Professor William J. le Noble

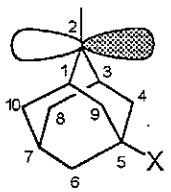
Biographical Sketch

William J. le Noble was born July 19, 1928, in Rotterdam, the Netherlands, where he spent his early years. He graduated with a B.S. in Chemical Engineering from the Advanced Engineering School in Dordrecht in 1949. After emigrating in the same year, he served in the U.S. Army in Korea until 1953. Subsequently he attended the University of Chicago, where he graduated in 1957 with a thesis project supervised by the late Professor G. W. Wheland. After a postdoctoral stint with the late Professor N. Kornblum at Purdue, he joined the Faculty at Stony Brook, which was then in its third year of operation. He is now Professor Emeritus of Chemistry; his service to the Department of Chemistry has included a term as Chair. He is the author of 175 publications including several chapters, a graduate level text ("Highlights of Organic Chemistry"), two articles invited by the Encyclopedia of Science and Technology ("Resonance" and "Physical Organic Chemistry") and one by the Encyclopedia of Life Sciences ("Organic Reaction Mechanisms").

His two principal research interests have been the use of pressure as a tool in mechanistic investigations, and stereochemistry. He has served as Visiting Professor at the Universities of Amsterdam, Groningen and Leiden in the Netherlands, of Oulu in Finland and of Oita in Japan. He was awarded a Senior U.S. Scientist Award by the Humboldt Foundation in 1985, and a Senior Scientist Award by Mombusho (Japan Ministry of Education and Science) in 1987. His colleagues in high-pressure chemistry both in the U.S. and abroad honored him recently with a Special Issue of the Journal "High Pressure Chemistry." He served as Senior Editor of the Journal of Organic Chemistry under Professor F. D. Greene from 1977-1988, and he has held the same position with the Recueil de Travaux Chimiques des Pays-bas.

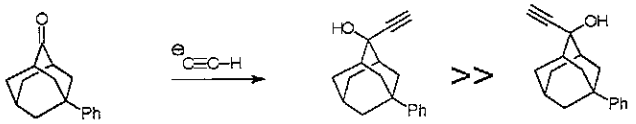
Research Summary and Publications

The contributions of Professor W. J. le Noble to organic chemistry are in two main areas. The first of these is the study of electronic face selection in the chemistry of trigonal carbon; this is the research to be recognized by the award for which this nomination is written. The second is the study of organic reactions in compressed solutions; this was the focus of le Noble's earlier research. Reference numbers below refer to the list of publications.

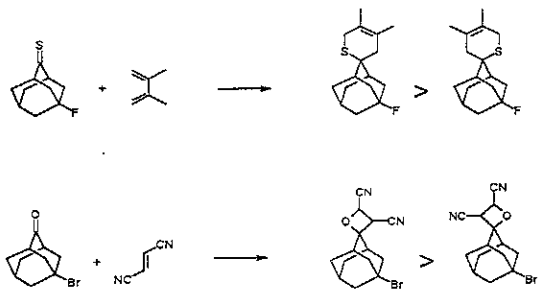


The work on face selection is based on the use of 5-substituted 2-adamantylidene derivatives. The virtues of this probe are several: the two faces are sterically virtually identical, it is conformationally constrained, and addition gives two products both of which are achiral. Like most adamantanes, the products are generally solids, easily separated and purified; the configurations can be assigned by a variety of physical techniques.

This work began in the mid seventies with the observation (then unexpected) that ethynylation of 5-phenyladamantanone is not stereorandom but gives the E- and Z-propargyl alcohols in a 3:1 ratio.[71] All the literature on the subject of 4-substituted cyclohexanes up to that time had been solidly based on the assumption that the cross-ring substituents have no effect upon the chemistry at the 1-position; the deviation from a 50/50 product distribution in this case clearly showed that the assumption was wrong.

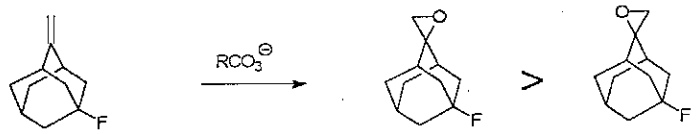


Subsequent investigations showed that nucleophiles such as $NaBH_4$, $LiAlH_4$, CH_3Li, CH_3MgBr, *p*-X-C_6H_4MgBr, C_2F_5Li and H-C≡C- always preferentially attack the zu face of the adamantanone if the 5-substituent is electron withdrawing[115,128] (halogen, hydroxy, trifluoromethyl, phenyl, p-nitrophenyl), and the en face if it is electron donating (trimethylsilyl, trimethylstannyl).[135]



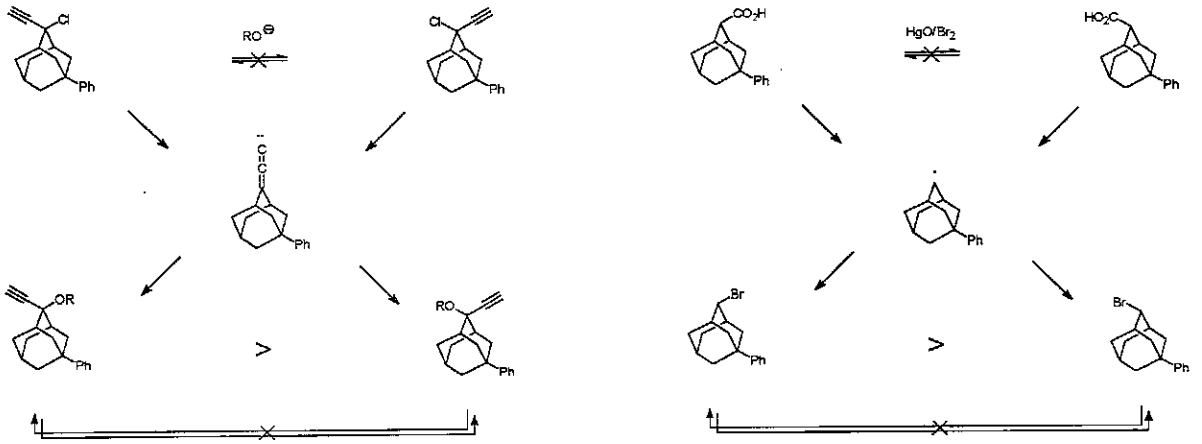
The same selectivity is observed in pericyclic reactions. Examples include Diels-Alder cycloaddition,[143] photocycloaddition,[144] the oxy-Cope rearrangement[132] and Claisen rearrangement. In the Diels-Alder reaction, it was shown that the same selectivity characterizes both reaction partners, [144] and in the Claisen rearrangement,[156] that it applies at both termini.[156]

Electrophiles attacking 5-substituted 2-methyleneadamantanes also preferentially do so on the side syn to an electron withdrawing group such as phenyl or fluoro, for example, carbene capture, hydroboration, oxymercuration[118] and bromination, both of olefins and ketones.[157]

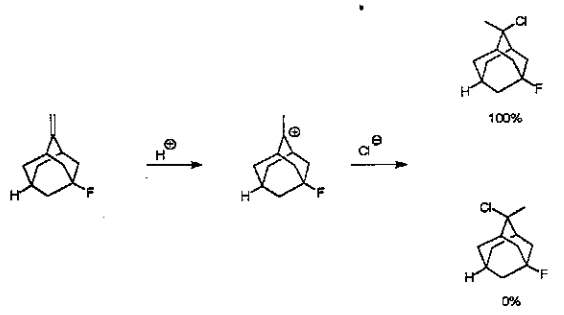


Transient trigonal carbon species are no exception either; carbenes,[71] radicals[141] and carbocations[65] are included. Other additions have been the metal

complexation of olefins[144] and the oxidation of sulfides.[154] Substituting C_5 by positive nitrogen greatly magnifies the effect.[145]

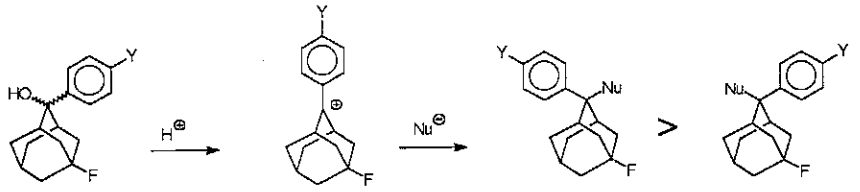


All of these observations (no exceptions have been found to date) empirically fit the rule that the preferred face is the one anti-periplanar to the more electron rich bond(s). Thus, the 5-halo-substituted substrates are attacked from the syn side since that places the more electron-rich CC-bonds, C_1C_8 and C_3C_{10} in the antiperiplanar positions.



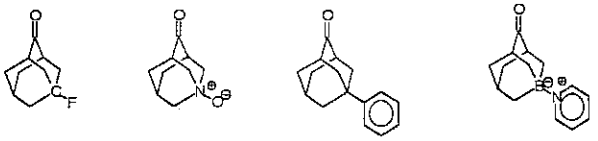
To explain these results, le Noble favors the notion offered by Cieplak to account for the oft-observed preference of nucleophiles to attack cyclohexanones at the (more hindered) axial face. In this model, antiperiplanar vicinal bonds stabilize the transition state via hyperconjugative delocalization into the sigma* component of the newly forming bond. le Noble fitted all of his initial results on that basis, and furthermore greatly expanded its usefulness by unifying it with Winstein's sigma delocalization. The main difference between the two concepts, in le Noble's view, is provided by the recipient orbital: the $\sigma^{=*}$ -orbital in addition reactions, and the vacant p-orbital in carbocations. This insight allowed him to answer several. questions left unresolved during the "carbonium ion controversy," among them the similarity -often pointed out by H. C. Brown- of the stereochemistries of ketone reduction and carbocation capture and formation. In fact, the notion of sigma delocalization itself was still controversial, even after the long and inconclusive battle against steric and solvent-separated-ion-pair explanations of retentive solvolysis; however, le Noble's experiments with the adamantyl substrates refute these alternatives. Thus, 5-deuterio-2-adamantyl tosylate hydrolyzes with retention;[115] the steric explanation is ruled out in this case. Furthermore, the same face selection obtains whichever precursor alcohol (E or Z) produces the cation, so that solvent-separated ion-pairs cannot be responsible either.

Having thus ruled out the alternative theories for the 2-adamantyl cation, le Noble was in a position to test the validity of the principal argument that had been used so vigorously against sigma participation in the 2-norbornyl ion, to wit, that cation stabilizing substituents fail to suppress it. He found that the 2-p-phenyl-substituted 5-fluoro-2-adamantyl cations all capture nucleophiles such as Cl- or BH_4- with the same syn/anti ratio (3.2 ± 0.2), from Y = CF_3 to Y = OMe. Even a methoxy group bound directly to the carbocationic center does not reduce its face selectivity!



Clearly, the premise used in the 2-norbornyl studies was never valid to begin with; cation-stabilizing substituents, so effective in suppressing π participation, are irrelevant in studies of sigma participation.[127] Dramatic proof of this assertion is found in the fact that σ-participation-induced stereoselection is subject to orbital symmetry control, while π participation is not.[137,153] Further work is in progress. The insights gained will sharpen the organic chemists' ability to predict face selection in the more complex cases where the steric and conformational simplicity of the adamantyl system are absent.

Work in the other major area, that of high-pressure chemistry, began soon after le Noble had joined the Chemistry Department at SUNY Stony Brook in 1959. The relations $-RT\delta\ln k$ (or K)$/\delta P = \Delta V^{\ddagger}$ (or ΔV), where $\Delta V^{\ddagger}$ and ΔV are the activation and reaction volumes, respectively, were well known at that time, and a handful of reactions had been studied under pressure. le Noble learned that measurements of these volume differences and of the molar volumes of the starting materials and products led to volume profiles of reactions and that these profiles gave remarkable insights into the mechanisms of reactions.[69,133] These insights derive from the following simple facts. When a given species dissociates without change of overall charge, the volume increases, and hence pressure inhibits such dissociation, and promotes association. When dissociation is in the form of ionization, the volume strongly decreases, due to the powerful attraction of solvent molecules by the ions; hence ionization is promoted by pressure, and neutralization inhibited. The Born equation formalizing this dependence furthermore shows that the attraction is diminished when the charge is delocalized; thus, the ionization of acetic acid is less enhanced by pressure than that of water. By means of these simple generalizations, le Noble was able to learn details of the mechanisms of reactions that had remained obscure or controversial before. Some examples follow.



le Noble found the activation volume to be a good criterion for concertedness. Thus, pressure causes a large acceleration in concerted cycloadditions because both pairs of termini are in the process of becoming covalently bonded.[77] In diradical stepwise analogs, the acceleration is much smaller;[68] in zwitterionic processes, the appearance of the charges makes the acceleration extraordinarily large.[50] This same basic criterion has also been applied to sigmatropic shifts[99] and to fragmentation reactions.[52] It is so reliable that an unusual value of $\Delta V^{\ddagger}$ became the initial hint that something was amiss in the case of one fragmentation, the products of which were eventually found to be formed in a highly circuitous indirect route.[39]

The activation volume was also used to learn whether neutral transient intermediates are generated free, or bound to solvent. Thus, dihalocarbenes[14] and fluoronitrene[23] are formed in solvolysis reactions that are strongly inhibited by pressure; this can only mean that the rate is controlled by bond cleavage to produce the free intermediates. On the other hand, the presumed formation of the metaphosphate intermediate is accelerated by pressure. The volume decreases in the process, and this suggests strongly that metaphosphate becomes bound even as it is released; in other words, it does not have a free existence in water.[116]

When non-classical ions and sigma participation were still controversial notions, le Noble used high pressure to show that these ions are formed in processes that are pressure-enhanced, but less so than analogous reactions that produce localized ions.[21] This was a clear argument for sigma delocalization. Later on, when high pressure variable temperature NMR became available, le Noble was able to confirm this notion by showing that the racemization of a classical ion such as 1,2-dimethoxy-2-norbornyl via the nonclassical tradition state is retarded by pressure,[72] in contrast to the non-classical 7-methylnorbornadienyl cation which undergoes the bridge flipping process via a classical transition state.[82]

Other uses of high pressure as a tool in le Noble's laboratory have included studies of cyclodextrins as enzyme models (in collaboration with R. Breslow),[84] of the remarkable dehydration that accompanies the migration of cations through vesicle walls (in collaboration with C. Springer),[85] and of the outstanding acceleration of sterically hindered processes.[32] It was clear even in the earliest papers[8] on the subject that high pressure had a synthetic potential, and his knowledge has in recent years began to diffuse throughout the organic chemical community.

Publications
by
W. J. le Noble

1. W. J. le Noble and G. W. Wheland, "The Entropies of Activation in the Nitration on Ethyl Benzoate". *J. Am. Chem. Soc.* **1958,** *80,* 5397.

2. N. Kornblum, P. J. Berrigan and W. J. le Noble, "Chemical Effects Arising from Selective Solvation: Selective Solvation as a Factor in the Alkylation of Ambident Anions". *J. Am. Chem. Soc.* **1960,** *82,* 1257.

3. W. J. le Noble, "The Keto-Enol Equilibrium of Ethyl Acetoacetate Under High Pressure". *J. Am. Chem. Soc.* **1960,** *82,* 5253.

4. W. J. le Noble, "The Configurations of Some Substituted β-Haloacrylic Acids". *J. Am. Chem. Soc.* **1961,** *83,* 3897.

5. W. J. le Noble, J. LuValle,, and A. Leifer, "The Strength of Butyric and *o*-Toluic Acids". *J. Phys. Chem* **1962,** *66,* 1188.

6. W. J. le Noble and P. J. Crean, "The Thermal Decarboxylation of β-Alkoxycrotonic Acids: A New Synthesis of Isopropenyl Ethers". *J. Org. Chem.* **1962,** *27,* 3875.

7. N. Kornblum, P. J. Berrigan, and W. J. le Noble," Solvation as a Factor in the Alkylation of Ambident Anions: The Importance of the Hydrogen Bonding Capacity of the Solvent". *J. Am. Chem. Soc.* **1963,** *85,* 1141.

8. W. J. le Noble, "The Effect of Pressure on the Homogeneous Alkylation of Phenoxide Ion". *J. Am. Chem. Soc.* **1963,** *85,* 1470.

9. W. J. le Noble, "The Effect of Pressure on the Equilibration of α- and γ-Methylallyl Azide". *J. Phys. Chem* **1963,** *67,* 2451.

10. W. J. le Noble and M. Duffy, "The Effect of Pressure on the Rates of Acid-Catalyzed Hydrolysis of Trimethylene Oxide and of Epichlorohydrin". *J. Phys. Chem.* **1964,** *68,* 619.

11. W. J. le Noble, "The Effect of Pressure on the Benzylation of 1-Methyl-2-naphthoxide Ion". *J. Phys. Chem* **1964,** *68.* 2361.

12. W. J. le Noble, P. J. Crean, and B. Gabrielsen, "The Formation of 2,4-Dimethoxy-6-Methylphenylacetone from 3,5-Dimethoxybenzyl Isopropenyl Ether. A New Variant of the Claisen Rearrangement". *J. Am. Chem. Soc.* **1964,** *86,* 1649, 5710.

13. W. J. le Noble and M. Duffy, "The Effect of Pressure on the Rate of Hydrolysis of Chloroform: The Nature of the Transition State". *J. Am. Chem. Soc.* **1964,** *86,* 4512.

14. W. J. le Noble, "The Effect of Pressure on the Hydrolysis of Chloroform, Chlorodifluoromethane, and 3-Chloro-3-methylbutyne. The Nature of the Intermediates". *J. Am. Chem. Soc.* **1965,** *87,* 2434.

15. W. J. le Noble and B. L. Yates, "The Activation Volumes in the Solvolysis of *exo*- and *endo*-2-Norbornyl Brosylate". *J. Am. Chem. Soc.* **1965,** *87,* 3515.

16. W. J. le Noble, "Activation Volumes and Mechanism of the Hydrolysis of Chloramines". *Tetrahedron Lett.* **1966,** *727.*

17. W. J. le Noble and J. E. Puerta, "Alkyl Group Effect in the Alkylations of Ethyl Acetoacetate in Dimethyl Sulfoxide". *Tetrahedron Lett.* **1966,** *1087.*

18. W. J. le Noble, "Kinetics of Reactions in Solutions Under Pressure". *Progr. Phys. Org. Chem.* **1967,** *5,* 207.

19. W. J. le Noble, "Reacties in Oplossingen onder Hoge Druk (I)". *Chem. Weekbl.*, **1967,** *63,* 16.

20. W. J. le Noble, "Reacties in Oplossingen onder Hoge Druk (II)". *Chem. Weekbl.*, **1967,** *63,* 39.

21. W. J. le Noble, B. L. Yates, and A. W. Scaplehhorn, "The Activation Volumes of Some Solvolysis Reactions". *J. Am. Chem. Soc.* **1967,** *89,* 3751.

22. W. J. le Noble, "Reactions in Solutions Under Pressure". *J. Chem. Educ.* **1967,** *44,* 729.

23. W. J. le Noble and D. Skulnik, "Fluoronitrene". *Tetrahedron Lett.* **1967,** 5217.

24. W. J. le Noble and H. F. Morris, "Alkylations in Highly Basic Solvents". *Quart. Reports Sulfur Chem.* **1968,** *3,* 182.

25. W. J. le Noble, Review of "Fundamentals of Theoretical Organic Chemistry", O. A. Reutov. *Quart. Rev. Biol.* **1968,** *43,* 79.

26. W. J. le Noble, R. Goitien and A. Shurpik, "The Effect of Pressure on the Rate of Fragmentation of β-Bromoangelate Ion". *Tetrahedron Lett.* **1969,** 895.

27. W. J. le Noble and H. F. Morris, "O- *vs.* C-Alkylation of Ethyl Acetoacetate". *J. Org. Chem.* **1969,** *33,* 1969.

28. W. J. le Noble and B. Gabrielsen, "The Claisen Rearrangement of Benzyl Phenyl Ethers". *Chem. & Ind.* **1969,** 378.

29. W. J. le Noble, "Conditions for the Alkylation of Ambident Anions". *Synthesis* **1970,** *2,* 1.

30. W. J. le Noble and B. Gabrielsen, "The Effect of Pressure in Some Reactions Characterized by Ar_1-participation". *Tetrahedron Lett.* **1970,** 45.

31. W. J. le Noble, Y. Tatsukami, and H. F. Morris, "Evidence for an Anion-Carbene Pair". *J. Am. Chem. Soc.* **1970,** *92,* 5681.

32. W. J. le Noble and Y. Ogo, "The Effect of Pressure on Sterically Hindered Menshutkin Reactions". *Tetrahedron*, **1970,** *26,* 4119.

33. W. J. le Noble and A. R. Das, "Volume Change During the Solvent Separation of a Tight Ion Pair in a Solvent of Low Dielectric Constant". *J. Phys. Chem. 1970, 74,* 3429.

34. W. J. le Noble and A. Shurpik, "The Effect of Pressure on Some Sterically Hindered Solvolysis Reactions". *J. Org. Chem.* **1970**, *35*, 3588.

35. W. J. le Noble T. Hayakawa, A. K. Sen, and Y. Tatsukami, "The Effect of Pressure on the Alkylation of Hindered Phenoxides". *J. Org. Chem.* **1971**, *36*, 193.

36. W. J. le Noble, E. M. Schulman, and D. N. Skulnik, "The Base Promoted Hydrolysis of Difluoramine. The Intermediacy and Behavior of Fluoronitrene".*J. Am. Chem. Soc.* **1971**, *93*, 4710.

37. W. J. le Noble and B. Gabrielsen, "The Base Promoted Reactions of 3-(p-Hydroxyphenyl)-propyl Brosylate". *Tetrahedron Lett.* **1971**, 3417.

38. W. J. le Noble and S. K. Palit, "Reversal of the Effect of Pressure on the Product Ratio in the Alkylation of an Ambident Anion as a Result of Ion-Pairing". *Tetrahedron Lett.* **1972**, 493.

39. W. J. le Noble and Y.-S. Chang, "The Fragmentation of Chloroacetylhydrazide". *J. Am. Chem. Soc.* **1972**, *94*, 5402.

40. W. J. le Noble, "Pressure Effects in Reactions Involving Ion-Pairs". *Acta Pharmac. Suecica* **1972**, *9*, 633.

41. W. J. le Noble and Y.-S. Chang, "A Visible Transient Intermediate". *J. Chem. Educ.* **1973**, *50*, 418.

42. W. J. le Noble and W.-S. Chang, "N-Phenyl-N'-Chlorodiimide N-oxide ("Chlorazoxobenzene"). *Synthesis* **1973**, 106.

43. T. Asano and W. J. le Noble, "The Ionization Constants and Ionization Volumes of 2,6-Dialkylpyridines. The Effect of Pressure on Sterically Hindered Reactions". *Rev. Phys. Chem. Japan* **1973**, *42*, 136.

44. W. J. le Noble, "Highlights of Organic Chemistry". Marcel Dekker, New York, **1974**.

45. T. Asano and W. J. le Noble, "Void and Expansion Volume Contributions to Reaction and Activation Volumes of Nearly Non-Polar Reactions". *Rev. Phys. Chem. Japan* **1974**, *43*, 82.

46. W. J. le Noble and R. Mukhtar, "Effect of Pressure on the Competing [2+2] and [2+2+2] Cycloadditions of Tetrachlorobenzyne and Norbornadienes". *J. Am. Chem. Soc.* **1974**, *96*, 6191.

47. W. J. le Noble and T. Asano, "The Special Effect of Pressure on Highly Hindered Reactions as a Possible Manifestation of the Hammond Postulate". *J. Am. Chem. Soc,*. **1975**, *97*, 1778.

48. W. J. le Noble and T. Asano, "The Ionization Constants and Volumes of Highly Hindered Pyridines in Methanol". *J. Org. Chem.* **1975**, *40*, 1179.

49. W. J. le Noble, H. Guggisberg, T. Asano, L. Cho, and c. A. Grob, "Effect of Pressure on the Rates of Fragmentation Reactions". *Rev. Phys. Chem. Japan* **1975**, *44*, 643.

50. W. J. le Noble and R.Mukhtar, "Nature of the Intermediates Involved in the [2+2] Cycloaddition of Tetracyanoethylene and Enol Ethers". *J. Am. Chem. Soc.* **1975,** *97,* 5938.

51. W. J. le Noble and B. Ojosipe, "Effects of Pressure on the [4+6] Cycloaddition of Tropone to Cyclopentadiene". *J. Am. Chem. Soc.* **1975,** *97,* 5939.

52. W. J. le Noble, H. Guggisberg, T. Asano, L. Cho, and C. A. Grob, "Pressure Effects in Solvolysis and Solvolytic Fragmentation: A Correlation of Activation Volume with Concertedness". *J. Am. Chem. Soc.* **1976,** *98,* 920.

53. W. J. le Noble, E. H. White, and P. M. Dzadzik, "Effects of Pressure on the Stereochemistry of Ion Pair Collapse in the *N*-Nitrosamide Deamination". *J. Am. Chem. Soc.* **1976,** *98,* 4020.

54. W. J. le Noble and R. Schlott, "All Quartz Optical Cell of Constant Diameter for Use in High Pressure Studies". *Rev. Sci. Instrum.* **1976,** *47,* 770.

55. W. J. le Noble, Review of "Physical Chemistry. An Advanced Treatise," H. Eyring, D. Henderson and W. Jost, Ed.; Vol. VII/Reactions in Condensed Phases". *J. Am. Chem. Soc.* **1976,** *98,* 6770.

56. W. J. le Noble, A. R. Miller and S. D. Hamann, "A Simple, Empirical Function Describing the Reaction Profile, and Some Applications". *J. Org. Chem.* **1977,** *42,* 338.

57. W. J. le Noble and S. K. Tamura, "Pressure Effects in a [2+2] Photocycloaddition and -reversion". *Tetrahedron Lett.* **1977,** 495.

58. W. J. le Noble, "Reactions in Compressed Solutions". *High Temp., High Press.* **1977,** *9,* 493.

59. W. J. le Noble, D. M. Chiou, H. Maluszynska, and Y. Okaya, "Configurational Assignment of Several 1.4-Substituted Adamantanes". *Tetrahedron Lett.* **1977,** 3865.

60. W. J. le Noble, "Carbanions"; Chr. 2, "Reactive Intermediates". Vol. I. M. Jones and R. A. Moss, Eds. Wiley, N.Y. **1978,** 27.

61. W. J. le Noble, "Rapid Degenerate Equilibrations". *Chimia* **1978,** *32,* 31.

62. Y. Okaya, H. Maluszynska, D. M. Chiou, and W. J. le Noble, "Structure of *E*-2-Chlorovinylidene-5- phenyladamantane". *Acta Cryst.* **1978** *B34* 3434.

63. W. J. le Noble, "Organic Model Reactions Under Pressure". Proc. NATO/ASI, High Pressure Chemistry, H. Kelm, Ed.; **1978,** 325.

64. W. J. le Noble, "Organic Problem Reactions Under Pressure". Proc. NATO/ASI, High Pressure Chemistry, H. Kelm, Ed.; **1978,** 345.

65. W. J. le Noble, D. M. Chiou and Y. Okaya, "Stereospecific Return in the Methanolysis of Propargyl Halides. Remote Phenyl Directive Effect on the Stereoselection of Carbonium Ion Capture". *Tetrahedron Lett.* **1978,** 1961.

66. W. J. le Noble and P Staub, "Volume Change during the Solvent Separation of the Sodium Naphthalenide Tight Ion Pair in Tetrahydrofuran". *J. Organomet. Chem.* **1978,** *156,* 25.

67. W. J. le Noble, D. M. Chiou, and Y. Okaya, "Shape and Inversion of an Allenic Anion". *J. Am. Chem. Soc.* 1978, *100*, 7743.

68. W. J. le Noble and M. R. Daka, "Effect of Pressure on Concerted and Stepwise Sigmatropic Shifts". *J. Am. Chem. Soc.* 1978, *100*, 5961.

69. T. Asano and W. J. le Noble, "Activation Volumes and Reaction Volumes". *Chem. Rev.* 1978, *78*, 407.

70. W. J. le Noble and A. R.Miller, "Chlorine Kinetic Isotope Effects in the Methylation of Pyridine and 2,6-Lutidine". *J. Org. Chem.* 1979, *44*, 889.

71. W. J. le Noble, D. M. Chiou and Y. Okaya, "Evidence for a Carbene-Anion Pair. 1,4-Disubstituted Adamantanes as a Stereochemical Probe". *J. Am. Chem. Soc.* 1979, *101*, 3244.

72. W. J. le Noble, S. Bitterman, P. Staub, F. K. Meyer, and A. E. Merbach, "Volume Profile of the Degenerate Equilibration of a Classical Norbornyl Ion". *J. Org. Chem.* 1979, *44*, 3263.

73. Y. Okaya, D. M. Chiou, and W. J. le Noble, "The Structure of *Z*-2-Ethylnyl-5-phenyl-2-adamantanol". *Acta Cryst.* 1979, *B35*, 2268.

74. W. J. le Noble, "Pairing under Pressure". High Pressure Science and Technology, 1979, *2*, 800; Proc. VIIth Airapt Conf. le Creusot, France, 1979.

75. Y. Okaya, S. Y. Lin, D. M. Chiou, and W. J. le Noble, "The Structure of *E*- and *Z*-2-Ethynyl-2-chloro-5- phenyladamantane". *Acta Cryst.* 1980, *B36*, 977.

76. W. J. le Noble, "In Memory of H. L. Meerwein (Topics in Current Chemistry)". *J. Am. Chem. Soc.* 1980, *102*, 5131.

77. W. J. le Noble and H. Kelm, "Chemistry in Compressed Solutions". *Angew. Chem., Int. Ed. Engl.* 1980, *19*, 841 (Germ. Ed.: p. 887).

78. W. J. le Noble, "The Volume Profile of Chemical Reactions". *Rev. Phys. Chem. Japan* 1980, *50*, 207.

79. W. J. le Noble, S. Chang, J. Child, T. Ushijima, and J. Zias, "Mechanism of the Base Promoted Fragmentation of Chloroacetylhydrazide". *Tetrahedron. Lett.* 1981, *22*, 417.

80. W. J. le Noble, R. Wedinger, and R. Schlott, "All Glass Mixing Device for Reactions under Pressures in the 10 Kbar Range". *Rev. Sci. Instrum.* 1981, *52*, 128.

81. W. J. le Noble, S. Basak and S. Srivastava, "Dimethylpentatetraenylidene". *J. Am. Chem. Soc.* 1981, *103*, 4638.

82. W. J. le Noble, E. M. Schulman, and A. E. Merbach, "Volume Profile of the Equilibration of a Non-Classical 7-Norbornadienyl Cation". *J. Org. Chem.* 1981, *46*, 3352.

83. W. J. le Noble and C. S. Springer, "Volume Profiles of Chemical Reactions". Proc. 17th State-of-the-Art Symposium, "High Pressure as a Reagent and as an Environment", Washington, D.C. 1981, 128.

84. W. J. le Noble and C. S. Springer, "Volume Profile of Chemical Reactions". Proc. 8th Airapt Conf. Uppsala, Sweden, 1982, 62.

85. J. H. Balschi, V. P. Cirillo, W. J. le Noble, M. M. Pike, E. C. Schreiber, S. R. Simon, and C. S. Springer, "Magnetic Resonance Studies of Metal Cation Transport across Biological Membranes: Use of Paramagnetic Lanthanide Ions". *Rare Earths in Mod. Sci. Technol.* **1982**, *3*, 15.

86. W. J. le Noble, "Resonance". Encyclopedia of Science and Technology, 5th Ed. McGraw-Hill, New York, N.Y. 1982, 584.

87. E. M. Schulman, A. E. Merbach, and W. J. le Noble, "Effect of Pressure on Chemically Induced Dynamic Nuclear Polarization (CIDNP)". *J. Org. Chem.* **1982**, *47*, 431.

88. W. J. le Noble, K. R. Brower, C. Brower, and S. Chang, "Pressure Effects on the Rates of Aromatization of Hexamethyl (Dewar Benzene) and Dewar Benzene. Volume as a Factor in Crowded Molecules". *J. Am. Chem. Soc.* **1982**, *104*, 3150.

89. W. J. le Noble, E. Gebicka, and S. Srivastava, "The Effect of Pressure on the Rate of Alkaline Fading of Malachite Green. A Reinvestigation". *J. Am. Chem. Soc.* **1982**, *104*, 3154, 6167.

90. S. Y. Lin, M. Ionov, Y. Okaya, D. M. Chiou, and W. J. le Noble, "The Structure of *E*-2-Ethynyl-2-methyoxy-5- phenyladamantane". *Acta. Cryst.* **1982**, *B38*, 1666.

91. S. Y. Lin, Y. Okaya, D. M. Chiou, and W. J. le Noble, "Structure of 2-Ethynyladamantan-2-o1". *Acta Cryst.* **1982**, *B38*, 1669.

92. W. J. le Noble, S. Srivastava, and C. K. Cheung, "5-t-Butyladamantan-2-one". *J. Org. Chem.* **1983**, *48*, 1099.

93. W. J. le Noble, "Sodium borohydride explosion". Letter Ed. *Chem Eng. News*, **1983**, *2*, 5/9.

94. W. J. le Noble, S. Srivastava, R. Breslow, and G. Trainor, "Effect of Pressure on Two Cyclodextrin-Promoted Ester Hydrolyses". *J. Am. Chem. Soc,*. **1983**, *105*, 2745.

95. S. Chang and W. J. le Noble, "Study of Ion-Pair Return in 2-Norbornyl Brosylate by Means of ^{17}O NMR". *J. Am. Chem. Soc,*. **1983**, *105*, 3708.

96. E. Gebicka and W. J. le Noble, "Pressure-induced Changes in Solvent Sorting by Solute Molecules". *Tetrahedron Lett,*. **1983**, *24*, 2427.

97. G. Jenner, S. Srivastava, and W. J. le Noble, "Solvolysis of 9-Chloropentacyclo-[4.3.0.$0^{2,4}$.$0^{3,8}$.$0^{5,7}$] nonane ("Coates' Chloride") under Pressure". *Tetrahedron Lett.* **1983**, *24*, 2429.

98. S. Srivastava, S. Chang, J. Lauher, G. Jenner, and W. J. le Noble, "Structure of Solid Di-9-Pentacyclo [4.3.0.$0^{2,4}$.$0^{3,8}$.$0^{5,7}$] nonyl Ether ("Coates' Ether"). Bond Shortening in an Eclipsed Bicyclopropyl". *Tetrahedron Lett.* 1983, *24*, 2431.

99. E. M. Schulman, A. E. Merbach, M. Turin, R. Wedinger, and W. J. le Noble, "Effects of Pressure on the Rates of Sigmatropic Shifts. The Volume as an Indication of a Wide Mechanistic Range". *J. Am. Chem. Soc.* 1983, *105*, 3988.

100. W. J. le Noble, "Der Einflusz des Drucks auf organische Reaktionen in Lösung". *Chemie i.u. Zeit*, **1983**, *17*, 152.

101. G. Jenner, M. Papadopoulos, and W. J. le Noble, "Ring Size Effect on the Activation Volume in the High Pressure [4 + 2] Cycloadditions of Hexachlorocyclopentadiene with *cis*-Cycloalkenes". *Nouv. J. Chim.* **1983**, *7*, 687.

102. W. J. le Noble and R. Schlott, "Truly Constant Diameter High-Pressure Quartz Optical Cell". *Rev. Sci. Instrum.*, **1984**, *55*, 132.

103. S. Chang and W. J. le Noble, "Search for Oxygen Scrambling during Ethanolysis of [*ether*-^{17}0]-*endo*-2-Norbornyl Mesylate. The True *Exo/Endo* Rate Ratio and the Nature of the Rate-Controlling Steps". *J. Am. Chem. Soc.* **1984**, *106*, 810.

104. S. Srivastava and W. J. le Noble, "5-Hydroxyadamantane-2-one". *Synthetic Commun.* **1984**, *14*, 65.

105. A. R. Katritzky, K. Sakizadeh, B. Gabrielsen, and W. J. le Noble, "Identification of Classical S_N2 and Ion-Molecule Pair Mechanisms in the Second Order Piperidine Displacement of Pyridines from N-Benzylpyridinium Cations". *J. Am. Chem. Soc.* **1984**, *106*, 1879.

106. R. Wedinger, H. Hogeveen, and W. J. le Noble, "Structures of Pyridines Obtained in the Aluminum Bromide Mediated Cyclocongregation of Acetylenes with Cyanoformates". *J. Org. Chem.* **1984**, *49*, 1338.

107. W. P. Roberts, S. Srivastava, and W. J. le Noble, "On the Road to Dodecahedrane". *Indust. Chem. News.* August **1984**, *5*, 24.

108. S. D. Hamann and W. J. le Noble, "The Estimation of Activation Parameters: Corrections and Incorrections". *J. Chem. Educ.* **1984**, *61*, 658.

109. K. Tamara, S. Sugiyama, and W. J. le Noble "Macroscopic Diffusion Control in High Pressure Photochemistry". *J. Org. Chem.* **1984**, *49*, 3836.

110. S. Srivastava, M. J. DeCicco, E. Kuo, and W. J. le Noble, "Ionization Volumes by Means of Direct Dilatometry". *J. Solution Chem.* **1984**, *13*, 663.

111. S. Srivastava and W. J. le Noble, "SET Mechanism in the Lithium Aluminum Deuteride Reduction of Chloroadamantanes, and its Induction by Remote Substituents". *Tetrahedron Lett.* **1984**, *25*, 4871.

112. S. Srivastava, J. Minore, C. K. Cheung and W. J. le Noble, "Reduction of Aromatic Rings by 2-Propanol with Raney Nickel Catalysis". *J. Org. Chem.* **1985**, *50*, 394.

113. S. Srivastava, C. K. Cheung, and W. J. le Noble, "Definitive Identification of the C_5 and C_7 Signals of 2-Adamantanol". *Magn. Res. Chem.* **1985**, *23*, 232 and **1989**, *27 (6)*, II.

114. E. Kuo, S. Srivastava, C.K. Cheung, and W. J. le Noble, "Facile Reduction of Aromatic Nitro Compounds to Anilines with 2-Propanol and Raney Nickel". *Synthetic Commun.* **1985**, *15*, 599.

115. C. K. Cheung, L. T. Tseng, M. H. Lin, S. Srivastava, and W. J. le Noble, "Geometric Equivalents of Enantiomers in Studies of the Stereochemical Course of Substitution at Carbon. Electronic Effects on Nucleophilic Addition to Carbonyl Groups and to Carbocations. Virtual Proof of the Existence of Sigma Participation by Unstrained Carbon-Carbon Bonds". *J. Am. Chem. Soc.* **1986,** *108*, 1598 and **1987**, *109*, 7239.

116. F. Ramirez, J. Marecek, J. Minore, S. Srivastava, and W. J. le Noble, "On the Freeness of Metaphosphate Anion in Aqueous Solutions". *J. Am. Chem. Soc.* **1986,** *108,* 348.

117. M.-H. Lin and W. J. le Noble, "Preparation of *E*- and *Z*- 5-Deuterioadamantan-2-ol". *J. Lab. Comp. Radiopharm.* 1987, *24*, 1285.

118. S. Srivastava and W. J. le Noble, "Hyperconjugation as a Stereoinductive Factor in the Approach of Electrophiles to Trigonal Carbon". *J. Am. Chem. Soc.* **1987,** *109,* 5874.

119. W. J. le Noble, "Kinetics of Organic Reactions at High Pressure". High Pressure Chemistry and Biochemistry, R. van Eldik and J. Jonas, Ed. D. Reidel, Boston, MA, **1987**, 279.

120. W. J. le Noble, "Organic Synthesis at High Pressure," High Pressure Chemistry and Biochemistry, R. van Eldik and J. Jonas, Ed. D. Reidel, Boston, MA, **1987**, 295.

121. E. M. Schulman, C. K. Cheung, A. E. Merbach, H. Yamada, and W. J. le Noble, "Pressure Effect on the ^{1}H NMR Spectra of Organic Compounds in the Presence of Lanthanide Shift Reagents. A Formally Associative Process Characterized by Volume Expansion". *J. Am. Chem. Soc.* **1987,** *109*, 7206.

122. W. J. le Noble, "Renaissance of Hyperconjugation". *Chemica* (India), **1987**, 4.

123. S. Basak, S. Srivastava, and W. J. le Noble, "Search for Ethynylogs of Allenylidene. Zwitterionic Nature of Dimethylpentataetraenylidene". *J. Org. Chem.* **1987**, *52*, 5095.

124. W. J. le Noble, "Introduction". Ch. 1, "High Pressure Organic Chemistry," W. J. le Noble, Ed. Elsevier, Amsterdam, **1988**.

125. E. Whalley and W. J. le Noble, "Carbocationic Reactions". Ch. 8, "High Pressure Organic Chemistry," W. J. le Noble, Ed. Elsevier, Amsterdam, **1988**.

126. W. J. le Noble, "Carbenes and Related Species. Conclusions". Ch. 14, "High Pressure Organic Chemistry," W. J. le Noble, Ed. Elsevier, Amsterdam, **1988**.

127. M.-H. Lin, C. K. Cheung, and W. J. le Noble, "Sigma Delocalization Induced Stereoselectivity in the Capture of Cumyl Cations, and Failure of Stabilizing Substitutents to Suppress It". *J. Am. Chem. Soc.* 1988, *110*, 6562.

128. M.-H. Lin, J. E. Silver, and W. J. le Noble, "Search for Nucleophilicity Effect on the Face Selectivity of Addition to a Sterically Unbiased Ketone". *J. Org. Chem.*,1988, *53*, 5155.

129. W.-S. Chung, N. J. Turro, S. Srivastava, H. Li, and W. J. le Noble, "Hyperconjugation as a Factor in Face Selectivity during Cycloaddition". *J. Am. Chem. Soc.* **1988,** *110*, 7882.

161. M. Kaselj and W. J. le Noble, "Reduction od Adamantanone: Face Selection Induced by 4-Halo- and 4,9-Dihalo Substitution". *J. Org. Chem.* **1996**, *61*, 4157.

162. E. M. Gonikberg, F. Picart, and W. J. le Noble, "Enhanced Stereoselectivity in the Capture of a 5-Substituted 2-Adamantyl Radical by Substitution of C-5 by Negative Boron". *J. Org. Chem.* **1996**, *61*, 9588 and **1997**, *62*, 4885.

163. W.-S. Chung, T.-L. Tsai, C.-C. Ho, M.Y. N. Chiang, and W. J. le Noble, "Face Selectivity in the 1,3-Dipolar Cycloaddition Reactions of Benzonitrile Oxide with 5-Substituted Adamantan-2-thiones and 2-Methyleneadamantanes". *J. Org. Chem.* **1997**, *62*, 4672.

164. W. J. le Noble, Review of "Chemistry under Extreme or Non-Classical Conditions". R. van Eldik and C. D. Hubbard, Eds. *J. Chem. Educ.***1997**, *74*, 764.

165. W. J. le Noble and C. S. Springer, "Shaper Image". Letter to the Editor, *Scientific American*, **October** 1997, 8.

166. W. J. le Noble, Review of "Perspectives on Structure and Mechanism in Organic Chemistry". F. A. Carroll. *J. Chem. Educ.* **1998**, *75*, 417.

167. C. D. Jones, M.Kaselj, R. N. Salvatore, and W. J. le Noble, "Effects of Substituent Modification on Face Selection in Reduction". *J. Org. Chem.* **1998**, *63*, 2758.

168. M. Kaselj, E. M. Gonikberg, and W. J. le Noble, "Effect of Remote Substitution in Addition Reactions of Nor- and Homoadamantan-9-ones and of Several Analogs". *J. Org. Chem.* **1998**, *63*, 3218.

169. A. Drijaca, C. D. Hubbard, R. van Eldik. T. Asano, M. V. Basilevsky, and W. J. le Noble, "Activation and Reaction Volumes 3". *Chem. Rev.* **1998**, *98*, 2167.

170. T.-L. Tsai, W.-C. Chen, C.-H. Yu, W. J. le Noble, and W.-S. Chung, "Temperature and Para Substituent Effects on the Face Selectivity of 1,3-Dipolar Cycloaddition Reactions of Benzonitrile Oxides with 5-Substituted Adamantan-2-imines and 2-methyleneadamantanes". *J. Org. Chem.* **1999**, *64*, 1099.

171. B. W. Gung and W. J. le Noble, "Introduction". *Chem. Rev.* **1999**, *99*, 1067.

172. M. Kaselj, W.-S. Chung and W. J. le Noble, "Face Selection in Addition and Elimination in Sterically Unbiased Systems". *Chem. Rev.* **1999**, *99*, 1387.

173. W. J. le Noble, "Organic Reaction Mechanisms". *Encyclopedia of Life Sciemces,* Nature Publishing Group, London **2001**, *13*, 546.

174. W. J. le Noble and T. Asano, "Comment on "Phantom Activation Volumes"" *J. Phys. Chem. A* **2001**, *105*, 3428.

175. W. J. le Noble, "Internal Pressure : Its Use and Abuse", Rev. High Press. Sci. & Technol., 2002, 12, 224.

176. S.D. Hamann and W. J. le Noble, "Comment on "Phantom Activation Volumes", J. Phys. Chem. A, 2004, 108, 7121.