

Correlations of Additions to Alkenes

Chemical reactivity of an alkene is directly related to the types (or properties), number, and relative positions of substituents attached to the alkenyl carbons. Therefore, understanding substituent effects upon alkene reactivity in a wide range of addition reactions to alkenes will enable recognition of patterns in the reactions; this will facilitate mechanistic studies of additions to alkenes and their use in syntheses.

We have developed a technique for correlating measurable characteristics in addition reactions of alkenes in order to gain information and identify patterns, which are useful mechanistically and synthetically. We have applied this technique to many reactions: hydroboration,¹⁻⁴ oxymercuration,²⁻⁴ bromination,³ epoxidation,⁴ sulfonyl halide addition,⁴ mercuric chloride complexation,⁴ silver ion complexation,⁵ diimide addition,⁵ oxidation with permanganate,⁶ carbene addition,⁷ nitrosyl chloride addition,⁷ oxidation with osmium tetroxide,⁷ chlorination,⁸ complexation with iodine,⁸ palladium chloride (Wacker) oxidation,⁹ hydrogenation using Wilkinson's catalyst $\text{RhCl}(\text{PPh}_3)_3$,¹⁰⁻¹² chromyl chloride oxidation,¹³ chromic acid oxidation,¹³ iodine thiocyanate,¹⁴ and others. This technique offers (1) a procedure to determine relative magnitudes of steric and electronic effects in the rate-determining step, (2) a relatively simple way to predict the effects of substituents on reaction rates for synthetic purposes, and (3) a method to choose between alternative proposed reaction mechanisms in some cases.

In these investigations, we apply this simple method by correlating the logs of the relative reaction rates ($\log k_{\text{rel}}$ values) versus alkene ionization potentials (IPs), with their highest occupied molecular orbital energies (HOMOs), and in some cases with their lowest unoccupied molecular orbital energies (LUMOs). Reactions with similar mechanisms give correlation plots which are similar in appearance, and those with different mechanisms give dissimilar correlation plots. For example, the correlation plots of hydroboration and bromination (Figs 1 and 2, Table I) show similar slopes caused by similar electronic effects but different groupings of alkenes due to steric effects; hydroboration exhibits a natural separation into sterically similar groups while bromination has a single line of correlation regardless of the steric requirements of the alkene.

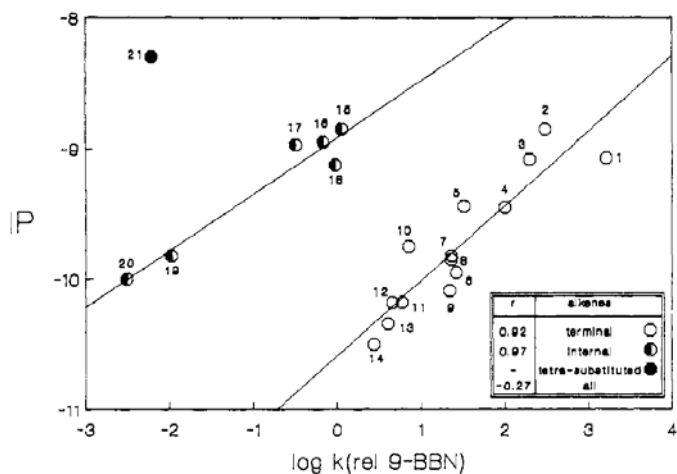


Figure 1. Plot of $\log k(\text{rel})$ for hydroboration of alkenes using 9-BBN versus alkene IP. Numbers next to data points refer to alkenes in Table I. The natural separation of sterically similar alkenes is more pronounced here than in oxymercuration, indicating a greater influence by steric requirements here. Within sterically similar groups, there is an excellent correlation between $\log k(\text{rel})$ and IP. Legend for octagon type versus site of B-C bond formation: open, H_2C ; half-filled, HRC; filled, R_2C .

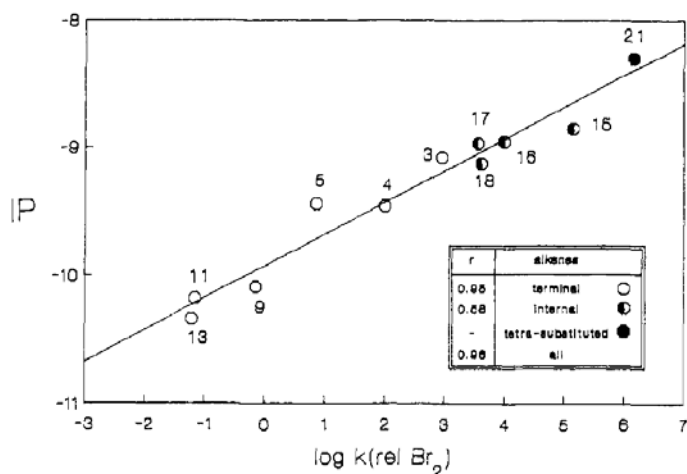


Figure 2. Plot of $\log k(\text{rel})$ for bromination of alkenes using Br_2 versus alkene IP. Numbers next to data points refer to alkenes in Table I. All alkenes, regardless of steric requirements, lie on one line, which has an excellent correlation constant; this indicates that the reaction is independent of steric effects. Legend for octagon type versus site of Br-C bond formation: open, H_2C ; half-filled, HRC; filled, R_2C .

On the other hand, plots of hydroboration (Fig 1) and palladium chloride (Wacker) oxidation (Fig 3, Table II) show similar groupings due to steric effects, but opposite slopes caused by opposite electronic effects. In order to develop further this new technique and to elucidate synthetically and mechanistically

important information from experimental or from computational data, we are applying the technique to additional important reactions with a variety of mechanisms.

Table I. Ionization Potentials and Relative Rates of Reaction of Alkenes

no.	alkene	IP, ^a eV	HOMO energy level	relative reactivity		
				hydroboration (9-BBN)	oxymercuration (Hg(OAc) ₂)	bromination ^b (Br ₂)
1		-9.07	-9.92	1615		
2		-8.85	-9.61	300		
3		-9.08	-9.79	196 ^c	1000 ^d	895
4		-9.48	-9.97	100	100	100
5		-9.44	-10.17	32.5	31.8	7.20 ^e
6		-9.95 ^f	-10.10 ^g	26.1		
7		-9.85	-10.03	22.8		
8		-9.82	-10.04	22.8	25.4	
9		-10.09 ^h	-10.34	21.9		0.72
10		-9.75 ^f	-10.17	7.1 ⁱ		
11		-10.18 ^h	-10.53	5.9		0.7
12		-10.18	-10.32	4.5 ^j		
13		-10.34	-10.48	4.0 ⁱ	2.36	0.06
14		-10.5 ^k	-10.39 ^g	2.71		
15		-8.68	-9.63	1.13 ⁱ	25.8 ^d	1.40 × 10 ⁵
16		-8.95	-9.76	0.68 ^j	11.7 ^{d,j}	9.76 × 10 ³
17		-8.97	-9.76	0.32 ⁱ	3.54 ^{d,j}	3.57 × 10 ³
18		-9.12		0.95 ^e		4.05 × 10 ³
19		-9.82	-10.05	0.011 ⁱ		
20		-10.00	-10.16	0.003 ⁱ		
21		-8.3	-9.49	0.006 ⁱ	1.27 ^d	1.40 × 10 ⁶

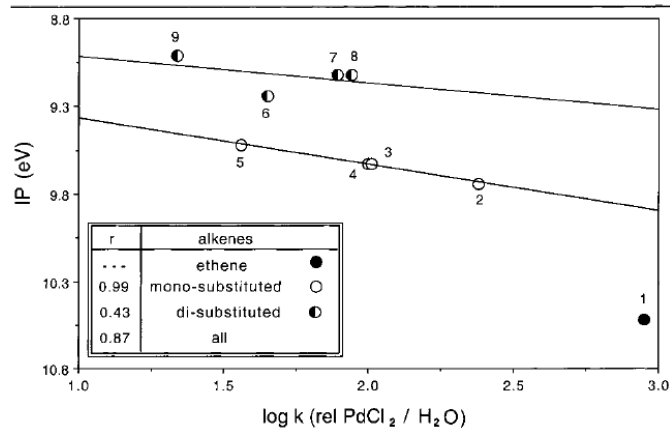


Figure 3. Plot of the $\log k_{\text{rel}}$ values for PdCl₂ oxidation of alkenes versus their corresponding IPs. Data are from Table 1. Lines of correlation for monosubstituted alkenes and for disubstituted alkenes are shown. Correlation coefficients r are given in the legend for monosubstituted alkenes, for disubstituted alkenes, and for all alkenes regardless of the degree of substitution about the double bond. The y -axis IP data are plotted in inverse order so that data reflecting lower π -electron energies appear at the bottom of the plot, to facilitate comparison with the plots of HOMOs and of LUMOs.

Table II. IPs, HOMOs, LUMOs, and Relative Rates of Palladium Chloride Oxidation of Alkenes

No.	alkene	IP (eV) ^a	HOMO (eV)	LUMO (eV)	k_{rel} PdCl ₂ ^b
1		10.52	-10.17	1.32	897
2		9.74	-9.97	1.12	241
3		9.63 ^c	-9.93	1.14	103
4		9.63	-9.94	1.12	100
5		9.52 ^d	-9.92	1.18	35.9
6		9.24	-9.80	0.99	44.9 ^e
7		9.12	-9.79	0.93	76.9
8		9.12	-9.78	0.93	87.2
9		9.01 ^f	-9.75	0.96	22.3

Publications / References

16. Substituent Effects in Acid-Catalyzed Hydration of Alkenes, Measured Under Consistent Reaction Conditions. Nelson, Donna J.; Li, Ruibo; Brammer Christopher N. *Tetrahedron Lett.* **2009**, *50*, 6454-6456; [doi:10.1016/j.tetlet.2009.08.128](https://doi.org/10.1016/j.tetlet.2009.08.128) .
15. Substituent effects in additions of iodine thiocyanate to alkenes. Brammer, C. N.; Nelson, Donna J.; Li, Ruibo. *Tetrahedron Lett.* **2007**, *48*, 3237.
14. Correlation of Relative Rates of Chromyl Chloride Oxidation and Chromic Acid Oxidation of Acyclic Alkenes Versus Alkene IPs and HOMOs. Nelson, Donna J.; Li, Ruibo; Brammer, C. N. *J. Phys. Org. Chem.* **2004**, *17*, 1033 - 1038.
13. Correlation of Relative Rates of Homogeneous Hydrogenation of Acyclic Alkenes in the Presence of Wilkinson's Catalyst vs Alkene IPs, HOMOs, and LUMOs. Nelson, Donna J.; Li, Ruibo; Brammer, Christopher N. Cover art for American Chemical Society Division of Organic Chemistry Calendar, Sep **2006**.
12. Correlation of Relative Rates of Homogeneous Hydrogenation of Acyclic Alkenes in the Presence of Wilkinson's Catalyst vs Alkene IPs, HOMOs, and LUMOs. Nelson, Donna J.; Li, Ruibo; Brammer, Christopher N. Cover art for *Journal of Organic Chemistry*. **2005**, *69*.
11. Correlation of Relative Rates of Homogeneous Hydrogenation of Acyclic Alkenes in the Presence of Wilkinson's Catalyst vs Alkene IPs, HOMOs, and LUMOs. Nelson, Donna J.; Li, Ruibo; Brammer, Christopher N. *J. Org. Chem.* **2005**, *69*, 761 - 767; **2004**, online <http://pubs.acs.org/cgi-bin/asap.cgi/jocean/asap/pdf/jo048968r.pdf>
10. The Correlation of Relative Rates of PdCl₂ Oxidation of Functionalized Acyclic Alkenes Versus Alkene Ionization Potentials, HOMO's, and LUMO's. Nelson, Donna J.; Li, Ruibo; Brammer, Christopher. *J. Am. Chem. Soc.* **2001**, *123*, 1564-1568.
9. Correlation of Ionization Potentials or HOMO Energies Versus Relative Reactivities of Cl₂, of Br₂, and of I₂ with Representative Acyclic Alkenes. Comparison with Other Additions to Alkenes. Nelson, Donna J.; Li, Ruibo; Brammer, Christopher. *J. Org. Chem.* **2001**, *66*, 2422.
8. The Use of Relative Magnitudes of Steric Effects to Explore Reactions of Molecular Halogens with Representative Acyclic Alkenes. Nelson, D. J.; Perng, Tamy. *Proceedings of the Oklahoma Academy of Science*. **2000**, *80*, 141. http://digital.library.okstate.edu/oas/oas_htm_files/v80/p141frames.html .
7. Selected Electrophilic Addition Reactions of Representative Acyclic Alkenes. Nelson, Donna J. *Tetrahedron Lett.* **1999**, 5823.
6. Relative Rates of Permanganate Oxidation of Functionalized Alkenes and the Correlation with the Ionization Potentials of Those Alkenes. Nelson, Donna J.; Henley, Robert L. *Tetrahedron Lett.* **1995**, 6375.
5. Diimide Reduction of Some Representative Alkenes and the Correlation of Their Relative Rates of Reduction with Their Corresponding Ionization Potentials. Nelson, Donna J.; Yao, Ziyun; Henley, Robert L.; Smith, Terrill D. *Tetrahedron Lett.* **1993**, 5835-8.
4. Using the Comparison of Steric Versus Electronic Effects to Infer Mechanistic Information in Stepwise Electrophilic Addition Reactions Involving Three-Membered Cyclic Intermediates. Nelson, Donna J.; Soundararajan, R. *Tetrahedron Lett.* **1988**, 6207-6210.
3. A Simplified Method of Ascertaining Steric Effects in Electrophilic Addition Reactions. A Comparison of Bromination, Oxymercuration, and Hydroboration. Nelson, Donna J.; Cooper, Penny J.; Soundararajan, R. *J. Am. Chem. Soc.* **1989**, *111*, 1414-1418.
2. A Comparison of the Relative Reaction Rates of Alkenes Toward Hydroboration and Toward Oxymercuration. Nelson, Donna J.; Cooper, Penny, J.; Coerver, Judy A. *Tetrahedron Lett.* **1987**, 943-944.
1. An Experimental and Theoretical Investigation of the Influence of Alkene HOMO Energy Level Upon the Hydroboration Reaction. Additional Evidence Supporting an Early Transition State Which has Retention of Alkene Character. Nelson, Donna J.; Cooper, Penny J. *Tetrahedron Lett.* **1986**, 4693-4696.

Presentations

73. Studies of Alkene Reactivity Applied to SWNT Reactions. Department of Chemistry, Texas Tech University, Lubbock, TX. Nov 9, 2005.
72. Comparing reactions of SWNTs, SWNT models, and simple alkenes. 230th ACS National Meeting. **PMSE 492**. Washington, DC. Aug 31, 2005.
71. Comparing halogenation of SWNTs, SWNT models, and simple alkenes. 230th ACS National Meeting. **CHED 208**. Washington, DC. Aug 29, 2005.
70. Correlations of Relative Reaction Rates of Addition of Iodine(I) Thiocyanate to Alkenes versus Alkene IPs and HOMO Energies. Comparison with Other Halogenations of Alkenes. 10th European Symposium on Organic Reactivity (ESOR10), Rome, Italy. Aug 27, 2005.
69. Comparing Computed Alkene HOMO and LUMO Energy Levels versus IPs and EAs: Their Substituent Effects and Alkene Molecular Parameters, η and χ . 10th European Symposium on Organic Reactivity (ESOR10), Rome, Italy. Aug 27, 2005.
68. Comparing Halogenation of SWNTs, SWNT Models, and Simple Alkenes. Nelson, D. J.; Li, R.; Brammer, C. N. 229th American Chemical Society National Meeting, San Diego, CA. **FUEL 40**. Mar 16, 2005.
67. Correlations in Reactions of Alkenes. Department of Chemistry, University of Washington, Seattle, WA. Oct 29, 2004.
66. Comparing Computational Methods for Calculating Alkene HOMO and LUMO Energy Levels 49th Annual ACS Oklahoma Pentasectional Meeting, Stillwater, OK. Oct 16, 2004.
65. Comparing Computational Methods for Calculating Alkene HOMO and LUMO Energy Levels. OU Supercomputing Center for Education and Research (OSCER) Symposium, Norman, OK. Oct 6, 2004.
64. Comparisons of Reaction Mechanisms of Additions to Alkenes via Correlations of Relative Rates and IPs. Department of Chemistry, Cornell University, Mar 16, 2004.
63. Relationship Between Various Alkene Characteristics and Rates of Alkene Addition. Texas Women's University, Denton, TX. Nov. 7, 2003.
62. Relationship between various alkene characteristics and rates of alkene addition. 59th SW ACS Regional Meeting, Oklahoma City, OK. **CHED 140**, Oct 27, 2003.
61. Relationship between various alkene characteristics and rates of alkene addition. 226th ACS National Meeting, New York City, NY. **CHED 153**, Sep 7, 2003.
60. Probing reaction mechanisms of additions to alkenes via correlations. 226th ACS National Meeting, New York City, NY. **ORGN 27**, Sep 7, 2003.
59. Probing reaction mechanisms of additions to alkenes via correlations. 9th European Symposium on Organic Reactivity. Oslo, Norway. Jul 15, 2003.
58. Probing reaction mechanisms of additions to alkenes via correlations. Gordon Research Conference on Physical Organic Chemistry. Holderness, NH. Jun 30, 2003.
57. Probing Reaction Mechanisms of Additions to Alkenes via Correlations. UT-Austin, TX, Mar 17, 2003.
56. Comparisons of Reaction Mechanisms of Additions to Alkenes via Correlations of Relative Rates and IPs. 224th ACS National Meeting, Boston, MA. **ORGN 331**, Aug 19, 2002.
55. Mechanistic Information via Correlations of Additions to Alkenes. International Conference of Physical Organic Chemistry (ICPOC)16, UC San Diego, La Jolla, CA., Aug 6, 2002.
54. Comparing Reaction Mechanisms of Additions to Alkenes via Correlations of Relative Rates vs IPs. UC-Berkeley, CA, Jun 13, 2002.
53. Correlations of Addition Reactions of Alkenes as a Probe of Reaction Mechanisms. 8th Herbert C. Brown Special Symposium, Purdue University, West Lafayette, IN, May 24, 2002.
52. Correlations of Additions to Alkenes. 222nd ACS National Meeting, Chicago, IL. **ORGN 443**, Aug 29, 2001.

51. Calculations on [2,3]-Sigmatropic Rearrangements, 222nd ACS National Meeting, Chicago, IL. **ORGN 111**, Aug 26, 2001.
50. Correlations of Relative Reactivities of Acid-Catalyzed Hydration of Representative Alkenes versus their Ionization Potentials and HOMOs. ACS Meeting in Miniature, Ada, OK. **No. 5**, Apr 7, 2001.
49. Correlations of Relative Reactivities of Acid-Catalyzed Hydration of Representative Alkenes versus their Ionization Potentials and HOMOs. Honors Undergraduate Research Day, Norman, OK. Apr 7, 2001.
48. Use of Alkene Reactivity Correlations in Organic Synthesis: Women in Organic Chemistry. 221st ACS National Meeting, San Diego, CA. **ORGN 235**, Apr 2, 2001.
47. Correlations of Relative Reactivities of Acid-Catalyzed Hydration of Representative Alkenes versus their Ionization Potentials and HOMOs. Sigma Xi OU Chapter Meeting, Norman, OK. Mar 29, 2001.
46. Computational Stabilization of Butadienyllithiums and Representative 1-Chloro-1-lithio-2-phenylalkenes. 46th Annual ACS Oklahoma Pentasectional Meeting, Lawton, OK. **No. 2**, Mar 3, 2001.
45. Correlations of Addition Reactions of Alkenes. Sigma Xi Forum and Annual Meeting, Albuquerque, NM. Nov 9, 2000.
44. Relative Rates of PdCl₂ Oxidation of Functionalized Acyclic Alkenes and Their Correlation with Alkene Ionization Potentials. 220th ACS National Meeting, Washington, DC. **ORGN 302**, Aug 21, 2000.
43. Correlations of Relative Rates of Additions to Alkenes vs. IPs, HOMOs, and LUMOs. University of California, Los Angeles, CA. Jul 24, 2000.
42. Correlations of Relative Rates of Additions to Alkenes vs. IPs, HOMOs, and LUMOs. University of California, Berkeley, CA. Jul 21, 2000.
41. Correlations of Relative Rates of Additions to Alkenes vs. IPs, HOMOs, and LUMOs. American University, Washington, DC. Jun 26, 2000.
40. Relative Rates of PdCl₂ Oxidation of Functionalized Acyclic Alkenes and Their Correlation with Alkene Ionization Potentials. Southwest Missouri State University, Springfield, MO. May 1, 2000.
39. Relative Rates of PdCl₂ Oxidation of Functionalized Acyclic Alkenes and Their Correlation with Alkene Ionization Potentials. 45th Annual ACS Oklahoma Pentasectional Meeting, Stillwater, OK. **ORGN 7**, Apr 15, 2000.
38. A Device to Make Balancing Simple Equations Easier. 45th Annual ACS Oklahoma Pentasectional Meeting, Stillwater, OK. **Poster 11**, Apr 15, 2000.
37. Relative Magnitudes of Steric Effects in Reactions of Chlorine, Bromine, and Iodine with Representative Acyclic Alkenes. 218th ACS National Meeting, New Orleans, LA. **ORGN 165**, Aug 22, 1999.
36. Relative Magnitudes of Steric Effects in Reactions of Cl₂, of Br₂, and of I₂ with Representative Acyclic Alkenes. 26th National Triennial Convention of Iota Sigma Pi, Portland, OR. **Paper No. 3**, Jun 24, 1999.
35. Addition Reactions of Alkenes that Evince a Grouping by Degree of Alkene Substitution. Sigma Xi Forum and Annual Meeting, Vancouver, British Columbia, Nov 14, 1998.
34. Addition Reactions of Alkenes that Evince a Grouping by Degree of Alkene Substitution. 216th ACS National Meeting, Boston, MA. **ORGN 211**, Aug 23, 1998.
33. Correlations of Some Addition Reactions of Acyclic Alkenes Manifest a Grouping by the Degree of Alkene Substitution. 215th ACS National Meeting, Dallas, TX. **ORGN 125**, Mar 29, 1998.
32. Relative Rates of Addition Reactions to Functionalized Acyclic Alkenes and Their Correlation with Alkene Ionization Potentials. 211th ACS National Meeting, New Orleans, LA. **ORGN 102**, Mar 24, 1996.
31. Relative Rates of Addition Reactions to Functionalized Alkenes and Their Correlation with Alkene Ionization Potentials. Nazarene University, Oklahoma City, OK, April 9, 1996.

30. Relative Rates of Addition Reactions to Functionalized Alkenes and Their Correlation with Alkene Ionization Potentials. Langston University, Langston, OK, April 10, 1996.
29. Relative Rates of Addition Reactions to Functionalized Alkenes and Their Correlation with Alkene Ionization Potentials. 40th ACS Oklahoma Pentasectional Meeting, Norman, OK. **No. 2**, Apr 29, 1995.
28. Relative Rates of Addition Reactions to Functionalized Alkenes and Their Correlation with Alkene Ionization Potentials. 209th ACS National Meeting, Anaheim, CA. **CHED 77**, Apr 3, 1995.
27. The Effects of Complexation Upon Representative α -Chloroisobutenylmetals. Department of Chemistry, University of Singapore, Singapore, Mar 24, 1994.
26. An MNDO Study of Isomerization and Ionization of Representative 1-Chloro-2-methyl-1-propenylmetals. 207th ACS National Meeting, San Diego, CA. **ORGN 24**, Mar 13, 1994.
25. The Reaction of 1-Chloro-2-methyl-1-propenyllithium with a Selection of Organolithiums. The Development and Synthetic Utility of Novel Base/Nucleophile Combinations. 205th ACS National Meeting, Denver, CO. **ORGN 199**, Mar 31, 1993.
24. Relative Rates of Permanganate Oxidation of Functionalized Alkenes and Their Correlation with the Ionization Potentials of Those Alkenes. 205th ACS National Meeting, Denver, CO. **ORGN 198**, Mar 31, 1993.
23. Ascertaining Steric Effects in Electrophilic Addition Reactions. Department of Chemistry, University of Singapore, Singapore, Jan 13, 1993.
22. Comparison of Steric vs Electronic Effects to Infer Mechanistic Information in Stepwise Electrophilic Addition Reactions. Department of Chemistry, University of Singapore, Singapore, Mar 7, 1991.
21. An MNDO Study of Isomerization and Ionization of Representative α -Chloroisobutenylmetals. Viability of Metal-Assisted Ionization. 198th ACS National Meeting, Miami, FL. **ORGN RD-1**, Sep 10, 1989.
20. Studies of α -Chloroisobutenylmetals and Their Derivatives. Second J. J. Zuckerman Organometallic Chemistry Workshop, Norman, OK. May 28, 1989.
19. A Simplified Method of Determining Steric Effects in Electrophilic Additions to Alkenes. 22nd Reaction Mechanisms Conference, Pittsburgh, PA. **No. 33**, Jun 14, 1988.
18. A Simplified Method of Ascertaining Steric Effects in Electrophilic Addition Reactions. A Comparison of Bromination, Oxymercuration, and Hydroboration. 195th ACS National Meeting, Toronto, Canada. **ORGN 425**, Jun 9, 1988.
17. Correlations in some electrophilic additions to sterically similar alkenes. Department of Chemistry, Southern Methodist University, Dallas, TX. Dec 3, 1987.
16. Comparison of relative reactivities of bromination, oxymercuration, and hydroboration. Department of Chemistry, Cameron University, Lawton, OK. Oct 27, 1987.
15. Comparison of relative reactivities of bromination, oxymercuration, and hydroboration. ACS, Wichita Falls – Duncan Section Speaker, Lawton, OK. Oct 27, 1987.
14. Correlations of Relative Reactivities of Electrophilic Additions to Alkenes. 193rd ACS National Meeting, Denver, CO. **ORGN 8**, Apr 5, 1987.
13. Correlations of Some Electrophilic Additions to Sterically Similar Alkenes. Sixth International Meeting on Boron Chemistry (IMEBORON VI), Bechyne, Czechoslovakia. Jun 26, 1986.
12. Stereospecific Reactions of α -Haloalkenylmetals. 192nd ACS National Meeting, Anaheim, CA. **ORGN 17**, Sep 7, 1986.
11. Studies of Organoborane Reaction Mechanisms. Second Southwest Organometallic Chemistry Workshop, Norman, OK. Jun 1, 1986.
10. Relative Rates of Hydroboration of Allylic Compounds. 30th ACS Oklahoma Pentasectional Meeting, Norman, OK. **No. 26**, Mar 2, 1985.
9. The effects of substituents and solvent upon reactions of organoboranes. ACS, Wichita Falls –

Duncan Section Speaker, Lawton, OK. Nov 8, 1984.

8. The effects of substituents and solvent upon reactions of organoboranes. Department of Chemistry, Cameron University, Lawton, OK. Nov 8, 1984.
7. The Unusual Effect of Solvent on the Rate of Protonolysis of *B*-(1-Octenyl)-9-borabicyclo[3.3.1]nonane and of 1-Octenyldicyclohexylborane. 185th ACS National Meeting, Seattle, WA. **ORGN 133**, Mar 23, 1983.
6. Synthesis of *cis*-1-Halo-1-alkenes via Hydroboration/Protonolysis. 184th ACS National Meeting, Kansas City, MO. **ORGN 38**, Sep 13, 1982.
5. Kinetics of Hydroboration. Purdue University, West Lafayette, IN. Jun 29, 1982.
4. A General Mechanism for the Kinetics of Hydroboration with Organoboranes. 184th ACS National Meeting, Kansas City, MO. **ORGN 17**, Sep 13, 1982.
3. Study of Pathways to Carbene in Reaction of Atomic Carbon with Butyraldehyde. Symposium on Carbenes, Carbenoids, and Cyclopropanes in Organic Synthesis. Illinois Inst Tech. Chicago, IL. Jun 1, 1981.
2. Hydroboration of 1-Halo-1-alkynes with 9-Borabicyclo[3.3.1]nonane Dimer in Carbon Tetrachloride Solvent. 181st ACS National Meeting, Atlanta, GA. **ORGN 66**, Mar 30, 1981.
1. The Effect of Halogen Substitution on the Hydroboration of Alkenes Using 9-Borabicyclo[3.3.1]nonane Dimer in Tetrahydrofuran Solvent. Second Chemical Congress of the North American Continent, Las Vegas, NV. **ORGN 316**, Aug 28, 1980.