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BA in Chemistry, Kalamazoo College, 1962; PhD in Organic Chemistry, Baylor University, 1969. Assistant Professor, Associate Professor, and Professor of Chemistry, Drake University, 1967-2002, Visiting Scientist, Stanford University, 1983-84; Visiting Professor of Chemistry, University of Oregon, 1990-91; Visiting Professor of Chemistry, Visiting Scientist, Stanford University, 1998-99; Visiting Professor, Grinnell College, 2002—.

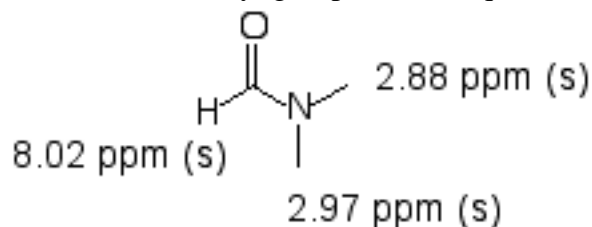
SYNTHETIC ORGANIC CHEMISTRY, applications of 1,3-dipolar cycloaddition; mixed aldol condensation as a route to unknown compounds; the organic chemistry of starting materials useful in synthesis of antisense oligonucleotides; PHYSICAL ORGANIC CHEMISTRY restricted rotation in amides; CHEMICAL EDUCATION, interactive Web pages for teaching organic chemistry.

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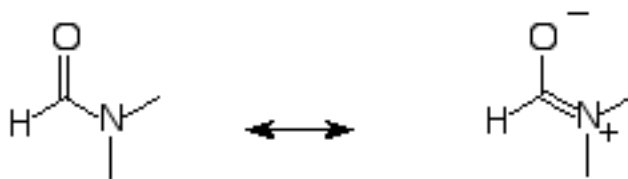
2 areas for summer 2006: restricted rotation; 1,3-dipolar cycloaddition

I. Solvent Effects in Restricted Rotation

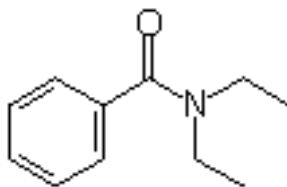
Because of the partial double bond character of the amide bond, there is a restriction in rotation about the amide bond. This is apparent in the classic case of N,N-dimethylformamide where the two methyl groups are nonequivalent.



The rationalization for nonequivalence includes the additional resonance form shown.



Students in Advanced Organic Chemistry synthesized a series of acid chlorides, esters, and amides in an exercise designed to discover interesting similarities and differences in NMR spectra and to observe the effect of restricted rotation on the chemical shifts of various amides. Observations were made that led Neil Tomson to pursue a study of the temperature dependence of N,N-diethylbenzamide.



In the process he discovered differing effects in several solvents. The two methylene protons at ambient temperature in D₂O were well resolved and widely spaced, but in d₆ acetone they were poorly resolved and nearer to coalescence. The properties varied coherently as the mixture was changed from one solvent to the other. One can rationalize that the polar, high dielectric water is stabilizing the charges thus enhancing the double bond character. A coalescence study was also conducted. It is expected that amides and solvents can be selected that will coalesce at a variety of temperatures. The Tomson work was presented at the 2004 Biennial Conference on Chemical Education, Ames, Iowa. The Tomson study will be extended during the summer to include other solvent mixtures.

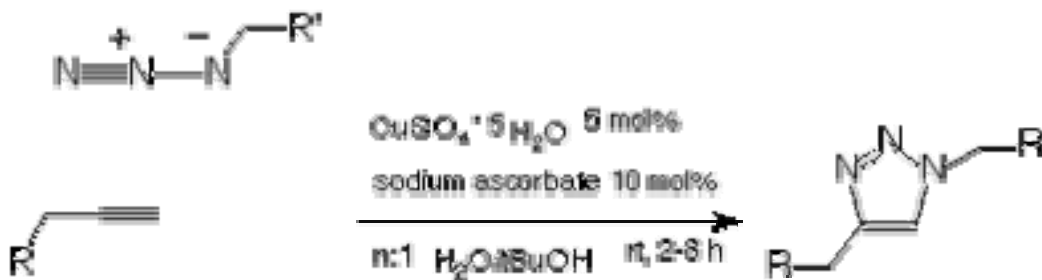
This project requires two semesters of physical chemistry. Based upon the summer research of 2006 posters will be presented on campus during the summer and fall. The work will be submitted to the *Journal of Chemical Education*.

References

- S. Braun, H.-O. Kalinowski, S. Berger, *150 and More Basic NMR Experiments*, 2nd Expanded Edition, Wiley-VCH, Weinheim, 1998
 Neil Tomson, "Integrating Synthesis, Restricted Rotation, and Solvent Effects through Amides," an independent project for Chemistry 325, Grinnell College, Fall, 2003
 Neil C. Tomson and James G. Lindberg, "Observing solvent effects on amide rotation in the organic laboratory," 18th Biennial Conference on Chemical Education, Ames, IA, July, 2004

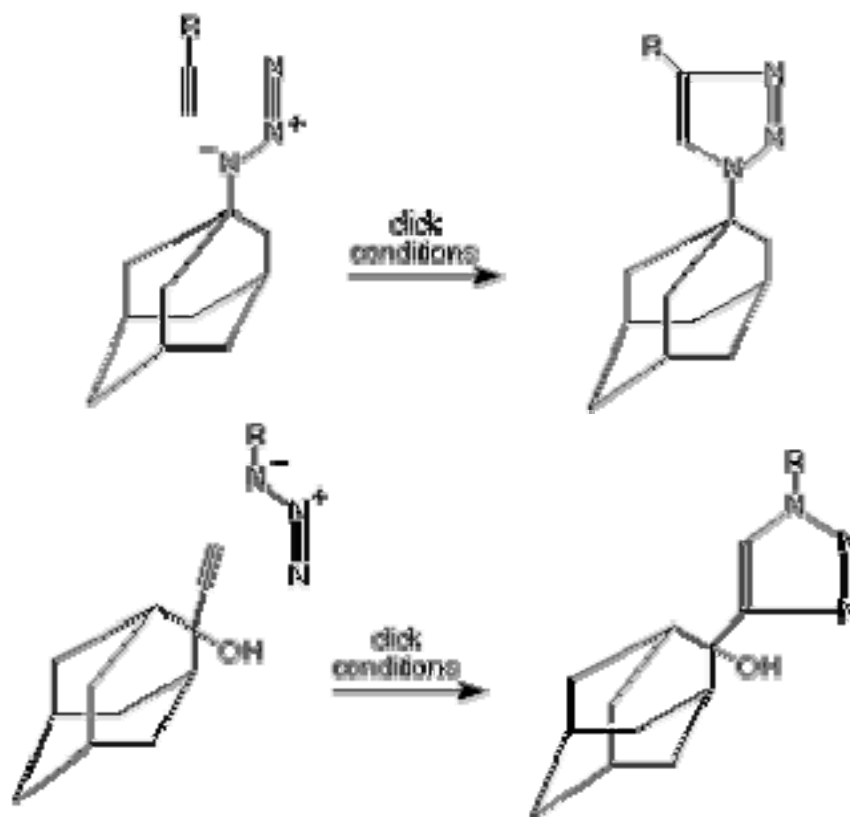
II. Synthetic applications of 1,3-dipolar cycloaddition

The field of 1,3-dipolar cycloadditions (click chemistry) is active and manageable. In this laboratory we have had considerable experience.



1,3-dipolar cycloaddition by the copper(II) ligation reaction (a "click" reaction)
 Because derivatives of adamantane have shown activity as antivirals and anti-Parkinson drugs, the MAP project of Amy Danowitz will be extended to include more derivatives.

Starting materials will include the commercially available 1-azidoadamantane and 2-ethynyl-2-adamantanol as prepared by Noah Bindman. Each will be combined with a variety of terminal alkynes and organic azides as supplied by William D. Sharpless '03.



Based upon the summer research of 2006 posters will be presented on campus during the summer and fall and submitted to national meetings and journals.

References

- William D. Sharpless, Peng Wu, Trond Hansen, and James G. Lindberg, *J. Chem Educ.*, **2005**, 82, 1833
- K. Feldman, B. Colasson, K. B. Sharpless and V. V. Fokin, *J. Am. Chem. Soc.*, **2005**, 127, 13444
- Vsevolod V. Rostovsev, Luke G. Green, Valery V. Fokin, and K. Barry Sharpless, *Angew. Chem. Int. Ed.*, **2002**, 41, 2596
- Brice E. Uno and James G. Lindberg, "Synthesis of 1,2,3-triazoles from aldehydes via propargyl alcohols," 231st National ACS Meeting, Atlanta, GA, March 2006
- Amy M. Danowitz and James G. Lindberg, "Synthesis of 1,2,3-triazole analogs of antiviral drugs," 229th National ACS, San Diego, CA, March, 2005
- Noah Bindman, "Synthesis of 1,2,3-triazoles through direct Grignard additions and 1,3-dipolar cycloadditions," Grinnell College MAP 2005
- Soek Hwa Tong, "Conjugate addition to chalcones and 1,3-dipolar cycloadditions," Grinnell College MAP 2005