugation", *WIREs Comput. Mol. Sci.*, **2019**, doi/full/10.1002/wcms.1389.

Non-planar aromatics from skipped alkynes

Helicenes:





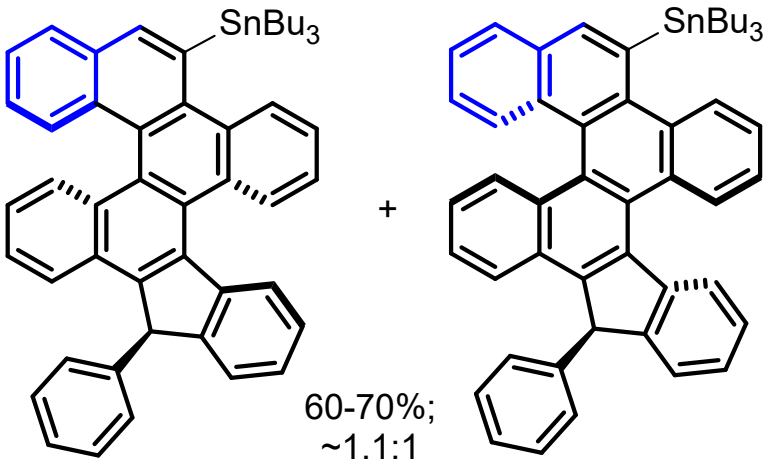
enantiomerically pure crystals

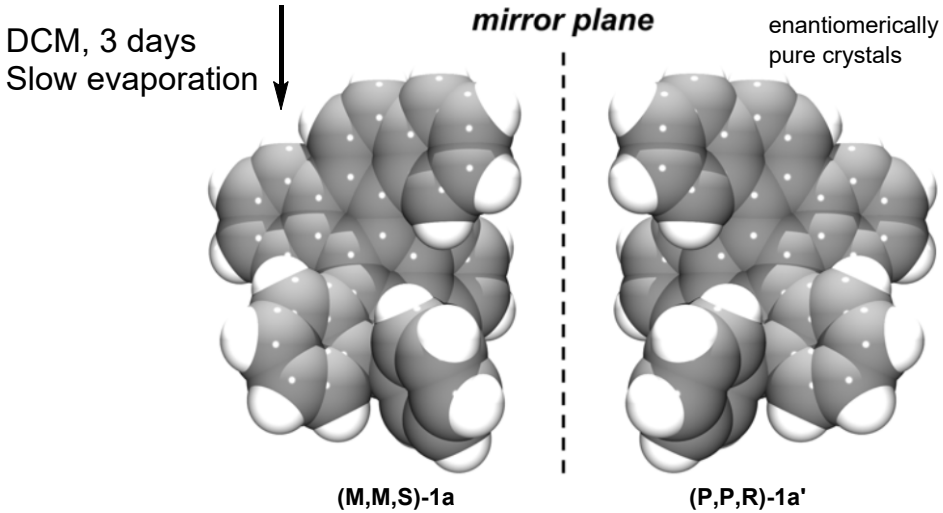
Pati, K.; Gomes, G. P.; Harris, T.; Hughes, A.; Phan, H.; Banerjee, T.; Hanson, K.; Alabugin, I. V. *JACS,* **2015**, 1165.

More on why this cascade works so well:

Design principles of the use of alkynes in radical cascades. C. Hu, J. Mena, I.V. Alabugin, *Nature Reviews Chemistry*, **2023**, https://www.nature.com/articles/s41570-023-00479-w.

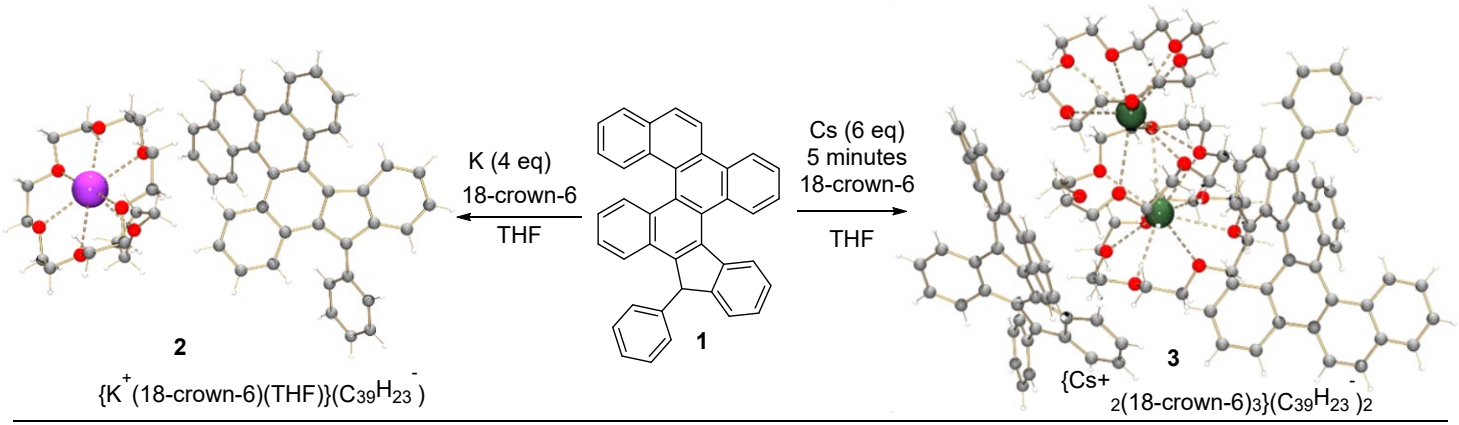
Fun with helicenes: how to make graphene chiral?

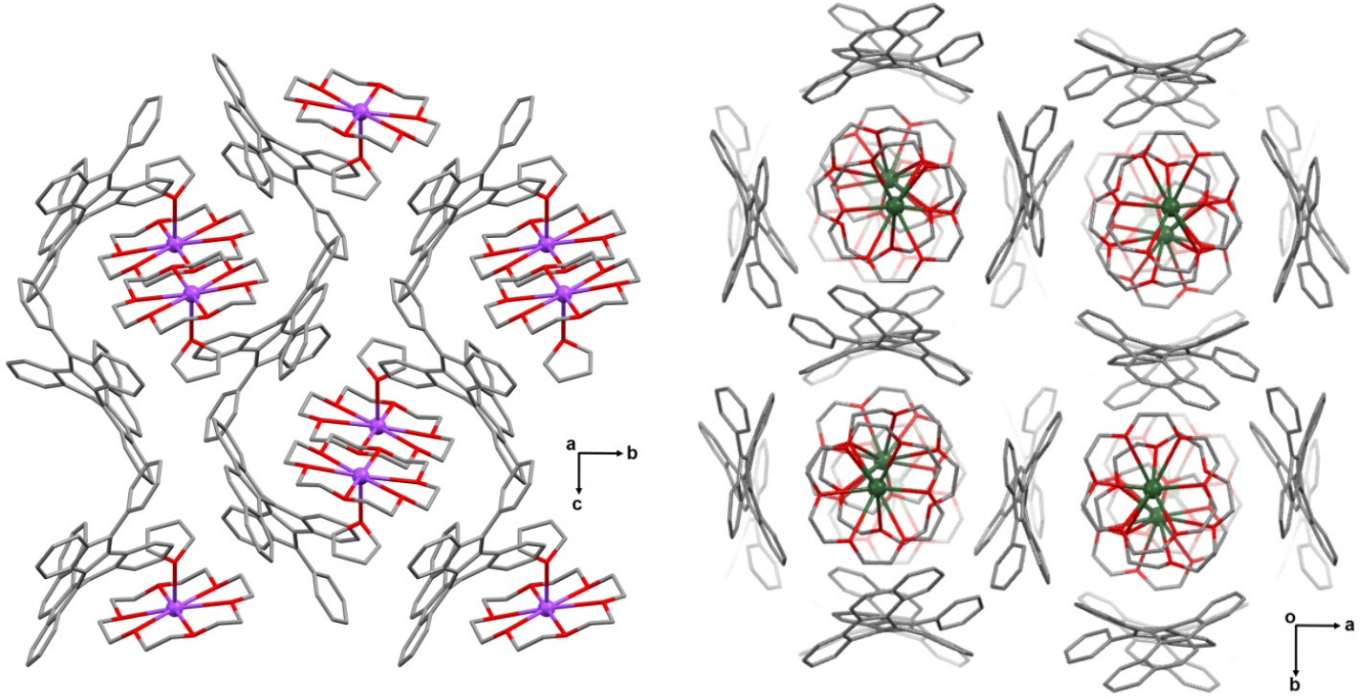




Zheng Zhou, Rahul Kisan Kawade, Renana Gershoni-Poranne, Zheng Wei, Febin Kuriakose, Marina A. Petrukhina, and Igor V. Alabugin, *Angew.Chem., 2020*

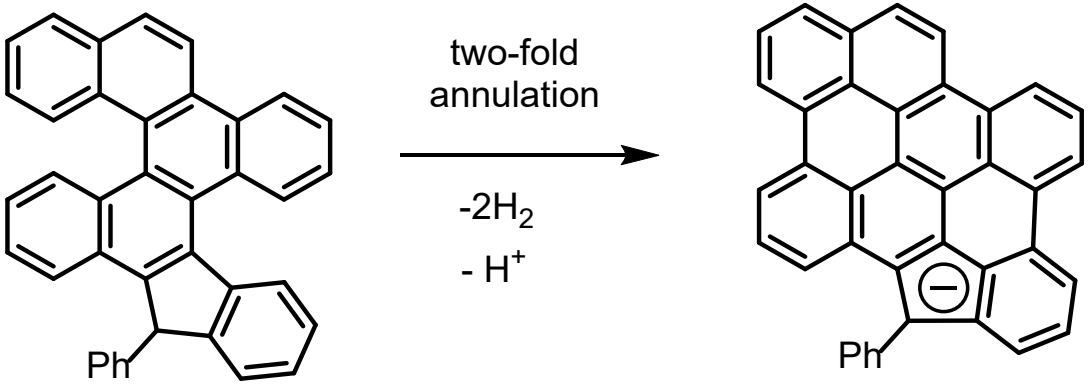
Fun with helicenes: how to make graphene anionic?

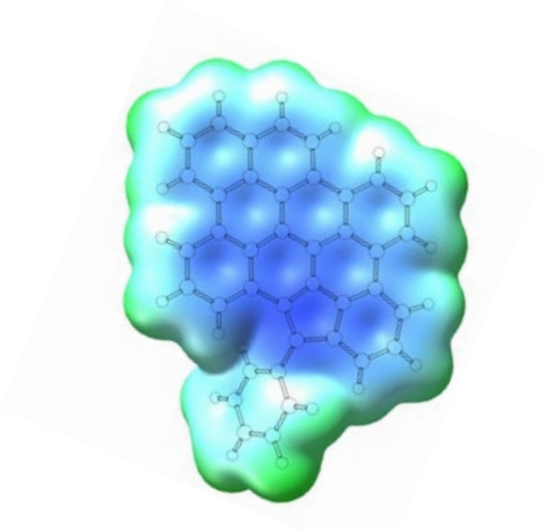


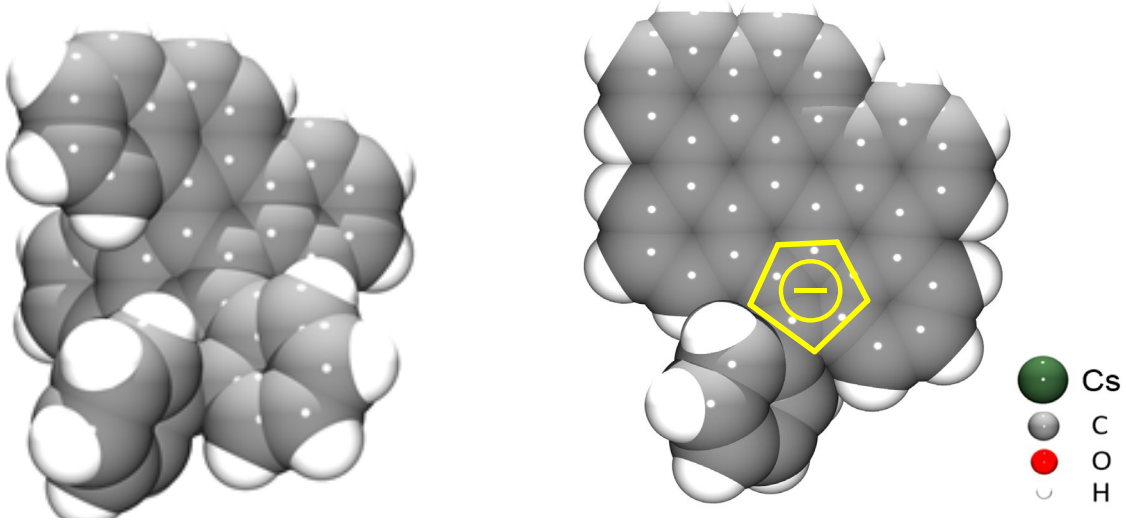


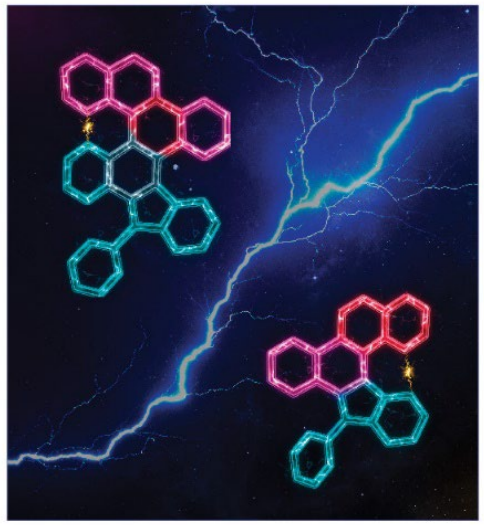
Zheng Zhou, Rahul Kisan Kawade, Renana Gershoni-Poranne, Zheng Wei, Febin Kuriakose, Marina A. Petrukhina, and Igor V. Alabugin, *Angew.Chem., 2020*

Towards a new form of carbon?



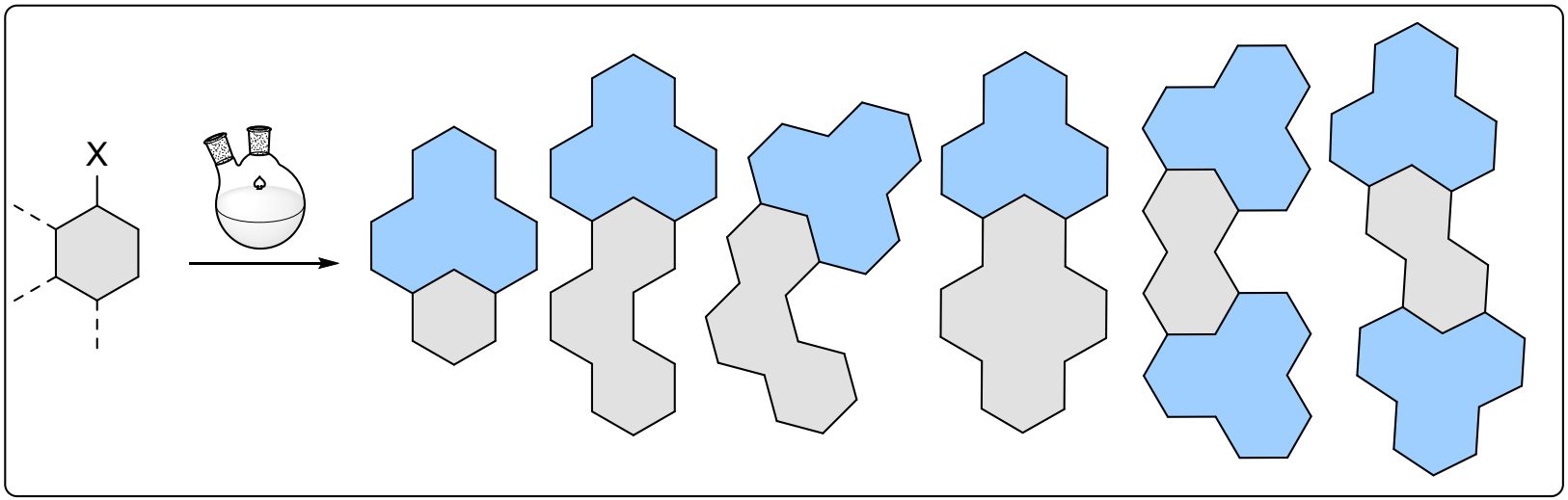






X-ray structures

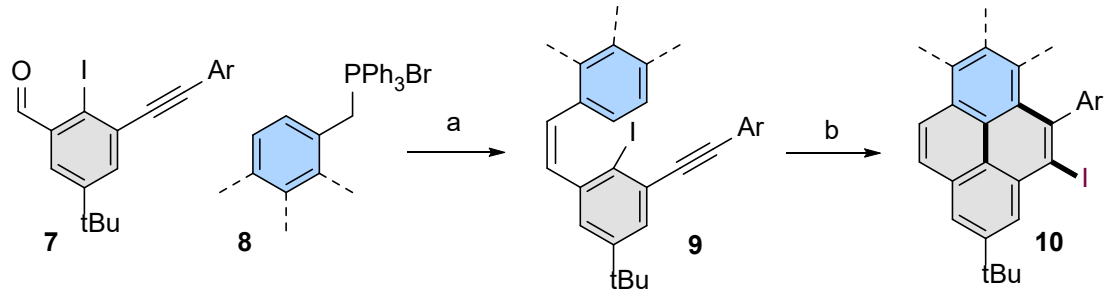
Phenalenannulations: “three-point” double annulation reactions that convert benzenes into pyrenes

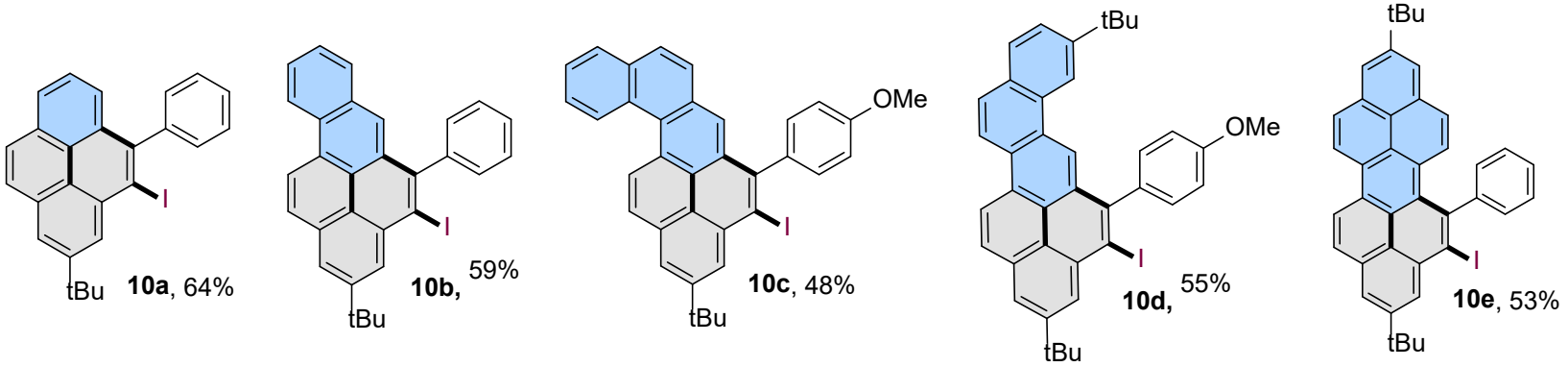


How to build polycyclic structures faster?

Kawade, R. K., Hu, C. W.; Dos Santos N. R., Watson, N., Lin, X., Hanson, K.; Alabugin, I. V. *Angew.Chem. Int. Ed.* **2020**, *59*, 14352-14357.

Scope of 3-point double annulations: design #2





a) KOtBu (1.4 equiv.), THF; b) i) [**9a**] 0.02 M, Bu_3SnH (1.3 equiv.), AIBN (0.3 equiv.), toluene, 90°C, ii) Bu_3SnH (3.0 equiv.), AIBN (2.0 equiv.), 110°C iii) I_2 (5.0 equiv.), DCM; isolated yields are reported from **9** to **10**

Ask Nik Dos Santos how to do it without Bu_3SnH, AIBN and any other chemicals!

Kawade, R. K., Hu, C. W.; Dos Santos N. R., Watson, N., Lin, X., Hanson, K.; Alabugin, I. V. *Angew.Chem. Int. Ed.* **2020**, *59*, 14352-14357

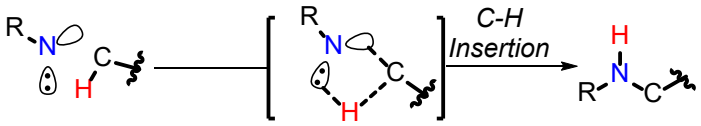
Tired of carbon?
How about a new way to make C-N bonds?

Reinventing C-H aminations

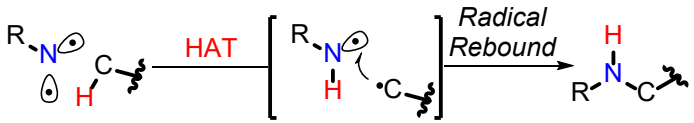
a) Direct Activation

- *Nitrogen is responsible for C-H activation*
- *Nitrogen is responsible for C-N and N-H bond formation*

Singlet Nitrene



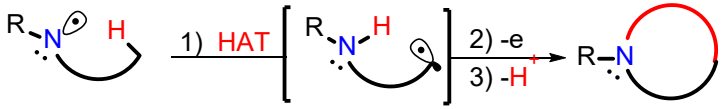
Triplet Nitrene



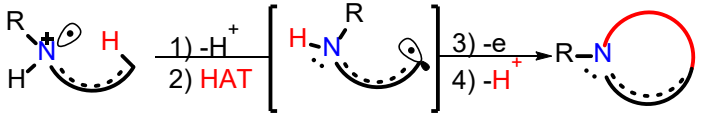
b) C-H Activation with Delayed C-N Bond Formation

- *Nitrogen is responsible for C-H activation*
- *Additional reagent needed for C-N bond formation*
- *Usually, remote intramolecular activation*

Nitrogen Centered Radical



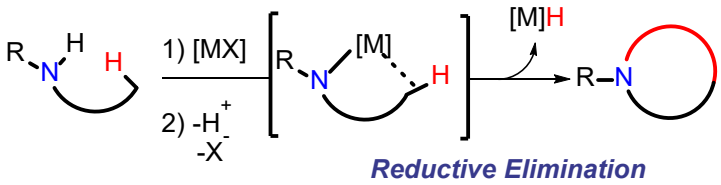
Conjugated Nitrogen Centered Radical Cation



c) Nitrogen-Assisted C-H Activation

- *Nitrogen is not directly involved in C-H activation*
- *Nitrogen may play a secondary role as directing group*

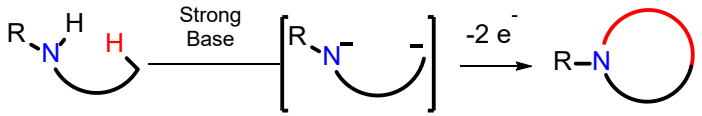
Transition Metal C-H activation



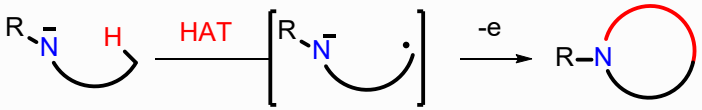
d) Independent N-H/C-H activation

- *Two independently formed reactive intermediates: N- and C-centered*

4iii ***Dianion*** ***"Reductive Elimination without a metal"***



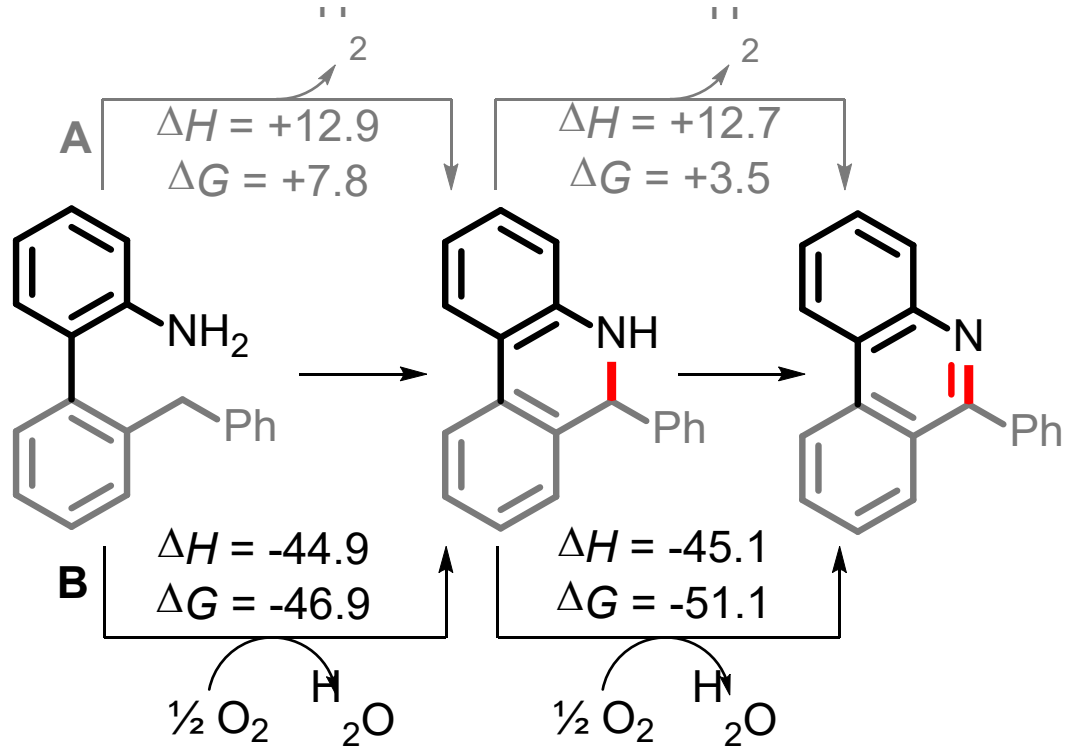
4ii ***Radical-anion*** **This work**



How to fix thermodynamics of C-H aminations

Experiments:
Chris Evoniuk

Calculations:
Gabe Gomes

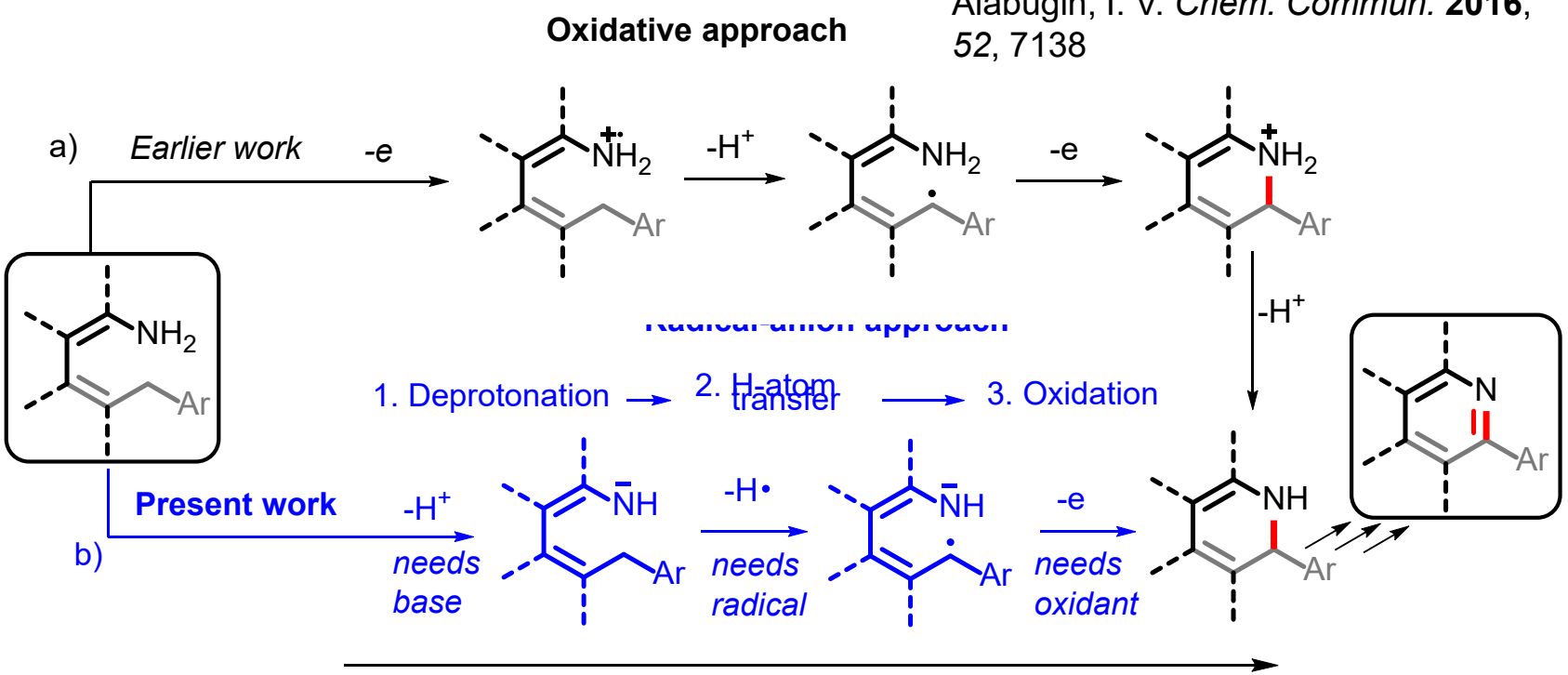


Evoniuk, C. J.; Gomes, G. dos P.; Hill, S. P.; Fujita, S.; Hanson, K.; Alabugin, I.V. *J. Am. Chem. Soc.* **2017**, *139*, 16210

(SMD=DMF)/(U)M06-2X(D3)/6-31+G(d,p)/int=ufine, kcal/mol

A milder approach to C-H aminations: the base/radical/oxidant trio

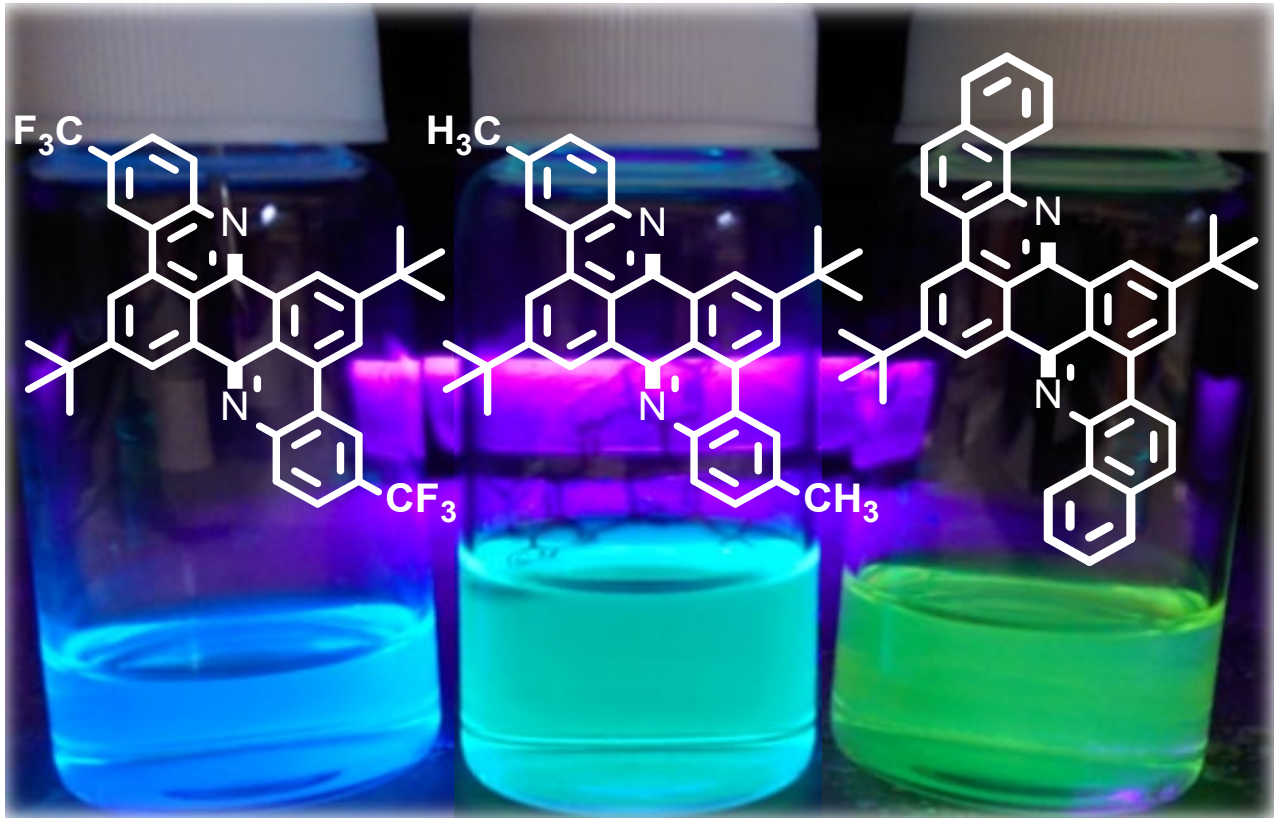
Evoniuk, C. J.; Hill, S. P.; Hanson, K.; Alabugin, I. V. *Chem. Commun.* **2016**, *52*, 7138



Need a build-up of reduction potential

Evoniuk, C. J.; Gomes, G. dos P.; Hill, S. P.; Fujita, S.; Hanson, K.; Alabugin, I.V. *J. Am. Chem. Soc.* **2017**, *139*, 16210

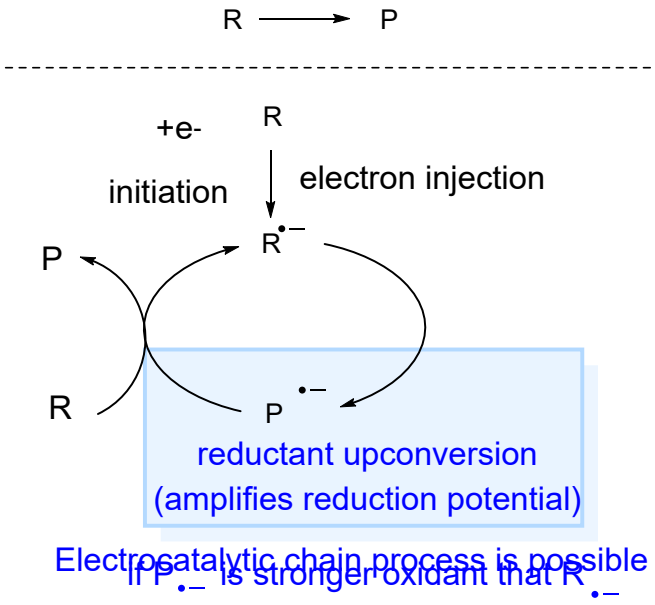
N-heterocycles twist and bend



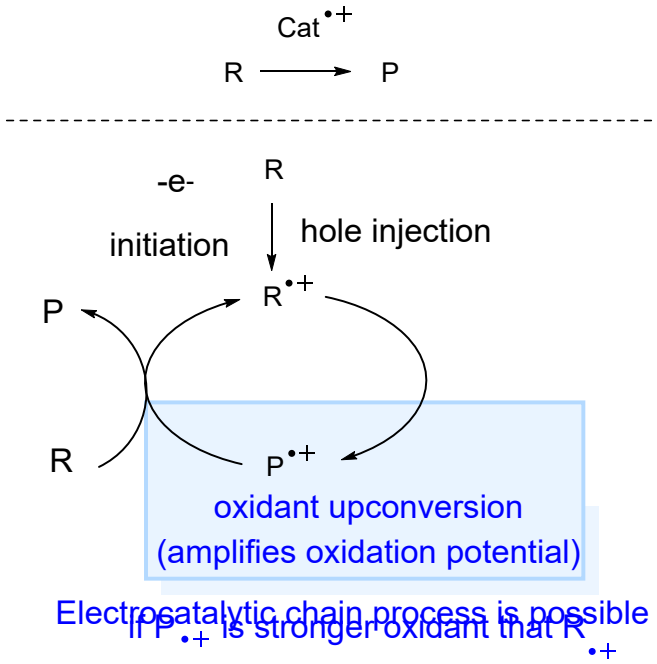
Evoniuk, C. J.; Gomes, G. dos P.; Hill, S. P.; Fujita, S.; Hanson, K.; Alabugin, I.V.
J. Am. Chem. Soc. **2017**, *139*, 16210

What is the smallest possible catalyst?

Electron?

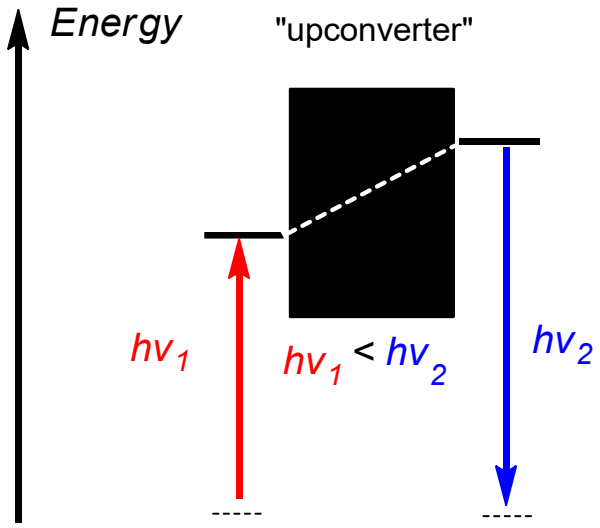


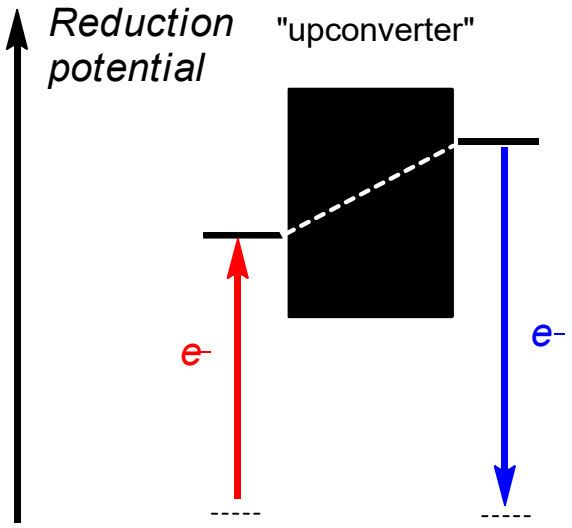
Or hole?



A new concept

Electron upconversion

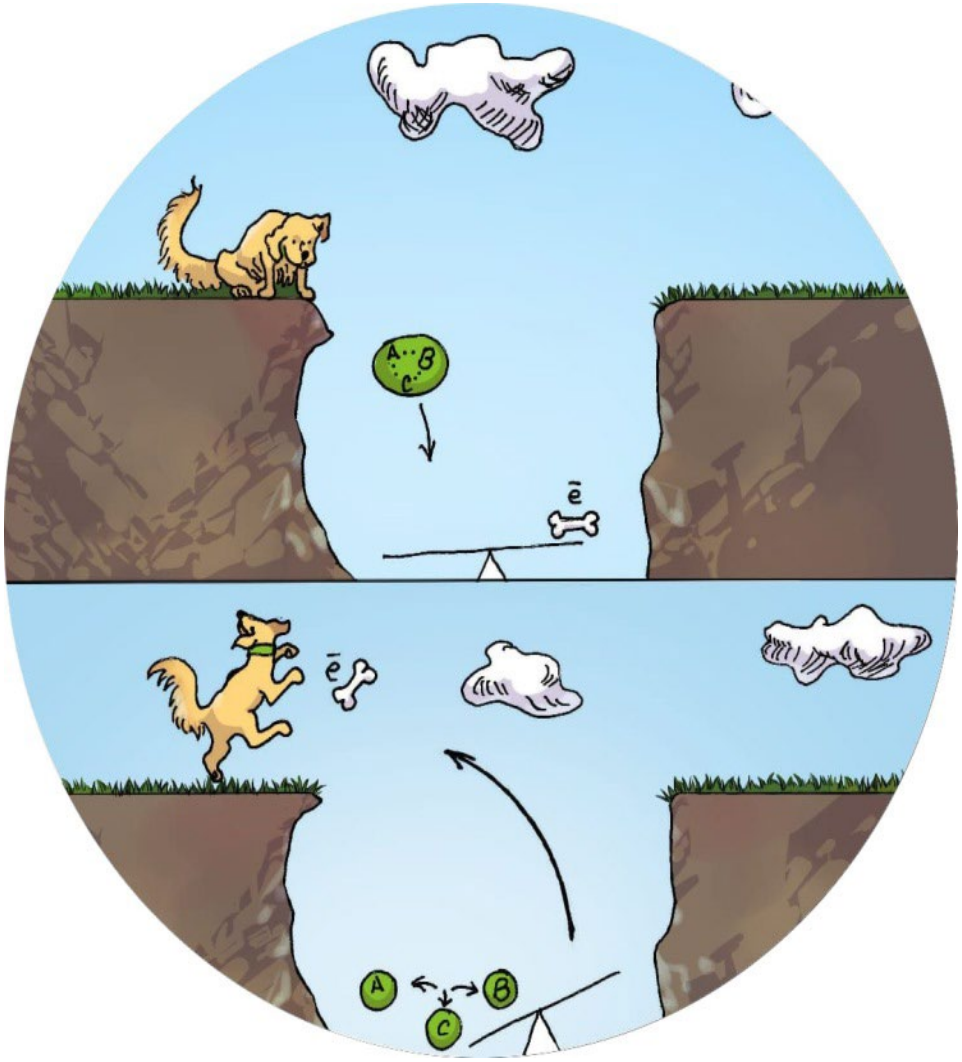




Can we figure out how to build this black box?

Electron upconversion is possible

…and you can be find a way to make it useful!

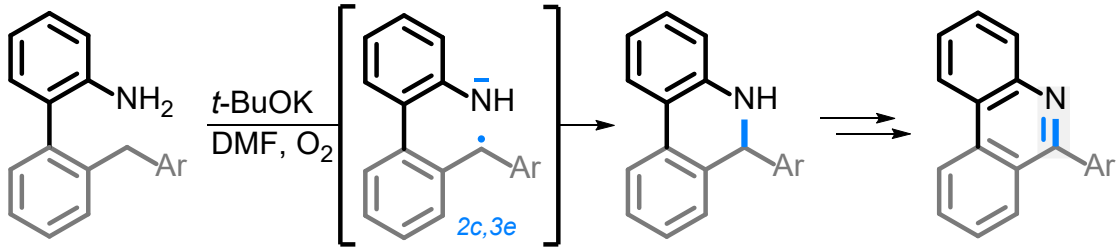


Angew. Chem. Int. Ed., **2019**, *57*, 5532

Expanding the scope of three-electron approach to C-N bond formation

Chris Evoniuk

Previous work: *6-membered aromatic heterocycles*



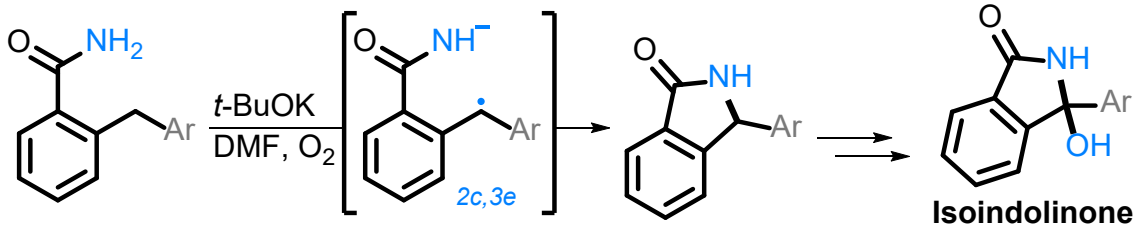
starts with anilines

ΔH = -11.0
ΔG = -8.9

C=N bond formation

Quintin Elliott

Current work: *5-membered non-aromatic heterocycles*



starts with benzamides

ΔH = -5.0
ΔG = -3.6

Isoindolinone

C-N/C-O bond formation

a 10-million-fold decrease in basicity of N-anion

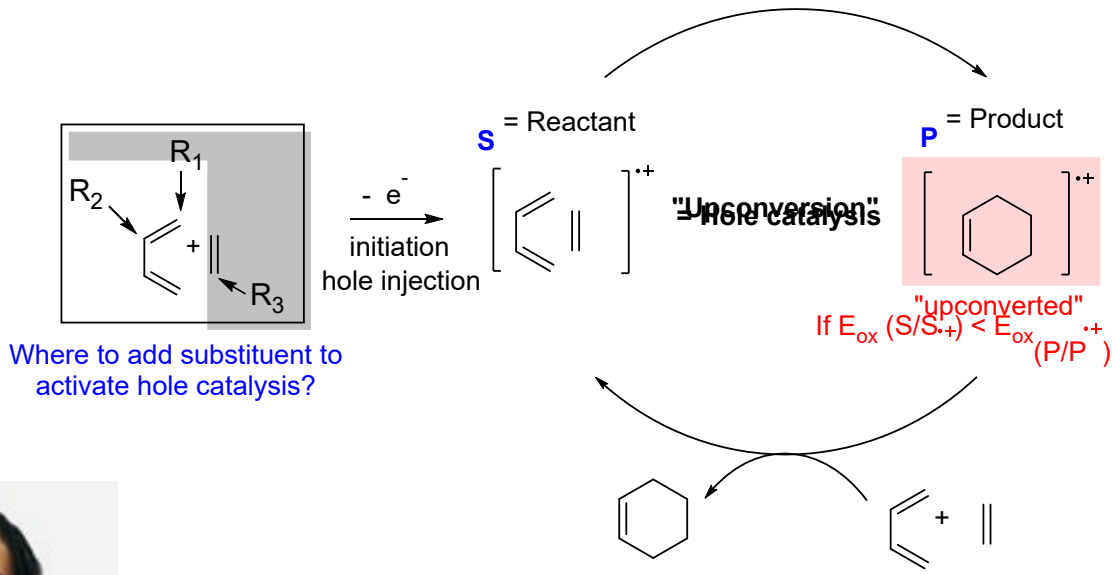
Why is it interesting?

Because it hides a paradox

Evoniuk, C. J.; Gomes, G. dos P.; Hill, S. P.; Fujita, S.; Hanson, K.; Alabugin, I.V. *J. Am. Chem. Soc.* **2017**, *139*, 16210. Q. Elliott, G. Gomes, C. J. Evoniuk, I. V. Alabugin, *Chem. Science*, **2020**, *11*, 6539

Level of theory: (SMD=DMF)/(U)M06-2X(D3)/6-31+G(d,p)/int=ufine

The smallest catalyst for the Diels-Alder reaction



Beauty Chabuka

ACM SIGHPC Computational and Data Science Fellowship (2023)

Hole Catalysis of Pericyclic Reactions: How to Activate and Control Oxidant Upconversion in Radical-Cationic Diels-Alder Cycloaddition. Beauty Chabuka, Igor Alabugin, *JACS, in print*

Level of theory: (SMD=DMF)/(U)M06-2X(D3)/6-31+G(d,p)/int=ufine

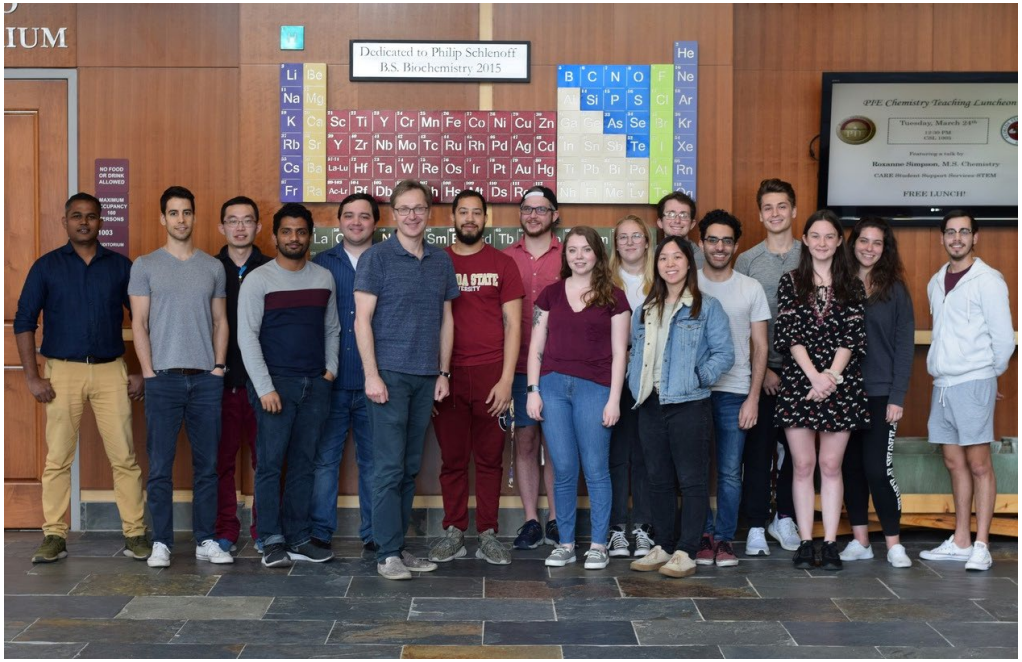
Collaborations

- 2016-2023:

Visiting students: Sweden, Germany, Mexico, Brazil, Russia, Spain

Coauthors in published papers: Sweden, Japan, Australia, Germany, Russia, Mexico, Spain, Iran, India, Czech Republic, Wales, France

The A-Group



Alumni: Dr. Kerry Gilmore, Dr. Phil Byers, Dr. Paul Peerson, Dr. Brian Gold, Dr. Sayantan Mondal, Dr. Kishore Pati, Dr. Nikolay Tsvetkov, Dr. Rana Mohamed, Dr. Stefan Bresch, Dr. Dinesh Vidhani, Dr. Trevor Harris, Dr. Chris Evonyuk, Dr. Audrey Hughes, Dr. Gabriel dos Passos Gomes, Dr. Edgar Rodriguez-Gonzalez, Dr. Rahul Kawade, Dr. Febin Kuriakose, Dr. Quintin Elliott, Dr. Chaowei Hu, Dr. Daria Tonkoglazova, Dr. Antony Sekar, Dr. Leah Kuhn

Graduate students/Postdocs: Nik Dos Santos, Beauty Chabuka, Michael Commodore, Favour Makurvet, Kimberley Christopher

Undergrads (out of >180): Jahbari Bowen, Joshua Loewenstern, Ian Vallari, Christopher Rincon, Devon Nobrega, Gage Bayliss, Thomas Suarez, Airionna Fordham

$$$: NSF, FSU, ACS Cope Scholar Fund