

THE NUCLEUS

December 1992

Of the Northeastern Section of the American Chemical Society

Vol. LXXI, No. 4

Monthly Meeting

*Symposium on
Molecular Modeling*

Dartmouth's New Laboratory

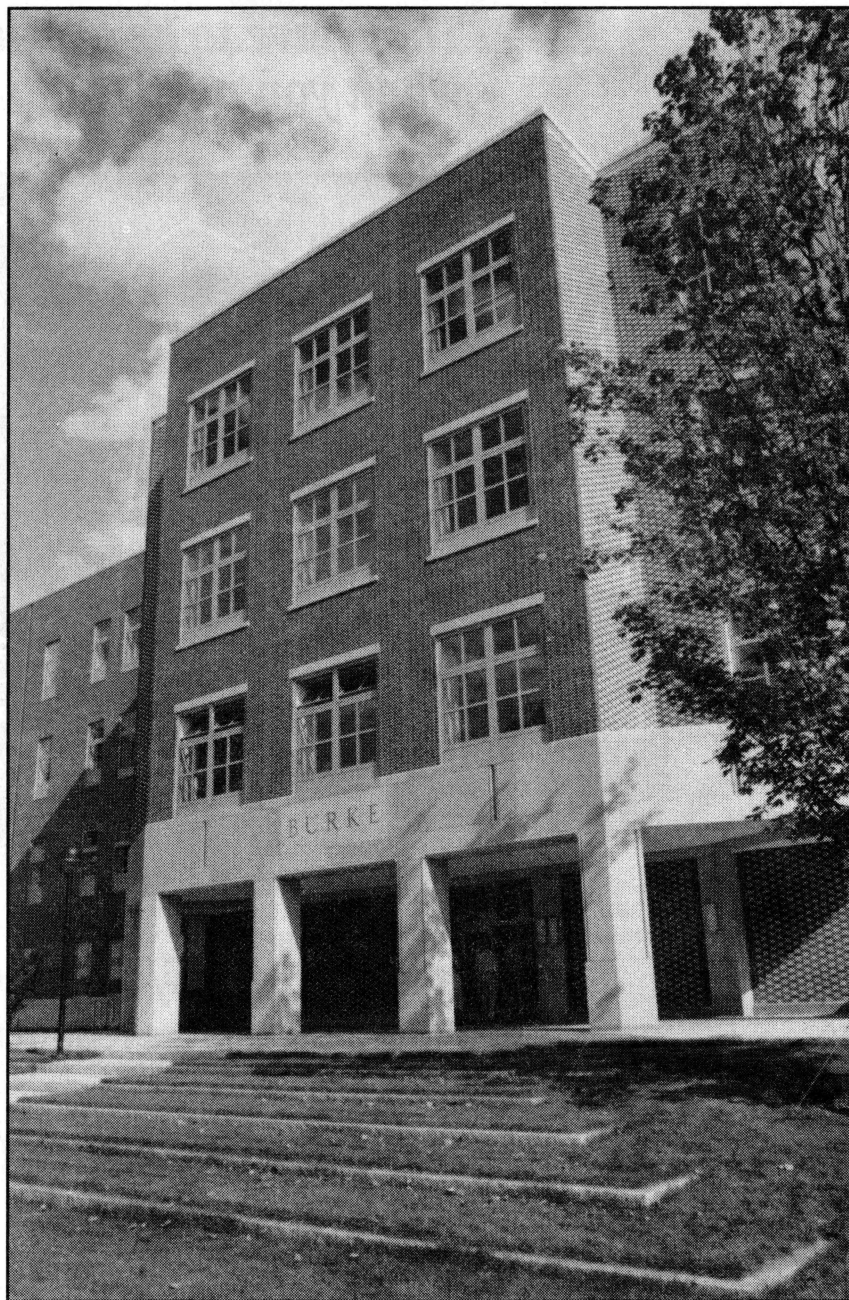
*New Burke Laboratory to House
Chemistry Teaching and Research*

Environmental Chemistry Column

*Acid, Acid Go Away:
Acid Rain Clean-Up*

Technological Leadership

*From Lester Thurow's talk at the
October NESACS Professional
Relations Meeting*



When you need to hire temporary personnel for your lab, chances are you have two basic requirements.

- 1. They have to be qualified.**
- 2. They have to be available when you need them.**



Call the one company that specializes in filling both of those requirements.



LAB SUPPORT

Science Professionals On Assignment

Boston (617) 229-2505

The Northeastern Section of The American Chemical Society, Inc.

Office: Sue O'Connor, 8 Winch Park Rd., Framingham, MA 01701. 1-800-872-2054. Any Section business may be conducted via the business office above. Washington, D.C. ACS Hotline: 1-800-227-5558

Officers 1992

Chairman
Katie Stygall
Bradford College
Bradford, MA 01830, 508-372-7161 ext. 311

Chairman-Elect
Dorothy J. Phillips
Waters Division of Millipore Corp.
34 Maple St., Milford, MA 01757, 508-478-2000 ext. 2860

Immed. Past Chairman
Charles E. Kolb, Jr.
Aerodyne Research, Inc., 45 Manning Rd.
Billerica, MA 01821, 508-663-9500

Secretary
Michael J. Hearn
Chemistry Dept., Wellesley College
Wellesley, MA 02181, 235-0320 ext. 3127

Treasurer
James Piper
Simmons College, 300 The Fenway
Boston, MA 02115, 738-2181

Auditor
Anthony L. Rosner
Chemistry Dept., Brandeis University
Waltham, MA 02154, 736-2000

Trustees
Phyllis Brauner John L. Neumeyer
Adrienne S. Dey

Councilors Alternate Councilors

Term expires 1/1/93 **Term expires 1/1/93**
Mary Burgess E. Joseph Billo
Adrienne S. Dey Wallace J. Gleekman
Esther B. Garber Donald O. Rickter
Thomas R. Gilbert Robert Stolow

Term expires 1/1/94 **Term expires 1/1/94**
Michaeline F. Chen Ernest I. Becker
Arno H.A. Heyn Doris I. Lewis
John L. Neumeyer Myron S. Simon

Term expires 1/1/95 **Term expires 1/1/95**
Catherine Costello Geoffrey Davies
Esther A.H. Hopkins Truman S. Light
Patricia L. Samuel Katie Stygall
Valerie A. Wilcox Alfred Viola

All Chairmen of standing Committees, the editor of THE NUCLEUS, and the Trustees of Section Funds are members of the Board of Directors. Any Councilor of the American Chemical Society residing within the section area is an ex officio member of the Board of Directors.



Contents

Monthly Meeting _____	5
<i>Symposium on Molecular Modeling: Mark A. Murcko, Jonathan Greer and Martin Karplus to Speak</i>	
Dartmouth's New Chemistry Laboratory _____	4
<i>Dartmouth Dedicates its New Burke Laboratory</i>	
The Environmental Chemistry Column _____	9
<i>David Ham on Techniques and Economics of Acid Rain Clean-Up</i>	
Technological Leadership in the 21st Century _____	12
<i>Dean Lester Thurow's Analysis of Coming Changes and Their Effect on the US Competitive Position</i>	
Historical Notes _____	14
<i>Continuation of Biographical Sketches of Recently Deceased Chemists</i>	
Consulting Chemists' Meeting _____	15
<i>Dick Menard to Speak on "Alternative Dispute Resolution". The Ins and Outs of Arbitration</i>	

Cover: *The New Burke Laboratory at Dartmouth.*
(Photo by Stuart Brateeman/Dartmouth College)

Deadline: *February, 1993 issue: December 18, 1992*

THE NUCLEUS

Dedicated to the Memory of James Flack Norris
Published monthly from October to May by the Northeastern Section of the American Chemical Society, Inc.



The Nucleus is distributed to the members of the Northeastern Section of the American Chemical Society, to the secretaries of the Local Sections, and to editors of all local publications. Forms close for advertising on the 1st of the month of the preceding issue. Text must be received by the editor six weeks before the date of issue.

Editor: Arno Heyn, 21 Alexander Rd., Newton, MA 02161, Tel or Fax: 969-5712
Associate Editor: Myron S. Simon, 20 Somerset Rd., W. Newton, MA 02165, Tel: 332-5273
Board of Publications: Joseph A. Lima (Chair), Catherine E. Costello, Michael E. Strem
Business Manager: Karen Piper, 19 Mill Rd., Harvard, MA 01451, Tel: (508) 456-8622
Advertising Manager: Vincent J. Gale, 56 Bartlett Island Way, Marshfield, MA 02050, Tel: 837-0424
Contributing Editors: Edward Atkinson, History of Chemistry, Book Reviews; Maryann Solstad, Health; Chris Arumainayagam, Calendar.
Proofreaders: Donald Rickter, M.S. Simon

Copyright 1992, Northeastern Section of the American Chemical Society, Inc.

Seventh Annual Holiday Chemistry Lecture

*"Once Upon a Christmas Cheery
in the Lab of Shkhashiri"*

Professor Bassam Shkhashiri
University of Wisconsin

assisted by his elves

Sunday, December 27, 1992 at 7:30 p.m.
Monday, December 28, 1992 at 4:00 and 7:30 p.m.

MUSEUM OF SCIENCE
BOSTON, MASSACHUSETTS

A Winter's entertainment for the entire family!

For tickets please send a self-addressed stamped envelope to
Museum of Science, Special Events Office
Science Park, Boston, MA 02114
Seating is limited with a 4-ticket limit per request
Please indicate first & second time choices.

Corporate Patrons

DuPont Merck Pharmaceutical
Company
W. R. Grace & Company
Hoechst Celanese Corporation
Polaroid Corporation
Chemical Research Division

Corporate Sponsors

Aerodyne Research, Inc.
Arthur D. Little, Inc.
Consulting Resources Corporation
Duracell, Inc.
Houghton Chemical Corp.
ICI Resins US
Johnson Matthey Catalog Co., Inc.
Organix, Inc.
Orion Research, Inc.
Physical Sciences, Inc.
Research Biochemicals, Inc.
Strem Chemicals, Inc.
Van Waters & Rogers, Inc. (VW&R)
Waters Division of Millipore

December Meeting

The 748th Meeting of the Northeastern Section of the
American Chemical Society, jointly with the Medicinal
Chemistry Group



Symposium on Molecular Modeling

Thursday, December 10, 1992
Boston College, Chestnut Hill, MA
Chemistry Building, Room 130

- 3:00** Refreshments
3:30 Mark A. Murcko, Vertex Pharmaceuticals, Inc.
Some Recent Examples of Computer-Assisted Drug Design
4:30 Jonathan Greer, Abbott Laboratories
*Comparative Homology Modeling of Proteins of the Mammalian
Serine Protease Family*

Faculty Dining Room, McElroy Commons

- 5:30** Social Hour
6:15 Dinner
7:45 Martin Karplus, Harvard University
*Simulations of the Recognition Processes in Proteins: Binding Free
Energies and Ligand Design*

Refreshments will be served after the program.

Dinner reservations should be made no later than December 4. Please call Sue O'Connor at (800) 572-2054. Reservations not cancelled at least 24 hours in advance must be paid. Members, \$21.00; Non-members, \$23.00; Retirees, \$12.50; Students, \$8.00. THE PUBLIC IS INVITED.

Anyone who needs special services or transportation, please call Sue O'Connor a few days in advance so that suitable arrangements can be made.

Parking will be provided in the garage off Beacon St. close to the Chemistry Building.

Next meeting: January 14, 1993 at Boston College, 5:30 p.m. Shea Forum Dining Room; 7:45 p.m. Chemistry Bldg., Rm. 127: Dr. Robert Varnerin, Boston University: Performance Standards - A Pro-active Approach to Chemical Safety. Members of the American Society of Safety Engineers have also been invited to this meeting.

Biography

Martin Karplus

Born in Vienna, Austria, Martin Karplus graduated from Harvard College, received his PhD from the California Institute of Technology where he worked with Linus Pauling, and was subsequently a postdoctoral fellow

with C.A. Coulson at Oxford University. Prof. Karplus has worked in diverse areas of theoretical chemistry including the interpretation of NMR and ESR molecular spectra using quantum mechanical methods, the development of techniques for the evaluation of molecular properties, and the formulation of detailed models for chemical reactions. Most recently, he has been primarily concerned with the calculation and simulation of the prop-

Abstract

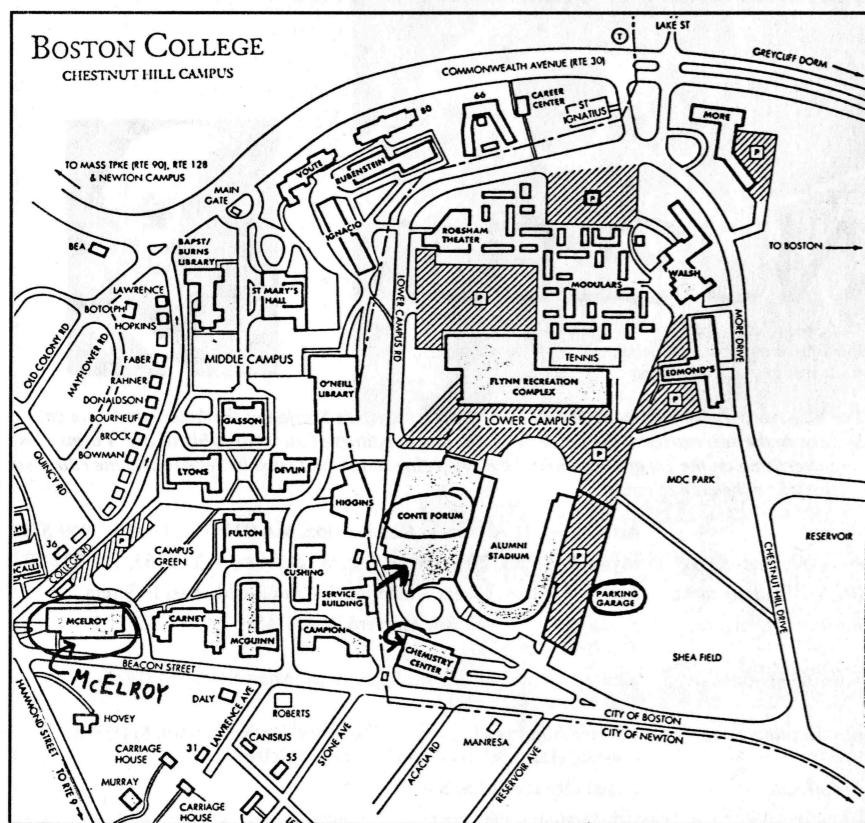
Simulations of the Recognition Processes in Proteins: Binding Free Energies and Ligand Design

Simulations of macromolecules of biological interest are useful for increasing our understanding of the structure, dynamics, and thermodynamics of these complex systems. After a brief introduction to the methodology, some applications will be presented. They include an analysis of free energies of binding and the description of new methods for ligand design. ◇

erties of biologically important molecules. Prof. Karplus is the author or coauthor of over 400 scientific publications and two books, one of which is a widely used book on quantum chemistry. Among the many honors that he has received, he is a member of the National Academy of Sciences and the first recipient of the recently instituted Theoretical Chemistry Award from the American Chemical Society. Currently, he is the Theodore William Richards Professor of Chemistry at Harvard University. ◇

Support Our Advertisers

PROTECT
Your Expensive Lab Work with Research and Development Record Books
STOCK RECORD BOOKS
B50D — Fifty pages and fifty duplicates.
1/4 inch sqs. on right pages.
B100P — 100-1/4 inch sqs. on right pages.
100-10 sqs. per inch on left pages.
B200P — 208 1/4 inch sqs. on right and left pages.
B200PH — 208 horizontally lined right and left pages.
Books have instruction and TOC's. Page size is 11 x 8 1/2.
Hard extension brown cloth covers. Pages open flat.
\$10.50 each, FOB Chicago
CUSTOM MADE BOOKS TO ORDER
SCIENTIFIC BINDERY PRODUCTIONS
1255 S. Wabash Ave., Chicago, IL 60605
Phone: 312-939-3449 Fax: 312-939-3787



Dartmouth's New Chemistry Research Building

In September Dartmouth College dedicated its new Burke Laboratory, the \$26.5 million home of its Chemistry Department.

Three of the building's most striking features are its open design to encourage faculty and student interaction, its attention to safety details and an extensive computer system which includes student work stations suitable for three-dimensional graphics.

The laboratory with 80,000 square feet and four levels represents a tremendous commitment by Dartmouth to the future of science education at both undergraduate and graduate levels. The facility includes a magnetic resonance laboratory and four physical chemistry research laboratories on the ground level, instructional laboratories for organic chemistry, physical chemistry and other advanced chemistry

continued on page 7

Biography

Mark A. Murcko

A native of Connecticut, Mark Murcko received his Bachelor's degree in chemistry from Fairfield University in Fairfield, Connecticut in 1982. He then moved on to graduate work at Yale University in the laboratory of Ken Wiberg. Dr. Murcko's research work involved calorimetry, molecular mechanics, and *ab initio* calculations on organic molecules of fundamental interest for which he received a Ph.D. in organic chemistry in 1987. He then joined the molecular modeling group at Merck Sharp & Dohme in West Point, Pennsylvania where he was involved in a number of drug design projects, most notably the carbonic anhydrase inhibitor work which lead to MK-507, currently in Phase III clinical trials for the treatment of glaucoma. In 1990, Dr. Murcko joined Vertex Pharmaceuticals Incorporated, a Cambridge-based start-up company dedicated to the use of structural information for the design of pharmaceutical agents. Dr. Murcko's major research focus is the application of structural information for the process of drug design using a wide variety of modeling and computational tools. ◇

Abstract

Some Recent Examples of Computer-Assisted Drug Design

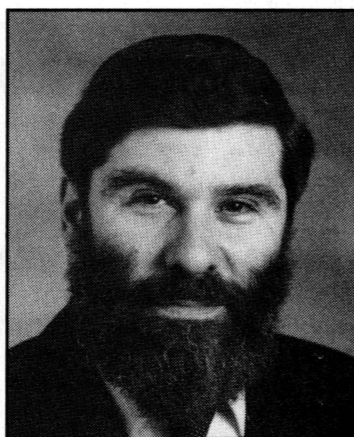
Computer-assisted drug design is most successful whenever atomic-level structural information is available to describe the interactions between drugs and biomolecules. More often than ever before, such information is available through X-ray crystallography and NMR spectroscopy. With access to such structural data, a wide variety of molecular modeling and computational chemistry techniques may then be employed.

One of the most exciting areas of research currently is "de novo" drug design, in which only the structure of the receptor is used to suggest novel inhibitors. Another important new technique is free energy perturbation, in which relative binding energies for related inhibitors may be calculated. These and other techniques, and their application to a variety of problems of current therapeutic interest, will be described. ◇

Biography

Jonathan Greer

Jonathan Greer received his Ph.D. from the University of Cambridge in 1970 where he worked with Max F. Perutz on the crystal structures of human mutant hemoglobins. Afterwards he was a Helen Hay Whitney Postdoctoral Fellow for three years in the laboratory of Frederic M. Richards at Yale University where he studied membrane proteins such as the visual pigment rhodopsin. Subsequently he joined the faculty of the Department of Biological Sciences at Columbia University where he studied the structure and function of the blood protein haptoglobin using a wide variety of techniques including crystallography, biochemistry, fluorescence, and electron microscopy. In 1982 Dr. Greer joined Abbott Laboratories as a senior project leader in the Computer Assisted Molecular Design Group of the Pharmaceuticals Products Division. Among his continuing research interests are the application of computational and experimental techniques to elucidate the structures of peptides, proteins, and protein-ligand complexes, developing comparative homology modeling methods to determine protein structures, and the use of three-dimensional structures of biological molecules to aid in the design of novel pharmaceutical agents. ◇



Abstract

Comparative Homology Modeling of Proteins of the Mammalian Serine Protease Family

The methods that are used to model homologous proteins will be described. Model structures will be illustrated by examples from the serine protease family. One of the proteins modeled is urokinase, a plasminogen activator involved in fibrin clot lysis and cell-cell interactions. A three-dimensional model of urokinase was developed and used to help understand the structure-activity of a new family of specific inhibitors, the phenylguanidines. The model was also valuable in rationalizing the abnormal enzymatic properties of a group of mutated urokinases. The nature of protein-protein interaction and aggregation was studied by docking a model of haptoglobin, a non-enzymatic serine protease homolog, on to a hemoglobin molecule to propose a three-dimensional structure for the extremely stable complex of these two proteins. A model structure of blood clotting factor Xa was recently used by Tulinsky and coworkers to solve the crystal structure of factor Xa. The model structure can now be compared to the refined crystallographic structure. ◇

Nominations ACS Nominations

Philip L. Levins Memorial Prize

Nominations for the Philip L. Levins Memorial Prize should be sent to William O. Foye, Chairman, Awards Committee, at 179 Longwood Ave., Boston, MA 02115 by February 15. The prize is awarded for outstanding performance by a graduate student whose research is in the area of organic, analytical or environmental chemistry. Please include a biographical sketch, transcript of graduate and undergraduate grades, a description of present research activity, and three references. ◇

Dartmouth

continued from page 4

courses on the first level, research laboratories for synthetic chemistry and biochemistry on the second and third levels.

The new research facility represents a major turning point for the Chemistry Department which has long been considered one of the college's strongest departments.

Recently, growth of the department has been limited by overcrowded facilities and obsolescence in its former 70 year-old building which was last renovated 30 years ago.

From a release of the Dartmouth College News Service ◇

Patterson-Crane Award

The Dayton and Columbus Sections solicit nominations for this international award which is bestowed on those who have made outstanding contributions to the field of chemical literature, especially in the documentation of chemistry, chemical information storage and retrieval, and implementation and management of chemical information services.

The award is bestowed in honor of Austin M. Patterson and E.J. Crane, who were members of the Ohio sections, each an outstanding pioneer in the field.

The biennial award consists of a \$2,000 honorarium and a personalized commendation.

Nominations must be in writing and should include the nominee's contribution to the field and an evaluation of his or her accomplishments, a biography and bibliography of publications. Seconding letters are required.

Send nominations by January 31, 1993 to: The Patterson-Crane Award Committee, Margaret Roach, Chairman, Wright State University, Dunbar Library, Dayton, OH 45435

Francis P. Garvan-John M. Olin Medal

Formerly known as the Garvan Medal; The Women Chemists Committee is inviting nominations for this award.

The purpose of the award is to recognize distinguished service to chemistry by women chemists who are citizens of the United States. The award was established in 1936 through a donation from Francis P. Garvan. The Olin Corporation assumed sponsorship of the award in 1990, hence the new name.

The award consists of a gold medal, a bronze replica thereof, an honorarium and an allowance for travel to the award presentation where the recipient will deliver an address upon the subject of her scientific work and is expected to address a Women Chemists' Luncheon.

For information about the Award please call Dr. Mary E. Thompson, chair of the Women Chemists' Committee at (612) 690-6619. For details on the nominating procedure, call the ACS Awards Office at (202) 872-4408.

The complete nominating document must be postmarked no later than February 1, 1993 and sent to: Awards Office, American Chemical Society, 1155 Sixteenth St., NW, Washington, DC 20036. ◇

Microscale Laboratory Workshop for Community Colleges on General and Organic Chemistry

Date: January 4th-8th, 1993

This workshop is for science faculty teaching chemistry at community colleges and will be held at Roxbury Community College, Roxbury Crossing, MA 02120-3400


Offered by:

Merrimack College Chemistry Dept., Roxbury Community College and the

Environmental Protection Agency (There is no cost for participants)

Deadline for application is December 10, 1992

For information, call Dr. Ronald M. Pike (508) 683-7111 ext. 4384



For Elemental & Chemical Bonding Analytical Services

The information you need...when you need it®

Your local lab in New England for:
Micro-FTIR, ESCA, SEM, Light Element EDS, SAM & SIMS

Call to schedule a free facility tour and consultation

4 Arrow Dr., Woburn, MA 01821 (617) 938-0300 Fax (617) 935-5087

The Longest Established Part-Time Graduate Program in
New England



EVENING GRADUATE PROGRAM in CHEMISTRY at NORTHEASTERN UNIVERSITY

Take courses to -
keep up-to-date
improve professional qualifications
apply toward the part-time Master's program.

*All courses meet for a two-hour period once a week
and carry two quarter-hours of graduate credit
toward the 40 quarter-hour requirement for an M.S. degree*

Courses are taught by Full-time Faculty in their area of expertise

OFFERED THIS WINTER QUARTER (Classes begin January 4, 1993)

Introductory Level Graduate Courses:

(Prerequisite: the equivalent of a Bachelor's degree in Chemistry)

Analytical Separations 1
Chemical Thermodynamics 1

Continuing Introductory Level Graduate Courses:

(Prerequisite: Completion of the previous Quarter course or its equivalent)

Introductory Quantum Chemistry 2
Advanced Organic Chemistry 2
Advanced Inorganic Chemistry 2

Advanced Level Graduate Course:

(Prerequisite: completion of a first year graduate course in Organic Chemistry)

Organic Stereochemistry and Reaction Mechanisms 1

(Additional Courses will be offered in the Spring Quarter)

For additional information contact:

Prof. John L. Roebber, Executive Officer
Department of Chemistry, 4HT
Northeastern University
Boston, MA 02115
Tel: (617) 437-2383

Northeastern University is an equal opportunity/affirmative action educational institution and employer.

Environmental Chemistry Column

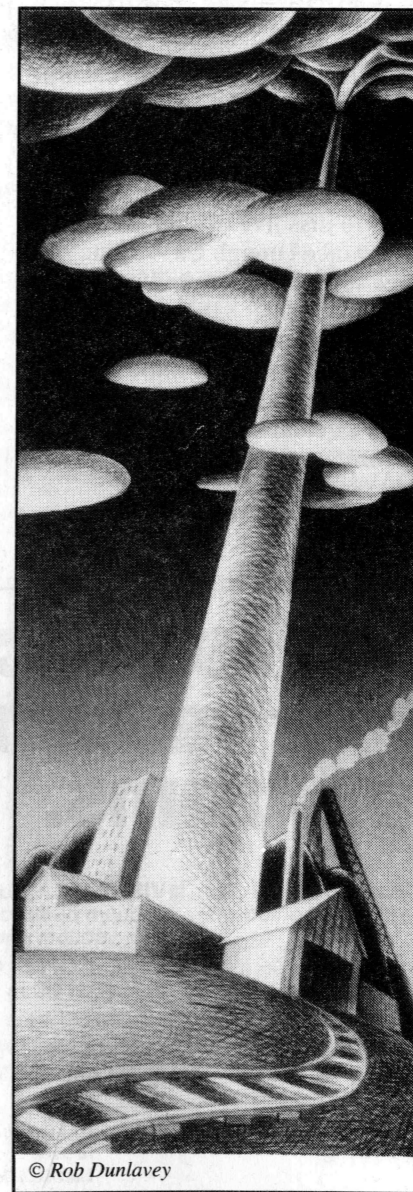
Acid, Acid Go Away: Acid Rain Clean-Up for Trade

by David Ham, President
Envirochem, Inc.

Acid rain is caused primarily by the emissions of SO_2 and NO_x (NO plus NO_2) from coal-fired electric power plants. The atmospheric chemistry of this very public issue was discussed in C.E. Kolb's article in the May 1992 issue of the *NUCLEUS*, "Acid Deposition/Precipitation - Titrating Heaven's Tears." Here, we consider some of the chemical engineering technologies to alleviate the pollution at the sources. These technologies received public attention with the debate and passage of the 1990 Amendments to the Clean Air Act and with claims for its credit in the recent presidential campaign. A hotly debated feature of this legislation established a precedent last month with the opportunity for utilities to buy and sell rights to pollute (allowances) on the Chicago Board of Trade. New SO_x control regulations have just been announced by EPA.

The fuel for the hot debate is the large cost involved in dealing with acid rain problems. About 55% of the electric power in the U.S. is produced by coal-fired power plants. The environmental controls in these plants, for the gaseous pollutants along with water and solid waste management, account for approximately 40% of the capital and 35% of the operating costs of coal-fired electric utilities.

The chief pollutants from coal-fired power plants are sulfur oxides, SO_x (mainly SO_2 with a little SO_3), particulate matter, and nitrogen oxides (NO_x). The SO_x concentrations are typically ten times larger than NO_x concentrations in flue gases. One of the long term goals of the Clean Air Act Amendments is a reduction of roughly 50% in these SO_2 emissions. Processes for removal of SO_2 from power plant flue gases are commonly referred to as flue gas desulfurization or FGD. Estimates for the costs of FGD systems



© Rob Dunlavey

alone by the end of the century are \$6-8 billion for capital expenditures with additional operating expenses of \$3 billion/year. Because of the importance of FGD technologies, this article is focused on these technologies for con-

trolling SO_x from coal-fired power plants.

Commercial Processes

The common commercial FGD processes use sorbent materials to absorb SO_2 from the flue gases. Those now in use are throwaway processes, that is, the sorbent material along with the sulfur removed is discarded in a waste pond or landfill. So far, about 92% of the FGD systems employed in the U.S. are wet scrubbers and 8% are dry scrubbers. Early experiences with these scrubbers were troublesome - dominated by high costs, large space requirements, high energy consumption, poor reliability, and waste disposal problems. The prevailing opinion that scrubbers are fraught with problems and are unreasonably expensive has been largely overcome by improvements stimulated by operating experience.

In wet scrubbers the flue gas is sprayed with a slurry, usually limestone in water. In a dry scrubber (or spray dryer) a finely atomized mist of a lime slurry is sprayed into hot flue gases where they absorb the SO_2 . Reaction occurs largely in the aqueous phase within the pores of the sorbent with similar chemistry as in the wet processes. The high temperature of the gas evaporates the water, forming dry particles. After drying the sulfite/sulfate deposits remain trapped in the sorbent that is collected in a baghouse or electrostatic precipitator.

Most scrubbers use limestone (CaCO_3) or lime (CaO) as the sorbent material. Lime is more reactive than limestone and removes more SO_2 . However, lime is produced by calcining limestone, so it is more expensive. The trade-offs have favored using limestone, except in dry scrubbers where lime's increased reactivity is

continued on page 10

Environmental Chemistry Column

continued from page 9

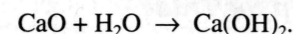
required. SO₂ reacts with either limestone or lime to form a CaSO₃/CaSO₄ sludge that is the throwaway waste.

The most important chemical aspects of these scrubber processes involve (1) the absorption of SO₂ in water and equilibration of bisulfite and sulfite ions, (2) the solubilities of the sorbent materials, and (3) the pH of the slurries.

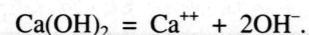
The biggest factors causing the high costs of scrubbing processes result from (1) the large gas flows containing low SO₂ concentrations (less than 0.5%), and (2) the limited solubilities of limestone and lime. These combine to force the use of very large chambers for reacting the slurries with the gases, using high liquid/gas ratios that require even larger overall systems.

CaCO₃ is only slightly soluble in

water, so it is used as a slurry made from finely pulverized limestone. Lime dissolves in water to form slaked lime



Ca(OH)₂ is about 10 times as soluble as CaCO₃, but still rather insoluble, dissociating to form an alkaline solution,



Both in the cases of limestone and lime, calcium ions react with bisulfite ions to remove SO₂ from the solution. Calcium ion concentrations depend upon the pH. In the limestone processes low pH's of 5.8 – 6.2 are required to dissolve enough limestone and produce enough Ca⁺⁺. Lime dissolves sufficiently to produce a solution with pH about 8.0.

Besides controlling the sorbent solubilities the pH is important for another reason; it controls the formation of calcium sulfate deposits. Sulfate ions are formed via oxidation of sulfite by excess oxygen in the flue

gas. The CaSO₄ (gypsum) deposits form a hard scale in the scrubber and downstream that fouls operation. As pH is lowered CaSO₃ becomes much more soluble, CaSO₄ solubility is reduced, and SO₃²⁻ is oxidized more rapidly to SO₄²⁻. These factors combine to limit the pH of limestone scrubbers to a narrow range around 6.0 to avoid scale formation. In lime scrubbers the low solubility of CaSO₃ at high pH leads to "soft pluggage" caused by the formation of leafy masses of CaSO₃. The pH in lime scrubbers must be controlled not to exceed 8.0 to avoid this problem.

Wet scrubbers typically achieve SO₂ removals of 90 – 95% and dry scrubbers achieve 70 – 90% removals. These performances, coupled with the cost of lime for the dry scrubbers that is 3 – 4 times the cost of limestone for the wet scrubbers, lead to the use of dry scrubbers for low sulfur coal applications and wet scrubbers for high sulfur coal applications.

Developmental Processes

The large, lucrative markets opened up by the new regulations have encouraged many companies to develop improved FGD processes. The goals of these developments are to reduce waste, achieve high removals, and, of course, reduce costs. The new regulations with trading provisions put a premium on high removal levels of any installed system to allow for off-setting pollution from older, less controlled plants. With very few new plants being built the primary need is for retrofit technologies that can be used on power plants built prior to the 1971 New Source Performance Standards (NSPS) that generally required new plants to install FGD systems.

Several development efforts have emphasized extending the dry scrubber technology principle by injecting dry powders into the furnace or the flue ducts, thereby avoiding the costs and space requirements for a separate reactor. These processes offer less expensive retrofit technologies but with lower removal rates. These processes also foul the systems and produce solid wastes that must be discarded.

Recently, emphasis for new FGD development is shifting toward regenerative processes, with no throwaway wastes. Regenerative processes convert the sulfur to a form that can be recovered with commercial value, usually as liquid SO₂ or sulfuric acid. Concentrated SO₂ can then be converted to sulfuric acid, elemental sulfur, or gypsum building material according to market demands for these byproducts. Regenerative processes have the advantages of lower costs for sorbents and waste disposal. However, these are offset by increased energy requirements and system complexity.

A large number of regenerative processes have been partially developed, but only the Wellman-Lord process has come close to commercial success. A local company, Raycon Research & Development of Brookline, MA, is developing the Tung process – an extension of the Wellman-Lord process.

In the Tung process, SO₂ is removed in a sodium sulfite scrubber and

extracted into a proprietary organic solvent, regenerating the sodium sulfite. The sulfite-loaded solvent is then stripped using steam, regenerating the solvent and leaving the SO₂ in a concentrated form as liquid SO₂ or converted into elemental sulfur or sulfuric acid. Performance projections for this process promise all the features desired in a replacement for scrubbers: high SO₂ removal (about 95%), the sulfur is converted to a usable form to avoid waste disposal, and favorable economics compared to existing scrubbers. Pilot level tests at the 2-3 MW_e level are scheduled to begin in a few months.

While FGD processes are the prevalent approach for reducing acid rain precursors, other approaches are currently being pursued. The sulfur that leads to the SO₂ emissions comes from sulfur in the coal, occurring as comparable amounts of inorganic sulfur (mostly pyrites) and organic sulfur. Chemistry plays an important part in the many coal beneficiation efforts being pursued to reduce the sulfur content in pulverized

coal prior to combustion. Another SO₂ emissions reduction approach is known as "fuel switching", converting to low-sulfur coal (less than about 1%S, mostly from Western U.S.) from high-sulfur coal (greater than about 2%S, from Eastern U.S.). Also, the U.S. DOE Clean Coal Program is funding large scale development of a wide range of future technologies. Two of the leading candidates for cleaner electric power generation are fluidized-bed combustion and coal gasification. A fluidized bed combustor uses a sorbent material fed along with the coal to remove sulfur as it is released from the coal. In gasification processes, sulfur is removed from a reducing gas, mostly as H₂S, before the product coal gas (CO plus H₂) is burned for power generation.

Acid precipitation has decreased over the last decade, and with new technologies and the trading of SO₂ allowances encouraged by the Clean Air Act Amendments, this trend is certain to continue with benefits for all of us in the Northeast. ♦

Let Mass-Vac solve all your vacuum pump problems.

VACUUM PUMP FLUIDS

- **MV-18** — A purified hydrocarbon, non-additive fluid designed especially for use in all types of mechanical vacuum pumps.
- **MV-19** — A distilled hydrocarbon fluid developed for all types of mechanical vacuum pumps and especially direct drive pumps.
- **FOMBLIN** — Perfluorinated polyether fluid. Ideal for use in pumping corrosive and explosive gases.
- **SILICONE DIFFUSION PUMP FLUIDS** — D-7040 and D-7050 silicone fluids are recommended for use in all types of diffusion pumps for high and ultra-high vacuum applications.
- **SILICONE GREASE** — Vacuum greases for use under extreme operating conditions and also more typical conditions.
- **VACUUM TUBING** — A pure red gum rubber tubing with a cloth impression. Available in sizes from 3/16" ID to 1 5/8" ID.
- **TUBING CLAMPS** — Stainless steel tubing clamps available for all sizes of our vacuum tubing.

- **VISI TRAP™** — Vacuum foreline traps to protect your vacuum pump and reduce oil backstreaming into your vacuum chamber.
- **OFHC COPPER GASKETS** — For CONFLAT* flanges from 1.33" OD to 10" OD.
*(CONFLAT is the Trademark of VARIAN ASSOC.)
- **VACUUM PUMPS** — A COMPLETE VARIETY OF PUMPS FROM 100 TORR TO 10⁻⁴ TORR ULTIMATE VACUUM.

We maintain a variety of Re-built Pumps in stock . . . ready for immediate delivery. Call us today for more information.

Tel. (508) 667-2393 Fax (508) 671-0014

MV MASS-VAC INC.
247 RANGEWAY ROAD, P.O. BOX 359
N. BILLERICA, MASS. 01862



"Since 1950"

MICROANALYSES

Analysis For All Elements,
Trace Analyses, ICP Scans,
TOX, Ion Chromatography,
Molecular Weights.

GALBRAITH LABORATORIES, INC.

P.O. Box 51610
Knoxville TN 37950-1610

2323 Sycamore Dr.
Knoxville TN 37921

Phone (615) 546-1335

FAX (615) 546-7209

Technological Leadership in the Twenty-first Century

A talk given by Dean Lester Thurow at the NESACS meeting of October 13, 1992, The Professional Relations Meeting.

The world of 2000 A.D. will be profoundly different. Six revolutions in the capitalistic world will produce these changes.

1. Every 60 to 80 years the capitalistic world goes mad.

When people look back on these periods they ask, "How could they do that?" Examples are Tulipmania, the South Sea Bubble, the Mississippi Land Bubble, the Roaring Twenties. The latter led to the giant crash and the Depression. Recovery was gradual. In the 80's the mania repeated. The savings and loan institutions lost their equity, residences were bid up and now are worth much less, the airlines are in deep trouble, likely to go bust. Recovery will be very gradual.

To repair the economy new systems will evolve, although the values of residential property will not spring back to previous heights. The idea of buying the largest house one can, using it as the retirement nest egg, and selling it for the money to retire on will no longer work. Once again saving has become the only way to provide for retirement.

Other examples of G.B. Shaw's "Money fogs minds": 26 billions were loaned to a single family to develop the Canary Wharf project in London without a careful investigation of the financial background. Fort Dodge, Iowa, farmland, good only for agricultural use and at maximum capable of generating \$750 per acre sold for \$3000 per acre at the peak. It has since been bought back at \$500 per acre.

There is no easy way out of the mess that the 80's bubble created. In 1988 assets were 40% greater that

debts. By now that has been reversed, debts now are 10% greater than assets!

2. Eastern Europe will change all Western capitalistic countries.

Russian metals are presently flooding the markets, halving the uranium price, dumping 85 million pounds of aluminum on the market. This will bankrupt smelters in Western countries who can't compete with the lowered prices.

US farmers depend upon exporting half or more of their crops. They will go out of business as modern farm machinery is introduced into the Ukraine. The combination of richer soil and far cheaper transportation (all Ukrainian rivers flow south, providing inexpensive barge and boat traffic) will sink the American farmers.

3. The largest market writes the rules for world trade.

In the 19th century Britain wrote the rules and profited enormously by them. After World War II the US wrote the rules. On January 3, 1993 the US will be reduced to the second largest economy in the world. The Europeans will write the rules and that means that the Germans will write them. Free trade is an American game. The Europeans will go to quasi-trading blocs. They will incorporate the former USSR, the Turks, etc. and will have a market of 800-900 million people, twice as big as Japan and the US combined, and about as big as China.

The Czechs will be brought into the Common Market first. They are a tempting target, having remained debt-free under Communist rule. Their per capita income is \$5000-7000, about that of Korea. Threat of the Koreans will bring them in. Per capita income determines the level of competition, but the Czechs cannot compete with the Koreans, so to induce them to join the Common Market they will be

offered a market sheltered against Korean intrusion.

The Europeans are not going to let the Japanese do to them what was done to the US. They will ban Japanese cars from Europe to protect the European car makers. The Hondas made in the US are banned as well, as being Japanese cars. This managed economy will be turned against the US as well.

4. In the past a nation's economy depended on natural resources, capital, technology and the education of its people. This no longer obtains.

Who has the best steel industry in the world? The Japanese, without either iron or coal in their land. They simply go out and buy what they need. Thus, natural resources no longer enter the equation.

With telecommunications, computers, world-wide banking, all capital is borrowed from the same places. Dollar for dollar can be matched in Bangkok as well as in New York.

Reverse engineering has done away with the technological advantage.

The British conquered the world markets by their head start in textile manufacture, with the Spinning Jennies. They could sell cloth in India cheaper than the Indians could, in spite of the penny a day wage scale. Nowadays the new products are developed in one country but may not stay there. The video camera and fax were invented in the US, CD players in Holland. They are now "owned" by the Japanese. The inventions were taken away by the better process technology which allowed the Japanese to make them cheaper without sacrifice of quality.

Raw materials can be bought, capital can be borrowed, technology can be copied. The only difference is the skill of the workforce.

At the top end of personnel the US

is better, but at the bottom end Japan is better. It is more important to have a better trained workforce at the bottom.

5. Competition and per capita income.

In 1950 the per capita income of the Japanese was low, of Germans was higher and of US citizens was the highest. The Japanese went after industries at the low end of the market, the Germans at the higher and the US at the highest. There was no competition among them. In the 1990's the per capita income is about the same. The Japanese MITI asked, to what Japan should give priority? The answer, industries which add high value, have high growth, high demand, and are complementary to existing industries: microelectronics, biotechnology, telecommunications, civilian aviation, new materials science, robots and machine tools. The Deutsche Bank list was the same and US economists agree. These are all brain power industries which have no natural home, all are up for grabs.

6. Work attitudes are critical - we suffer by comparison.

This can be illustrated by a peculiarity in the English language, where one word can have several meanings. The word is "football." To the US this is a game with lots of time outs, lots of huddles. To most of the rest of the world it is what we call soccer, with no time outs, action all the time. So it is with our work ethic. Let's further illustrate by comparing two farmers, an American and a Japanese.

The American farmer wants the biggest car, the biggest house and the longest Caribbean vacation he can get. The Japanese farmer doesn't care about a big car, but he does want the best tractor in the world, because, while he may spend an hour in his car, he will be spending eight and more hours in his tractor. He doesn't much care for a big house, only useful for sleeping, while he will be spending almost all his time in the best barn he can get, taking care of the best cow he

can buy. Vacations are a foreign concept to him. Which will be more successful? The Japanese. This is a graphic example of producer economics, the Japanese, versus consumer economics, the American.

The message is, the world will not be recognizable in ten years. Get ready for it!

Answers during the question period.

One third of the people in the US are no better educated than the Mexicans. The wage will simply fall to Mexican levels and few jobs will be lost to Mexico. The Germans are seeing to it that the Portugese have the same wages as the Germans to forestall job loss.

We need a massive program to re-educate US workers. Eastern Europeans are well educated, while South Americans are not. South America does not supply educated workers to the US the way Eastern Europe does for Europe.

Many countries are outside the world market. No one gets rich selling to the poor. China, Bangladesh, Africa, parts of Asia, South America do not play a part in the world market. Korea has just become a player.

The oil monopoly has been broken, is no longer a controlling factor. The USSR has abundant natural gas and oil fields which can generate much oil using Western recovery methods. In real price terms after correcting for inflation \$1.10 gas is only 22¢.

Reported by M.S.Simon ◇

QTI Quantitative Technologies, Inc.

ELEMENTAL ANALYSIS
C, H, N, S, X,
24-Hour Turnaround

Inorganic & Trace Analysis
AA, ICP, & Ion Chromatography

Quality Assurance - Technical Excellence

P.O. Box 470, Salem Industrial Pk., Bldg. 5
Whitehouse, NJ 08888 (908)534-4445

Norris Award

in Physical Organic Chemistry

Prof. Keith U. Ingold has been named the 1993 recipient of this award which is sponsored by the Northeastern Section, but the recipient is selected by a committee of the ACS. Those with a long memory may remember that his father, Sir Christopher Kelk Ingold was the first recipient of the same award in 1965.

Keith Ingold is a world leader of research into the kinetics and mechanisms of free radical reactions in solution. The award will be conferred at the 1993 Spring ACS meeting in Denver, at which time there will most likely be a symposium in the Organic Chemistry Division in his honor.

For more details about the awardee, see p. 62 of the October 19, 1992 issue of *C&EN*. ◇

**CUSTOM
MANUFACTURING**
New Capacity Now Available

ChemDesign 
ChemDesign Corporation, 99 Development Rd.
Fitchburg, MA 01420, U.S.A., (508) 345-9999

Member News

Dartmouth Professor Named N.H. Professor of the Year

Only hours before the dedication ceremonies of Dartmouth Chemistry Department's new Burke Laboratory, Prof. Charles Braun was named one of the nation's top teachers for the second year in a row.

The Council for the Advancement and Support of Education named Braun as its 1992 New Hampshire Professor of the Year. Last year Dr. Braun was selected as one of the nation's six top chemistry teachers by the Chemical Manufacturers Association.

Dr. Braun joined the faculty in 1965 and became known for his pioneering research in photoconductivity and energy transfer in molecular solids.

The Northeastern Section congratulates Prof. Braun. ◇

Historical Notes

by Edward R. Atkinson, Amherst, MA

Henry Chaves, 80, died on March 7, 1992. For many years a resident of Peabody and Saugus, he majored in chemical engineering at Northeastern University and became an expert on electroplating. Until retirement in 1977 he was employed in Providence by the Coro Jewelry Manufacturers and the Imperial Knife Company. In Boston he became a partner in H. & H. Metals, Inc. In retirement he settled in the Panoche Valley in California where he raised various crops in a search for virus-resistant strains. At the time of his death he resided in Johnson City, Tennessee.

Adelaide Del Frate, 67, died on December 24, 1991, just one month after retiring as Administrative Librarian at NASA headquarters in Washington, DC. She was a Somerville native who received the B.S. from Simmons College in 1947. After two years

employment at M.I.T. she spent four years in the patent department of the Dewey and Almy Chemical Co. in Cambridge and was subsequently employed as a chemical library scientist at the Jackson & Moreland Co., W.R. Grace & Co., Raytheon Co., and Mobil Chemical. In 1966 she began a 25 year association with NASA, moving from the electronics research center in Cambridge to the Goddard Space Flight Center in Maryland and then in 1986 was promoted to the NASA headquarters in Washington. She was instrumental in the development and implementation of the agency's Aerospace Research Information Network, an online catalog linking all NASA libraries. Among awards received for her contributions to the profession was the 1990 John Cotton Award. In the early 1950s I was associated with Adelaide in the filing of chemical patents

at Dewey and Almy and recall that, despite a lifelong physical handicap, she gave us chemists efficient and very friendly service.

Daniel Del Gatta, 53, died on May 2, 1992. He was a 1957 graduate of Boston Technical High School and a chemical engineering graduate of Northeastern University in 1965. His professional career was spent at the United Engineering Company in Boston.

James F. Keaney, 62, died on March 3, 1992. He was a 1951 graduate of Boston College and subsequently received the M.S. in teaching from Boston State College. He served in the Mobile Army Surgical Unit (MASH) during the Korean War and received several USA and UN medals. He taught chemistry and physics at Boston's English High School for 23 years and at Umana High School in East Boston for 8 years. After joining the New England Association of Chemistry Teachers in 1970 he held many offices in NEACT and chaired many summer conferences and committees. He was also very ac-

tive in community volunteer work in Needham.

Alexander Korosi, 65, died on January 18, 1991. He was a native of Hungary and received a degree in chemical engineering at the Technical University of Budapest in 1950. After employment as a research manager in Budapest he became a research scientist for the National Coal Board in England in 1956, then came to the Boston area in 1958 to do research on coal for the Boston Gas Co. From 1962 until its closing in 1969 he was a senior research chemical engineer for the Monsanto research laboratory in Everett. He subsequently was employed by the Stone and Webster Engineering Corporation. He was the author of many articles and books on coal, combustion, and fuels. In international affairs he was a section chairman at anACHEMA meeting in Frankfurt, Germany; a USA representative at an ASME meeting in Beijing, China; and was host to Boston meetings of the International Flame Research Foundation in 1981 and 1985. ◇

SERVICES DIRECTORY

SERVICES

LABORATORY AUTOMATION. Off-the-shelf and custom software for PC and PDP-11. Laboratory instrument interfacing and data acquisition. Inorganic CLP reporting. R.N. Stillwell, Scientific Computer Applications, (617)275-2964.

RECRUITING?

The NUCLEUS readership is New England's best source for chemical industry personnel.

The Nucleus reaches more than 10,000 readers each month. These readers are in the following areas of activity:

Industry	Management & R&D	67%
Academe	Faculty & Admin	14%
Students	Grad & post-docs	10%
Consulting & Clinical Labs		5%

One company that recruited through The Nucleus said: We received more qualified resumes from our ad in The Nucleus than we did from our newspaper ad.

Call Nancy Bedell for more info:
(617) 837-0424

POLYMER PROBLEMS?

- Complete Polymer Deformation
- Good vs. Bad Comparison
- DSC, TGA, IR, UV-Vis, GC, HPLC, NMR
- GPC/SEC Molecular Weights and MWD
- Additive Package Analysis

4 Mill Street
Bellingham, MA
02019

(508) 966-1301



LABORATORY EQUIPMENT

BOUGHT • SOLD • EXCHANGED

Call or Fax for
Current Laboratory
Equipment Listing

American Instrument Exchange, Inc.
21 Canal Street, Lawrence MA 01840
TEL:508-794-3496 FAX:508-794-8431

CHEMICAL ANALYSIS AND PHYSICAL TESTING



444 W. County Rd. D
St. Paul, MN 55112
612-631-9412
FAX 612-631-8405

- Spectroscopy, AA, FT-IR, Micro IR
- Chromatography, LC, GPC, GC, Ion
- Thermal Analysis, DSC, TGA, DMA, TMA
- GC/MS CHNOS Microscopy Instron

SPECIALTIES

- GPC, high temp, aqueous and all solvents
- FTIR, with Micro capabilities
- Tensile and Puncture, -40°F to 600°F
- Headspace, Pyrolysis GC
- Oxidation Studies, TGA, DSC, TMA
- USP XXII Testing EP Toxicity ESD Testing
- Thermoplastic and Thermoset Formulations
- Gas Permeation Rates, most gases
- Residual solvents, monomers Outgassing

Consulting Chemists' Meeting

Alternative Dispute Resolution
December 17, 1992, 7:00 pm
Vista International Hotel
Waltham

Dick Menard, President & CEO
RAMBYTE Consulting Co.

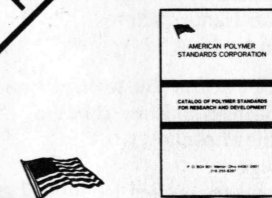
On settling disputes between client and consultant by arbitration.

Dinner at 5:30 pm

Reservations required by
December 15.

Call Debra Saez at
(508) 521-1327

FREE Polymer Standards Catalog



AMERICAN POLYMER
STANDARDS CORPORATION
P. O. Box 901, Mentor, Ohio 44061-0901
Phone: 216-255-2211 Fax: 216-255-8397

STRUCTURE PROBE®

SPECIALISTS IN MATERIALS RESEARCH

ANALYTICAL SERVICES
Electron Microscopy
&
Surface Analysis

63 Unquowa Road
Fairfield, CT 06430
(203) 254-0000

INSTRUCTOR IN CHEMISTRY

A full time temporary position is available for the spring semester of 1993 to teach and supervise some sections of General and Organic Chemistry laboratories at Boston College. The position requires an MS or higher degree in chemistry. Please send vita to:

Prof. Evan R. Kantrowitz,
Chairman, Department of
Chemistry, Merkert Chemistry
Center, Boston College,
Chestnut Hill MA 02167.

An Equal Opportunity/Affirmative
Action Employer.

ACS Dues Bills

If you have not received your 1993 dues bill, please contact the ACS Department of Member and Subscriber Services at (800) 333-9511. If you have questions concerning your membership, please call Jean Parr, Manager, Office of Member Services at (202) 872-4414.

Additional Reminder: In accordance with an ACS policy on a grace period for unrenewed ACS journals and *C&EN*, ACS cannot continue to send *C&EN* and journals after February 28 to those members whose 1993 dues and subscription payments are not received by February 1. If you have questions about your dues bill or wish to charge your payment by phone, call (800) 333-9511 or (614) 447-3600. Be sure to have your credit card handy for ready reference. ◇

Readers:

Please donate your copies of the *NUCLEUS* to your local High School when you no longer need them.

THE NUCLEUS

8 Winch Park Road
Framingham, MA 01701

Calendar

For additional information, call:

Boston College – (617) 552-3625
Boston University – (617) 353-2537
Brandeis University – (617) 736-2500
Clark University – (508) 793-7116
Dartmouth College – (603) 646-2501
Harvard University – (617) 495-5333
MIT – (617) 253-4080
Northeastern University – (617) 437-2822
Tufts University (Chemistry, Medford Campus) – (617) 381-3441
Tufts University (Chem. Eng., Medford Campus) – (617) 627-3900
Tufts University Health Science Campus – (617) 956-6867
UMass Dartmouth – (508) 999-8232
University of New Hampshire – (603) 862-1550

December 2

Dr. Susan Sobolov (Wesleyan University)
“The Use of Aldolase Enzymes as Biocatalysts in Organic Synthesis”
University of Massachusetts Dartmouth
Room 305 Science and Engineering Building (Group II) at 4:00 pm

December 3

Dr. Shaul Mukamel (University of Rochester)
“Cooperative and Ultra-fast Nonlinear Optical Response of Confined Excitons and Molecular Nanostructures”
M.I.T. Room 6-120 at 5:00 pm
Prof. Mary F. Roberts (Boston College)
“Peculiar Phospholipids as Probes of Water-Soluble Phospholipases”
Boston College
Merkert Chemistry Center, Room 127 at 4:00 pm

December 7

Prof. Fred Wudl (UCal, Santa Barbara)
“Recent Advances in the Chemistry of Buckminsterfullerene C₆₀”
Brandeis University
Gerstenzang 122 at 4:00 pm

December 9

Dr. Pradip Bhowmik (Univ. of Detroit)
“Liquid Crystalline Polymers”
University of Massachusetts Dartmouth
Room 305 Science and Engineering Building (Group II) at 4:00 pm

December 10

Dr. Stan Sander (Jet Propulsion Lab.)
“Kinetics and Photochemistry of Chlorine Compounds in the Polar Stratosphere”
Harvard University
Mallinckrodt Mb23 at 5:00 pm

December 14

Professor Don Wiley (Harvard University)
“Recognition of Antigens by Histocompatibility Glycoproteins During the Immune Response”
Harvard University
Mb-23 at 4:15 pm

December 17

Dr. Oren Becker (Harvard University)
“Quench Echoes in Proteins”
Harvard University
Mallinckrodt Mb23 at 5:00 pm

Notices for the Nucleus Calendar should be sent to:

Chris Arumainayagam
Department of Chemistry
Wellesley College
Wellesley, MA 02181
Telephone (617) 283-3326
Fax (617) 283-3642
e-mail: CARUMAINAYAG@LUCY.WELLESLEY.EDU

NONPROFIT ORG.
U.S. POSTAGE PAID
NORTHEASTERN
SECTION
AMERICAN CHEMICAL
SOCIETY