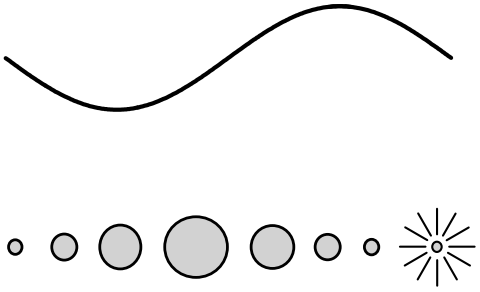
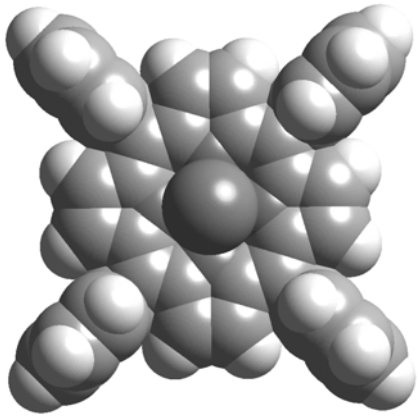
RESEARCH IN

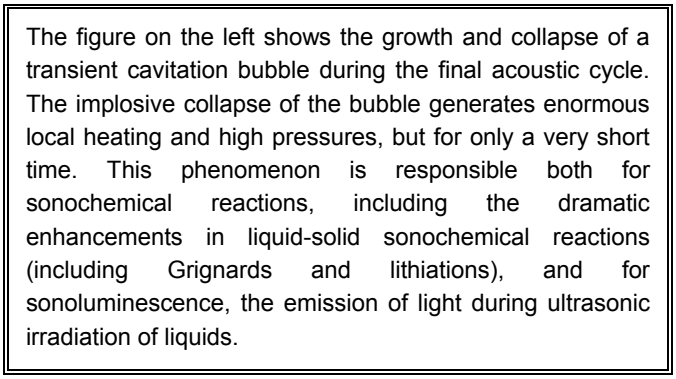
THE SUSLICK GROUP



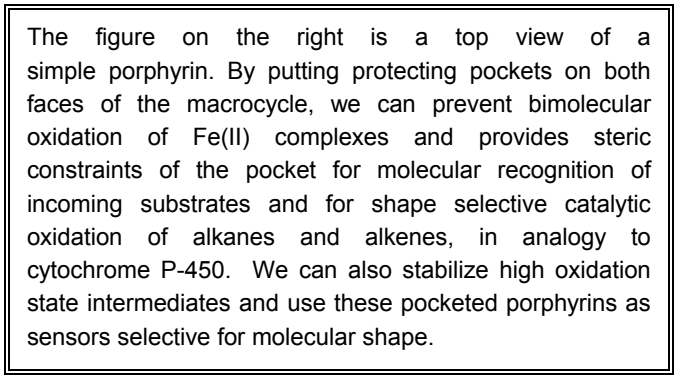


September 2004

Cover Page Figure Captions:



The figure on the left shows the growth and collapse of a transient cavitation bubble during the final acoustic cycle. The implosive collapse of the bubble generates enormous local heating and high pressures, but for only a very short time. This phenomenon is responsible both for sonochemical reactions, including the dramatic enhancements in liquid-solid sonochemical reactions (including Grignards and lithiations), and for sonoluminescence, the emission of light during ultrasonic irradiation of liquids.



The figure on the right is a top view of a simple porphyrin. By putting protecting pockets on both faces of the macrocycle, we can prevent bimolecular oxidation of Fe(II) complexes and provides steric constraints of the pocket for molecular recognition of incoming substrates and for shape selective catalytic oxidation of alkanes and alkenes, in analogy to cytochrome P-450. We can also stabilize high oxidation state intermediates and use these pocketed porphyrins as sensors selective for molecular shape.

Current versions of this information and *more information* are available on the Web at

http://www.scs.uiuc.edu/suslick

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INTRODUCTION

The multi-disciplinary nature of our research projects involves individuals with interests not only in inorganic, but also in bio-organic, materials, and physical chemistry. Our two major research areas are the chemical effects of ultrasound and the bioinorganic and materials chemistry of metalloporphyrins and heme proteins. As part of this diversity, we often collaborate with other researchers both at UIUC and at other universities across the world. Several of the students in this group are joint members in other research groups in the School of Chemical Sciences.

We have been exploring a broad range of both mechanistic and synthetic applications of ultrasound. The origin of "sonochemistry" is acoustic cavitation: the formation, expansion, and implosive collapse of bubbles in liquids irradiated with ultrasound. The compression within such bubbles generates intense local heating and high local pressures. We have recently been able to measure these conditions spectroscopically from light emission during cavitation: ≈5000 K at 1000 atm., but lifetimes less than a microsecond. The chemistry generated by these hot-spots is different than either ordinary thermal or photochemical processes, and sonochemistry represents a fundamentally unique interaction of energy and matter.

Much of our work in this area has dealt with organometallic and catalytic sonochemistry. Examples include multiple ligand substitution and clusterification, homogeneous catalysis, intercalation into layered inorganic solids, and activation of heterogeneous catalysis. In some cases, we have been able to enhance reaction rates by as much as a million-fold! We recently discovered a simple process for the sonochemical synthesis of amorphous metals, unusual materials without the long-range order of ordinary metals or crystalline materials. In these studies, we make heavy use of sophisticated surface analysis techniques to characterize the effects of ultrasound on solids.

The second research area in the group is metalloporphyrin chemistry. In order to gain new insights into the structure and function of metalloproteins, we are involved in the design, synthesis, and physical characterization of small (or at least smallish!) molecules that look like and behave like enzyme active sites. Our principal focus is on heme proteins including myoglobin and hemoglobin (O_2 binding), peroxidase and catalase (peroxide detoxification), and cytochrome P-450 (oxidative metabolism, including drugs and carcinogens).

Metalloporphyrins provide a versatile synthetic base on which to design desired properties: i.e., molecular engineering. To probe the origins of molecular recognition, we have used sterically hindered, "bis-pocket" porphyrins to *reverse* the normal reactivity of hydrocarbons. In this work with synthetic metalloporphyrins and with dendrimer-porphyrins, we are developing superstructured macrocycles as shape, size, and polarity selective oxidation catalysts and as selective molecular sensors. We are also exploring the binding of totally synthetic polypeptides to metalloporphyrins. Our goal here is the generation of rationally designed artificial heme proteins, the ultimate interface between inorganic and biological chemistry.

We have also recently discovered a new and simple approach to detection of odorants using the colorimetric response from a library of immobilized vapor-sensing metalloporphyrins and other chemoresponsive dyes. We call this technique “smell-seeing”. This technology is presently being successfully commercialized by a start-up company, ChemSensing, Inc.

Other porphyrin projects are more materials and biomaterials oriented. For example, we are developing the use of porphyrins as nanoporous catalytic materials. The latter involves the use of poly-functionalized metalloporphyrins as building blocks for the *molecular* assembly of molecular sieves.

In a project that bridges between our two research areas, we have recently discovered a sonochemical preparation of proteinaceous microspheres for drug delivery and blood substitutes. Ultrasonic irradiation of various proteins (e.g., serum albumin and Hb) creates micron-sized spheres that can be either gas-filled or non-aqueous liquid-filled. We have had substantial success in recent development of proteinaceous microspheres as blood substitutes for O_2 transport, as contrast agents for magnetic resonance imaging, and as spin-label probes for *in vivo* O_2 and temperature profiling.

OUTLINE OF CURRENT RESEARCH PROJECTS

I. Porphyrins, Metalloporphyrins, and Bio-In/Organic Chemistry of Heme Proteins

Molecular Recognition: Oxidation Catalysis and Molecular Sensors

Molecular Recognition, Shape and Polarity Selectivity with Super-Structured Porphyrins

Dendrimer Porphyrins, Oxygen Atom Transfers; Cytochrome P450 Intermediates

Artificial Olfaction: "Smell-Seeing" and Selective Molecular Sensors; Olfactory Receptors

Porphyrinic Materials Chemistry

Network Solids; Nanoporous Porphyrin Solids, Shape Selective Heterogeneous Catalysts

Non-fullerene Nanotubes

II. The Chemical Effects of Ultrasound

Physical and Mechanistic Sonochemistry and Sonoluminescence

Mechanisms of Sonochemistry, Surface-Surface Reactivity

Spectroscopic Probes of Cavitation Conditions, Multi-Bubble and Single-Bubble Cavitation

Synthetic, Materials, and Catalytic Applications of Sonochemistry

Organometallic Sonochemistry; Heterogeneous and Organic Sonochemistry

Liquid-Solid Reactions; Interparticle Mechanochemistry

Heterogeneous Catalysis; Nanostructured and Amorphous Metals, Carbides, Sulfides

Biomedical Applications of Sonochemistry

Protein Microspheres and Microencapsulation

Microspheres as Drug Delivery Systems

Medical Imaging Contrast Agents (OCT, MRI, sonographic, x-ray)

SOME RECENT PUBLICATIONS

Professor Suslick has edited four books and published more than 250 scientific papers; below is a sampling of these, available as reprints in PDF format at his website: www.scs.uiuc.edu/suslick/ Along with his journal publications, he takes some pride in his popularizations of sonochemistry and in his contributions to art in science. The former include invited feature articles in *Scientific American* (1989), the British equivalent *New Scientist* (1990 & 1996), *Science* (1990), the *Encyclopaedia Britannica Yearbook of Science and the Future* (1993), and numerous technical encyclopedias. The latter include numerous journal covers: two *Science* (23 Mar. 1990 and 20 Sept. 1991), *Nature* (25 Jul 2002), *Bulletin of the Materials Research Society* (April, 1995; October 2004), and *Supramolecular Chemistry* (Sept., 1999).

The Chemical Effects of Ultrasound

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2. Mdleleni, M. M.; Hyeon, T.; Suslick, K. S. "Sonochemical Synthesis of Nanostructured Molybdenum Sulfide" *J. Am. Chem. Soc.*, **1998**, *120,* 6189-6190.
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4. McNamara III, W. B.; Didenko, Y.; Suslick, K. S. "Sonoluminescence Temperatures During Multibubble Cavitation," *Nature*, **1999**, *401*, 772-775.
5. Dantsin, G.; Suslick, K.S. "Sonochemical Preparation of a Nanostructured Bifunctional Catalyst" *J. Am. Chem. Soc.* **2000**, *122*, 5214-5215.
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1. Huffman, D. L.; Rosenblatt, M. M.; Suslick, K. S. "Synthetic Heme-Peptide Complexes," *J. Am. Chem. Soc.*, **1998**, *120*, 6183-6184.
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4. Rakow, N. A.; Suslick, K. S. "A Colorimetric Sensor Array for Odour Visualization" *Nature* **2000**, *406*, 710-714.
5. Zimmerman, S. C.; Wendland, M. S.; Rakow, N. A.; Zharov, I.; Suslick, K. S. "Synthetic Hosts by Monomolecular Imprinting Inside Dendrimers" *Nature* **2002**, *418*, 399-403.
6. Kosal, M. E.; Chou, J.-H.; Wilson, S. R.; Suslick, K. S. "A Functional Zeolite Analogue Assembled From Metalloporphyrins" *Nature Materials*, **2002**, *1*, 118-121
7. Wang, J.; Luthey-Schulten, Z.; Suslick, K. S. "Is the Olfactory Receptor A Metalloprotein?" *Proc. Natl. Acad. Sci. U.S.A.,* **2003**, *100*, 3035-3039.
8. Suslick, K. S. "An Optoelectronic Nose: Colorimetric Sensor Arrays" *MRS Bulletin*, **2004**, *29*, in press.

Some Introductory Reviews

1. Suslick, K. S. "The Chemical Effects of Ultrasound," *Scientific American*, **1989 (2),** *260*, 80-86.
2. Suslick, K. S.; Van Deusen-Jeffries, S. "Shape Selective Biomimetic Oxidation Catalysis" *Comprehensive Supramolecular Chemistry*, vol. 5; Lehn, J. M., ed. Elsevier Publishers: Oxford, 1996; pp. 141-170.
3. K.S. Suslick "Sonochemistry," *Kirk-Othmer Encyclopedia of Chem. Tech*; 4th Ed. Wiley: 1998, vol. 26, 517-541.
4. Suslick, K.S.; Price, G. "Applications of Ultrasound to Materials Chem.," *Annu. Rev. Matl. Sci.*, **1999**, *29*, 295-326.
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6. Suslick, K. S.; Bhyrappa, P.; Chou, J. H.; Kosal, M. E.; Nakagaki, S.; Smithenry, D. W.; Wilson, S. R. "Microporous Porphyrin Solids" *Acc. Chem. Res.* **2004**, *37*, in press.

CURRENT RESEARCH GROUP MEMBERS, 10/04

Porphyrin Projects

Ming Fang
B.S., Jilin Univ., 2001

Michael Janzen
B.S., University of Manitoba
Ph.D., Univ. of Western Ontario
P.D., Yale University

Jesse Miller
B.S., UIUC, 2000.

Kwansima Quansah
B.A., Mount Holyoke College, 2003.

Jennifer Ponder-Wilson
B.S., Ball State University, 2000.

Chen Zhang
B.S., Beijing University, 2001.

Microsphere Projects

Farah Jean-Jacques
B.S., State Univ. New York, Stony Brook, 2000.

Elizabeth Dibbern
B.S., Univ. of Nebraska, 2002.

Sonochemistry Projects

Jin-Ho Bang
B.S., M.S., Seoul National University, 2001.

Yury Didenko
B.S., M.S., Moscow State University, 1970-75.
Ph.D., Moscow State University, 1985.
Head of Laboratory, Pacific Oceanological Inst., Vladivostok, Russia.
Research Associate, Univ. of Illinois.

Nathan Eddingsaas
B.S., University of Wisconsin, 2003.

David Flannigan
B.S., Univ. of Minnesota, 2001

Steve Hopkins
B.S., Washington & Lee University, 2000.

Annabeth Ryder
B.S., Indiana Univ., 2002.

Sara Skrabalak
B.A., Washington Univ., 2002.

Won Hyuk Suh
M.S. Seoul National Univ., 2002.

RESEARCH FUNDING

Major Research Funding, Current:

2004 – HSARPA; “Colorimetric Sensor Arrays” $300,000 / yr.

2003 – 06 NSF; "Chemical Effects of High Intensity Ultrasound" $562,500 / 3 yrs.

2001 – 04 NIH; "Heme Proteins, Microspheres, & Their Synthetic Analogs" $1,365,000 / 4 yrs.

1999 – 04 DARPA; "Chemical Control of Single Bubble Cavitation" $637,121 / 4 yrs.

1990 – xx DOE; UIUC Materials Res. Lab; "Field Responsive Porphyrinic Materials" $100,000 / yr.

Major Research Funding, Recent Past:

2000 – 03 NSF; "Chemical Effects of High Intensity Ultrasound" $480,000 / 3 yrs.

2000 – 01 PG Research Foundation; “Ultrasonic Gas Dispersion and Dissolution” $72,538 / yr.

1997 – 02 DOD; "Dendritic Materials Systems MURI" $500,000 / 5 yrs (KSS portion).

1997 – 00 NIH; "Heme Proteins, Microspheres, & Their Synthetic Analogs" $924,944 / 4 yrs.

1994 – 99 NSF; "Chemical Effects of Ultrasound" $738,673 / 4 yrs.

1996 – 99 DOE; "Cavitational Hydrothermal Oxidation" $478,027 / 3 yrs.

1995 – 99 VivoRx Pharmaceuticals, Inc.; "Biomedical Applications of Protein Microspheres" $60,000 / yr.

1995 – 98 University of Illinois Foundation, UIUC University Scholar; $36,000 / 3 yrs.

1996 DOE; "Sonoluminescence", subcontract from Lawrence Livermore Natl. Lab; $10,000.

1995 – 97 UIUC Critical Research Initiative; "Non-Natural Self-Organizing Molecules" $120,000 / 2 yrs.

1992 – 96 NIH; "Heme Proteins and Their Synthetic Analogs" $782,447 / 4 yrs.

1989 – 96 NSF; UIUC Materials Res. Lab; "Effects of Ultrasound on Heterog. Catalysis" $386,000 / 5 yrs.

1992 – 95 NSF; "Visualization in Teaching Chemistry" with S. S. Zumdahl, $368,505 / 3 yrs.

EXECUTIVE SUMMARIES OF RESEARCH

The Chemical and Physical Effects of Ultrasound

Our research group has pioneered the exploration of sonochemistry, most recently as a tool in materials chemistry. Our research has developed new approaches to the synthesis of amorphous and nanostructured materials, has shown great promise for the activation of heterogeneous catalysts, and has created a whole new class of medically important biomaterials.

Background — Ultrasonic irradiation of liquids causes high energy chemical reactions to occur [1]. The origin of sonochemistry is acoustic cavitation: the formation, growth, and implosive collapse of bubbles in liquids irradiated with high intensity sound. The collapse of bubbles caused by cavitation produces intense local heating and high pressures, with very short lifetimes.

Accomplishments — In order to understand the origins of sonochemistry, we found it essential to understand better the nature of cavitation and the conditions created during bubble collapse. To this end, we developed sonoluminescence as a spectroscopic probe of the cavitation hot spot [1, 2, 3]. In clouds of cavitating bubbles, these hot-spots [2,3] have equivalent temperatures of roughly 5000 K, pressures of about 1000 atmospheres, and heating and cooling rates above 10^{10} K/s. Thus, cavitation can create extraordinary physical and chemical conditions in otherwise cold liquids. Fig. 1 places sonochemistry in relationship to other forms of chemistry.

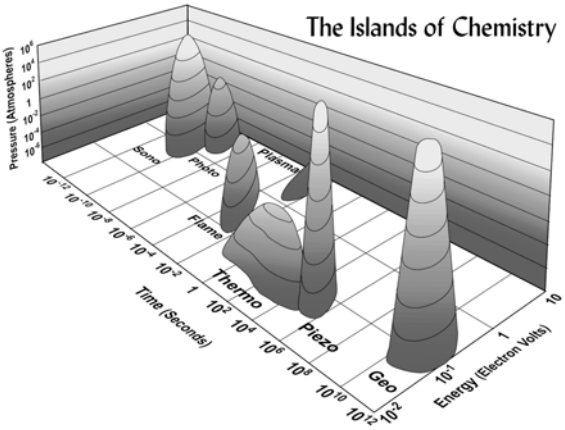

Fig. 1. Chemistry: the interaction of energy and matter.

Ultrasound has proved extremely useful in the synthesis of a wide range of nanostructured materials, including high surface area transition metals, alloys, carbides, oxides and colloids [4]. Sonochemical decomposition of volatile organometallic precursors in high boiling solvents produces nanostructured materials in various forms with high catalytic activities. Nanometer colloids, nanoporous high surface area aggregates, and nanostructured oxide supported catalysts can all be prepared by this general route. As one example, our discovery of a simple sonochemical synthesis of amorphous iron helped settle the longstanding controversy over its magnetic properties. Another example, shown in Fig. 2, provides an easy route to nanostructured heterogeneous catalysts with extremely high activities [4, 5].

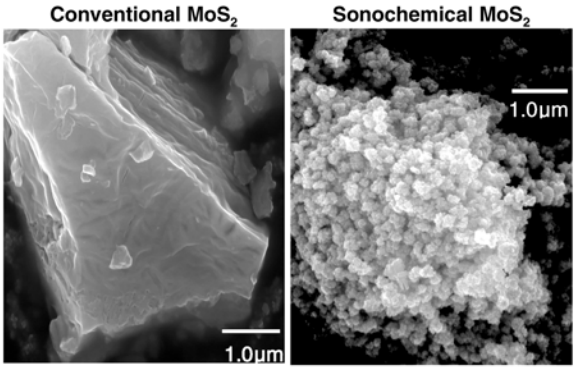

Fig. 2. Scanning electron micrographs of MoS_2, the predominant industrial hydrodesulfurization catalyst [5].

Another important application has been the sonochemical preparation of biomaterials, most notably protein microspheres [6]. Using high intensity ultrasound and simple protein solutions, a remarkably easy method to make both air-filled microbubbles and nonaqueous liquid-filled microcapsules has been developed. Figure 3 shows an electron micrograph of sonochemically prepared microspheres. These microspheres are stable for months, and being slightly smaller than erythrocytes, can be intravenously injected to pass unimpeded through the circulatory system. These protein microspheres, have a wide range of biomedical applications, including their use as echo contrast agents for sonography, magnetic resonance imaging contrast enhancement, drug delivery, among others.

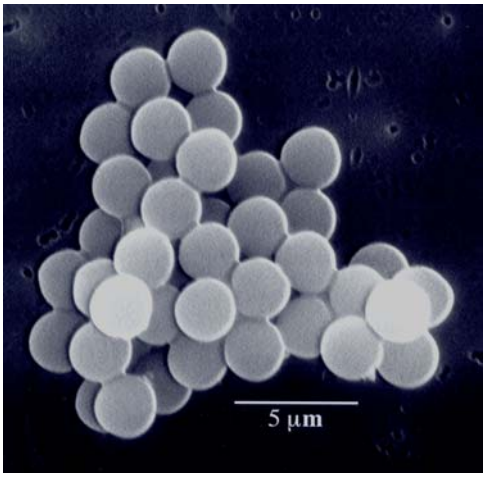

Fig. 3. Scanning electron micrograph of sonochemically synthesized hemoglobin microspheres.

When liquids that contain solids are irradiated with ultrasound, related phenomena can occur [1, 7]. When cavitation occurs near an extended solid surface, cavity collapse is non-spherical and drives high-speed jets of liquid into the surface. These jets and associated shock waves can cause substantial surface damage and expose fresh, highly heated surfaces.

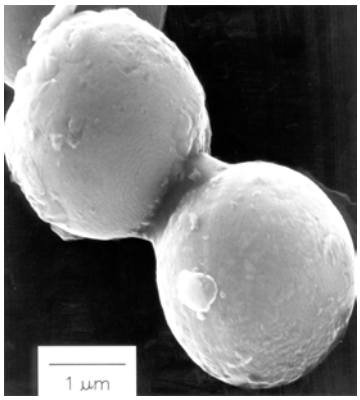

Fig. 4. Scanning electron micrograph of 5 μm diameter Zn powder. Neck formation from localized melting is caused by high-velocity interparticle collisions.

Ultrasonic irradiation of liquid-powder suspensions produces another effect: high velocity inter-particle collisions [7]. Cavitation and the shockwaves it creates in a slurry can accelerate solid particles to high velocities (Fig. 4). The resultant collisions are capable of inducing dramatic changes in surface morphology, composition, and reactivity. Heterogeneous catalysts often require rare and expensive metals. The use of ultrasound offers some hope of activating less reactive, but also less costly, metals. For example, the effects of ultrasound on Ni powder is shown in Fig. 5, with the chemical consequence of enormously increasing the catalytic rates of hydrogenation by Ni powder (>10^5-fold) [8].

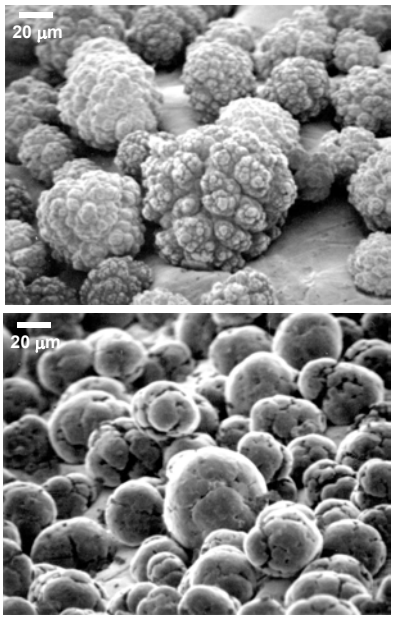

Fig. 5. The effect of ultrasonic irradiation on the surface morphology and particle size of Ni powder. High-velocity interparticle collisions caused by ultrasonic irradiation of slurries are responsible for the smoothing and removal of passivating oxide coating.

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[3] Didenko, Y.; Suslick, K. S. “Photons, Radicals, and Ions from a Single Bubble: An Energy Inventory During Cavitation” *Nature* **2002**, *418*, 394-397

[4] Suslick, K. S.; Price, G. "Applications of Ultrasound to Materials Chemistry” *Annu. Rev. Matl. Sci.*, **1999**, *29*, 295-326.

[6] Mdleleni, M. M.; Hyeon, T.; Suslick, K. S. "Sonochemical Synthesis of Nanostructured Molybdenum Sulfide" *J. Am. Chem. Soc.*, **1998**, *120,* 6189-6190.

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[7] S.J. Doktycz, K.S. Suslick *Science*, 247, 1067 (1990).

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EXECUTIVE SUMMARIES OF RESEARCH

Porphyrin and Metalloporphyrin Chemistry

Our research team been at the leading edge of research on synthetic metalloporphyrins for applications as synthetic analogs of heme proteins, shape selective oxidations, and diverse materials chemistry applications including nanoporous network solids, non-linear optical materials, and selective sensors.

Background — Porphyrins (which comes from the Greek for "purple") are based on 16-atom rings containing four nitrogen atoms (Fig. 1); they are of perfect size to bind nearly all metal ions. Heme proteins (which contain iron porphyrins) are ubiquitous in nature and serve many roles, including O_2 storage and transport (myoglobin and hemoglobin), electron transport (cytochromes b and c), and O_2 activation and utilization (cytochrome P450 and cytochrome oxidase).

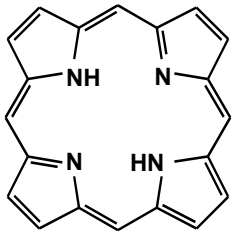

Fig. 1. Porphine, the simplest porphyrin.

In order to gain new insights into the structure and function of metalloproteins, we are involved in the design, synthesis, and physical characterization of complex molecules that look and behave like heme protein active sites. Here we are concerned with issues of oxidation chemistry, catalysis, and molecular recognition [1].

Metalloporphyrins and related macrocycles also provide an extremely versatile synthetic base on which to design physical and chemical properties. Another goal of our research effort has been the exploration of metalloporphyrin assemblies as field responsive materials, particularly for photo-responsive applications. Porphyrins can be molecularly engineered to provide erect desirable molecular and materials properties, including very large dipole moments, polarizabilities, and hyperpolarizabilities. The non-linear optical properties of these materials are of special interest. These molecules can be built for energy transfer with molecular control, giving them potential applications in optical communications, data storage, and electrooptical signal processing [2].

Accomplishments — To probe the origins of molecular recognition, we have used sterically hindered, "bis-pocket" porphyrins to *reverse* the normal reactivity of hydrocarbons, enabling us to oxidize selectively primary C-H bonds or the least substituted double bonds. In this work with synthetic metalloporphyrins and with dendrimer-porphyrins, we have synthesized superstructured macrocycles as shape, size, and polarity selective oxidation catalysts for both hydroxylation and epoxidation [1, 3].

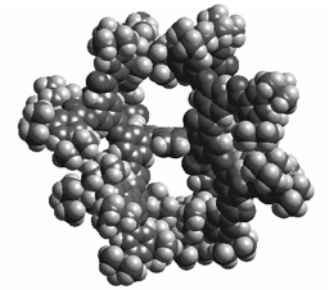

Fig. 2. A bis-pocketed dendrimer porphyrin. The protecting pockets on both sides of the porphyrin provides for molecular recognition of incoming substrates and for shape selective catalytic oxidation of alkanes and alkenes.

In other work, we are interested in the interaction of metalloporphyrins with peptides [4, 5]. For example, we have designed synthetic heme-peptide complexes by the coordination of amphiphilic peptides to heme and have been examined to determine the influence of the peptide on the properties of the heme and vice versa. The presence of hydrophobic residues flanking a coordinated histidine dramatically increases peptide binding to the heme by a factor of nearly 6000 relative to histidine. Hydrophobic interactions between the porphyrin face and the non-polar side chains of the amino acid residues make a major contribution to the stability of the heme-peptide complexes. Circular dichroism spectra demonstrate that heme binding induces substantial helix formation, presumably to maximize the hydrophobic stabilization. The complexes with the most hydrophobic peptides are the most difficult to reduce, as expected from relative ligand binding to Fe^{II} vs. Fe^{III}.

Other projects are more materials and biomaterials oriented. Metalloporphyrins are a versatile base for molecular engineering of desired properties. As one example, we have recently created a new class of bis-pocketed discotic liquid crystals of metalloporphyrins to create nanostructured assemblies of photoresponsive materials [6]. We are currently expanding this approach to generate cross-linked non-fullerene nanotubes for applications to catalysis and separations. Other projects involve the solid-state design of nanoporous porphyrinic solids, using hydrogen bonding or metal coordination network polymers to provide a catalytically active, shape-selective solid.

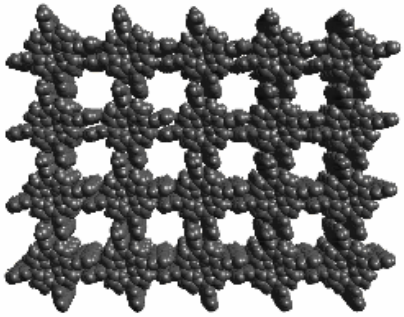

Fig. 3. A porphyrin nanoporous solid. Eight hydrogen bonds per porphyrin produce a columnar stacking in this molecular packing diagram of the x-ray structure of tetrakis(3,5-dihydroxyphenyl)porphyrin.

We are also developing new nanoporous network solids of highly functionalized porphyrins to provide controlled porphyrin orientation in the solid state and to produce molecularly-designed molecular sieves [7, 8]. We intend to explore the use of these solids as heterogeneous shape-selective oxidation catalysts. An example of one such structure is shown above. Other work has involved molecular imprinting of porphyrins into crosslinkable dendrimers, producing a synthetic analog of antibody-antigen systems [9]

We have also recently discovered a new and simple approach to detection of odorants using the colorimetric response from a library of immobilized vapor-sensing metalloporphyrins [10]. We call this technique "smell-seeing". We can visually identify a wide range of ligating vapors (including alcohols, amines, ethers, phosphines, phosphites, and thiols) and even weakly ligating vapors (arenes, halocarbons, and ketones). Unique color fingerprints can be obtained below 10 ppb for many biogenic odorants.

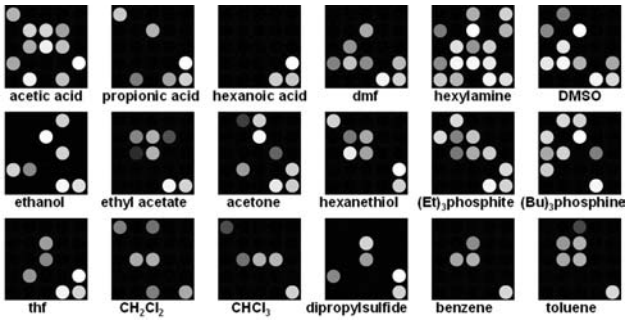

Fig. 4. The color changes from our "smell-seeing" array of metalloporphyrins are unique for each analyte. Sensitivities are generally better than the human nose.

[1] Suslick, K. S.; van Duesen-Jeffries, S. "Shape Selective Oxidation Catalysis" *Comprehensive Supramolecular Chemistry*, vol. 5; ed. Suslick, K.S.; Elsevier Publishers: Oxford, 1996, pp. 141-170.

[2] Chou, J.-H.; Kosal, M. E.; Nalwa, H.S.; Rakow, N.A.; Suslick, K. S. in *The Porphyrin Handbook* , Kadish, K.; Smith, K.; Guilard, R., ed.; Academic Press: New York, 2000; vol. 6, ch. 41, pp. 43-131.

[3] Bhyrappa, P.; Vaijayanthimala, G.; Suslick, K. S. "Shape-Selective Ligation to Dendrimer-Metalloporphyrins" *J. Am. Chem. Soc.* **1999**, *121*, 262-263.

[4] Huffman, D. L.; Rosenblatt, M. M.; Suslick, K. S. "Synthetic Heme-Peptide Complexes," *J. Am. Chem. Soc.*, **1998**, *120*, 6183-6184.

[5] Rosenblatt, M.M.; Huffman, D.L.; Wang, X. Remmer, H.A.; Suslick, K. S. "Cyclic and Hairpin Peptide Complexes of Heme" *J. Am. Chem. Soc.,* **2002**, *124*, in press.

[6] Patel, B. R.; Suslick, K. S. "Discotic Liquid Crystals from a Bis-Pocketed Porphyrin," *J. Am. Chem. Soc.*, **1998**, *120*, 11802-11803.

[7] Bhyrappa, P.; Wilson, S. R.; Suslick, K. S. "Hydrogen Bonded Porphyrinic Solids:," *J. Am. Chem. Soc.*, **1997**, *119*, 8492-8502.

[8] Kosal, M. E.; Chou, J.-H.; Wilson, S. R.; Suslick, K. S. "A Functional Zeolite Analogue Assembled From Metalloporphyrins" *Nature Materials*, **2002**, *1*, in press.

[9] Zimmerman, S. C.; Wendland, M. S.; Rakow, N. A.; Zharov, I.; Suslick, K. S. "Synthetic Hosts by Monomolecular Imprinting Inside Dendrimers" *Nature* **2002**, *418*, 399-403.

[10] Rakow, N. A.; Suslick, K. S. "A Colorimetric Sensor Array for Odour Visualization" *Nature* **2000**, *406*, 710-714.

CURRICULUM VITAE

KENNETH S. SUSLICK

Education:

1978	Ph. D., Stanford University, *Synthetic Analogs of Myoglobin and Hemoglobin*.
1974	B. S., California Institute of Technology (with Honors).

Research and Professional Positions:

2004 –	*Marvin Schmidt* Professor of Chemistry, University of Illinois at Urbana-Champaign.
1997 – 04	*William H. & Janet Lycan* Professor of Chemistry, University of Illinois at Urbana-Champaign.
2001 –	Founder and Chief Technical Officer, ChemSensing, Inc., Northbrook, IL.
1988 –	Professor of Chemistry, University of Illinois at Urbana-Champaign.
1993 –	Professor of Materials Science and Engineering, University of Illinois at Urbana-Champaign.
1993 – 98	Member, Board of Directors; Ney Ultrasonics Inc.; Bloomfield, Connecticut.
1994 – 98	Member, Scientific Advisory Board, VivoRx Inc.; Santa Monica, California.
1995 – 97	*Alumni Research Scholar* Professor of Chemistry, University of Illinois at Urbana-Champaign.
1989 – 92	Professor, Beckman Institute for Advanced Science and Technology.
1986	Visiting Fellow, Balliol College and Inorganic Chemistry Laboratory, Oxford University.
1984 – 88	Associate Professor, University of Illinois at Urbana-Champaign.
1978 – 84	Assistant Professor, University of Illinois at Urbana-Champaign.
1974 – 78	Research and Teaching Assistant, Stanford University.
1974 – 75	Chemist, Lawrence Livermore Laboratory, Laser Isotope Separation.
1971 – 74	Research and Teaching Assistant, California Institute of Technology.
1972	AEC Research Trainee, Lawrence Berkeley Laboratory.

Selected Honors and Awards:

2004	American Chemical Society Senior Cope Scholar Award
2003	J.T. Donald Lecturer, McGill University, Montreal.
2001	Wolfgang Göpel Award, 8th Intl. Symp. on Olfaction & Electronic Noses (ISOEN-8).
2000	1st Place, Illinois Technology Center Inventorship Competition.
1997	University of Melbourne Special Public Lectureship.
1997	W. Heinlen Hall Lectureship, Bowling Green State University.
1994	American Chemical Society Nobel Laureate Signature Award for Graduate Education.
1994	Materials Research Society Medal for Exceptional Recent Achievements in Materials Research.
1992 –	Fellow, American Association for the Advancement of Science.
1994 –	Fellow, Acoustical Society of America.
1994	Robert A. Welch Foundation Lecturer.
1994	Senior University Scholar, University of Illinois.
1992 – 94	NSF Special Creativity Extension Award.
1993	Excellence in Teaching Award, UIUC School of Chemical Sciences.
1991 – 92	Beckman Associate, UIUC Center for Advanced Study.
1985 – 90	NIH Research Career Development Award.
1985 – 87	Alfred P. Sloan Foundation Research Fellow.
1985	Excellence in Teaching Award, UIUC School of Chemical Sciences.
1979 – 80	DuPont Young Faculty Fellow.
1974 – 78	Silver Medal and Fellow, Royal Society for the Arts, Manufactures, and Commerce (London).
1974 – 78	Hertz Foundation Predoctoral Fellowship.
1973	American Chemical Society Undergraduate Award in Analytical Chemistry.

Personal Data:

b., Chicago, September 16, 1952. Spouse: Adele Mazurek, m. 1975. Son: Benjamin, b. 1992.
Hobbies: Bronze sculpting, folk and Celtic music, ethnographic art

CURRICULUM VITAE

Some Recent Special Lectures:

2004

Cherry Emerson Lecturer, Georgia Institute of Technology.

2003

J.T. Donald Lecturer, McGill University, Montreal.
Five College Lecturer (Amherst, Mount Holyoke, Smith, Hampshire and U. Mass. Amherst).
Invited Speaker, Gordon Conference on Chemical Sensors.
Frontiers of Chemistry Lecturer, Wayne State University.

2002

Invited Lecturer, International Symposium on Innovative Materials Processing (IMP2002), Miyagi, Japan.
Invited Lecturer, 16th International Symposium on Nonlinear Acoustics (ISNA-16), Moscow.
Invited Speaker, 9th Intl. Symp. on Olfaction & Electronic Noses (ISOEN-2002), Rome.
Invited Speaker, R.G. Bergman Symposium, University of California, Berkeley.
Invited Speaker, 2nd International Congress on Porphyrins and Phthalocyanines, Kyoto.
Invited Speaker, Chicago Technology Forum 2002.

2001

Plenary Lecturer, EURODEUR-AIRODEUR Conference, Paris.
Invited Speaker, 8th Intl. Symp. on Olfaction & Electronic Noses (ISOEN-8), Washington, D.C.
Plenary Lecturer, 17th Intl. Congress on Acoustics, Rome.
Plenary Lecturer, World Congress on Ultrasonics/IEEE Intl. Ultrasonics Symposium, Atlanta, GA.

2000

Keynote Speaker, Ultrasonics Industry Association Meeting, Columbus.
Invited Speaker and Symposium Organizer, Pacifichem 2000, Honolulu.
Invited Speaker and Symposium Organizer, 1st International Congress on Porphyrins and Phthalocyanines, Dijon.
Invited Speaker, 7th Meeting of the European Sonochemistry Society, Biarritz.
Invited Speaker, Chemistry under Extreme Conditions Symp., ACS Natl. Meeting, Washington, D.C.

1999

Pittsburgh Conference Lectureship, Duquesne University, Pittsburgh.
Invited Speaker, "Unusual Techniques in Inorganic Chemistry," 82nd Canadian Soc. for Chemistry Conf., Toronto.
Invited Speaker, 15th International Symposium on Nonlinear Acoustics, Göttingen.

1998

Director's Colloquium Speaker, Los Alamos National Laboratory.
Invited Speaker, Gordon Research Conference, Chemistry and Biology of Tetrapyrroles.

Current Major Research Funding:

2000 – 04	NIH 5R01-HL25934 "Heme Proteins, Microspheres, and Their Synthetic Analogs" $353,992 / yr.
1999 – 03	DARPA; "Chemical Control of Single Bubble Cavitation" $637,121 / 3.5 yrs.
1999 – 03	NSF; "Chemical Effects of Ultrasound," $480,000 / 3 yrs.
1997 – 02	DOD; Army MURI, "Dendrimeric Materials," Multi-PI proposal; K.S.S. portion: $100,000 / yr.
2000 – 02	PG Research Foundation "Ultrasonic Gas Dispersion and Dissolution" $52,933.
1990 –	DOE; UIUC Materials Res. Lab, "Field Responsive Porphyrinic Materials," $100,000 / yr.

Student and Postdoctoral Associates, Past and Present:

13 Ph.D. Graduate Students presently in group (08/03).
4 Postdoctoral Research Associates presently in group (08/03).
36 Ph.D. Graduate Students supervised and theses completed.
23 Past Postdoctoral Research Associates.
4 M.S. Graduate Students supervised and theses completed.
15 Undergraduate Research Assistants supervised.

MAJOR EQUIPMENT IN THE SUSLICK GROUP

Laboratory Space:

Contiguous labs and offices in the Chemical and Life Sciences Laboratory (dedicated April, 1997):
588 ft^2 office space;
3500 ft^2 laboratory space;
17 fume hoods;
224 linear feet of bench space.

Spectroscopic and Photochemical Instrumentation:

Hitachi 3300 Double Monochromator UV-vis Spectrophotometer with Constant Temperature Cell Housing
Hitachi Diffuse Reflectance Integrating Sphere.
HP 8452A Diode Array UV-vis Spectrophotometer with Constant Temperature Sample Holder.
Jobin Yvon Horiba FluoroMax-3 Spectrofluorometer.
Matrix Isolation Rig with Leybold-Heraeus Closed Cycle 8K Refrigerator.
Electrochemical Analysis Apparatus, Bioanalytical Systems CV51W.
2 Photochemistry rigs, 300W and 500 W Eimac compact Xe arcs with quartz optics and filters.

Microarray Printers and and Microscopy Instrumentation:

Perkin-Elmer PiezoArrayer sub-nanoliter non-contact printer
36 Split-Pin Array contact printer
Optical/Fluorescence Microscope, Zeiss Axioskop with polarization analyzer and fluorescence optics.
Optical Microscope, Inverted Configuration, Olympus CK2 with video imaging system.

Chromatographic Equipment:

Agilent 6890/5973 Gas Chromatograph / Mass Spectrometer.
Varian 3770 Capillary Gas Chromatograph with 50m Columns, FID.
Waters 600E Multisolvent HPLC with Waters 996 Diode Array Detector.
Chromatotron Centrifugal Preparative Thin Layer Chromatograph.

Gas Flow Controllers and Heterogeneous Catalysis Microreactor:

8 MKS Mass Flow Controllers
Digital Baratron Manometer
Flow Microreactor for Gas-Solid Heterogeneous Catalysis, interfaced to HP GC/MS
High Vacuum Line, Turbomolecular Pump and Penning Gauge, and
Quadrupole Mass Spectrometer Residual Gas Analyzer, Spectra #245-320.

Particle Sizing and Characterization:

Particle Counter and Sizer, Coulter Multisizer IIE, with computer interface.
Particle Sifter, ATM Sonic Sifter with Sieves.
Quantachrome Nova 2200e Gas Adsorption Surface Area Apparatus.

Ultrasonic Equipment:

4 Heat-Systems Ultrasonics 300 to 600W Immersion Ultrasonic Horns
and Power Supplies with High Pressure Cells and Inert Atmosphere Cells.
4 Sonics and Materials 500 - 600W, 20 kHz Immersion Ultrasonic Horns and Power Supplies.
Sonics and Materials 40 kHz Immersion Ultrasonic Horn and Power Supply.
Power Amplifier, AR 700A1, 700 W, 10 kHz-1MHz.
Power Amplifier, ENI AP400B, 400W, 10 kHz-2MHz
2 Function Generators, HP 8904A
Power Piezoceramic Transducers, 20 - 800 kHz.
4 Ultrasonic Spray Pyrolysis rigs with tube furnaces and vacuum lines
Magnetostrictive Transducer, 4 kW, manufactured by Russian Academy of Sciences.
Calibrated Hydrophone, Bruel&Kjaer 8103
Measuring Amplifier, Bruel&Kjaer 2525
Needle Hydrophone, Dapco Ind.
Dual Trace Oscilloscope, Hewlett-Packard 33120.
2 Digitizing Oscilloscopes, HP 54111D and 54112D, 100 MHz

MAJOR EQUIPMENT IN THE SUSLICK GROUP

Sonoluminescence Equipment:

Sonoluminescence Rigs:

Princeton Instruments Optical Multichannel Analyzer with Spec-10:100B/LN CCD Array Detector.
0.5 m Acton Research 505F with 3 grating turret and 0.2 m Thermal-Jarrell Ash Monochromators.
CCD Optical Spectrometer, Jobin Yvon-Spex TR190/CCD3000 system.
Gas Mixing/Mass Flow Controllers, 4-channel readout/power supply, MKS Model 247.

Image station for measurement of bubble dynamics.

Long distance video microscope.
Fiber optic illumination system, 150 W illuminator PL-800.
CCD monochrome camera Sony XC-77 with video capture card/PC interface.

Inert Atmosphere Equipment:

Vacuum Atmospheres Double Length Inert Atmosphere Chamber with O_2 Monitor & MO-40 Dritrain
Vacuum Atmospheres Single Length Inert Atmosphere Chamber with O_2 Monitor, MO-20 Dritrain, interfaced with internal sonicator and cooling.
12 Dual Argon-Vacuum Manifolds with Airless Glassware.
20 Two-Stage Vacuum Pumps
High Vacuum Line, Diffusion Pump and Penning Gauge.

Computers and Graphics Equipment:

1 PC Server, 2GHz with triplicate 120 GB RAID storage.
17 PC 2.5 GHz microcomputers (one per desk); 3 PC 1 GHz Microcomputers.
Silicon Graphics Indigo^2 Extreme graphics workstation, R4400 processor, with 8.5 GB Hard Drives, 64 MB RAM, 19" 24-bit color monitor, CD-R, Molecular Simulations molecular modeling software.
6 Hewlett-Packard LaserJet printers; 3 Hewlett-Packard Desk-Jet Color Printers.
4 high resolution color scanners.
Minolta 7000i 35 mm Camera with multiple lens;
Cannon Power Shot G1 Digital Camera.

Other Laboratory Equipment:

6 Refrigerated Constant Temperature Baths; Braun, Fisher.
NANOpure Water Purification System, Bioresearch Grade D4751.
Fisher Marathon 13K Centrifuge.
2 Buchi Rotary Evaporators and Vacuum Lyophilzer, 12 Port.
4 Mettler Analytical and Sartorius Analytical Top-loading Balances.
5 Laboratory Refrigerators and 1 Laboratory Storage Freezer.
4 Large Laboratory Ovens
5 Tube Furnaces, one with multi-zone capabilities
6-Station Stainless Steel Solvent Purification (Alumina Column) Rig

PAST RESEARCH GROUP MEMBERS

Chemical Effects of Ultrasound

Oleg Abramov
Professor, Russian Academy of Sciences;
Director of Research, Institute for Inorganic and General Chemistry.
Visiting Professor, UIUC, 1994.

Dominick J. Casadonte, Jr.
B.Sc., Case Western Reserve Univ., 1980.
Ph.D., Purdue Univ., 1984 (D. McMillin).
Postdoctoral Associate, UIUC, 1984-1986.
Associate Professor, Texas Tech Univ.

Seok-Burm Choe
B.Sc., Seoul National Univ., Korea.
Ph.D., Kansas State Univ. (K. Klabunde).
Postdoctoral Associate, UIUC, 1987-8.
Professor, Kei-Mgung Univ., Taegu, Korea.

Andrzej A. Cichowlas
Postdoctoral Associate, UIUC, 1991-1994.
Research Scientist, Polish Academy of Sciences.

Gennady Dantsin
B.S., State U. of New York, Binghamton, 1996.
Ph.D., UIUC, "Ultrasound Mediated Synthesis of Catalytic and Polymeric Materials", 2001.
Research Scientist, Air Products Corp.

Arul Dhas
B.S., Madurai Kamaraj University, 1988.
Ph.D., Indian Inst. of Science, Bangalore, 1994.
Postdoc. Assoc., Bar-Ilan U., Israel, 1995-1998.
Postdoc., UIUC, 1999-2001.
Research Scientist, Advanced Materials.

Steven J. Doktycz
B.Sc., UIC, 1984.
Ph.D., UIUC, "Effects of Ultrasound on Solid-Liquid Reactions," 1989.
T. S. Piper Thesis Research Prize, UIUC, 1989.
Staff Scientist, Dow Chemical Co.
Chief Financial Officer, ANGUS (Dow Corp.).

Theodore Dolter
B.Sc., St. Louis Univ.
M.S., Univ. of Illinois.
Science Teacher, Rosary High School, St. Louis.

Arash Ekhtiarzadeh
B.S., University of Scranton, 1997.
Ph.D., UIUC, "Sonochemically Generated Materials", 2001.
Research Scientist, Bettis National Laboratories.

Mingming Fang
B.S., M.S., Beijing Univ., 1987-1990.
Ph.D., UIUC, "Catalytic and Magnetic Properties of Nanostructured Materials Generated by Ultrasound," 1995.
Staff Scientist, Cabot Corp.

Edward B. Flint
B.Sc., Kenyon College, 1983.
Ph.D., UIUC, "Sonoluminescence," 1989.
Postdoctoral Associate, Professor H. Suhr, Tubingen, Germany.
Associate Professor, Bradley Univ.

Mark W. Grinstaff
A.B., Occidental College, 1987.
Ph.D., UIUC, "The Sonochemical Synthesis of Inorganic and Biological Materials," 1992.
T. S. Piper Thesis Research Prize, UIUC, 1991.
NIH Postdoctoral Fellow, Caltech.
ACS Nobel Laureate Signature Awardee, 1994.
Asst. Prof., Department of Chemistry, Duke Univ.

Chanchal K. Ghosh
B.Sc., M.S., Univ. of Dhaka, Bangladesh, 1975.
Ph.D., Univ. of Alberta, 1989.
Staff Scientist, Fabric & Hard Surface Technology, Procter and Gamble Company.

Lev Grundel
Ph.D., M.S., Moscow Univ., 1983
Postdoctoral Associate, UIUC, 1991.
Staff Scientist, Great Lakes Analytical, Chicago.

David A. Hammerton
B.Sc., Southern Connecticut State College, 1981.
Ph.D., UIUC, "The Sonochemical Hot Spot" 1987.
Staff Scientist, Rohm and Haas, Inc.
Technical Manager, UCB Chemicals.

PAST RESEARCH GROUP MEMBERS

Taeghwan Hyeon
B.S., M.S., Seoul National Univ., 1991.
Ph.D., UIUC, "Nanostructured Catalytic and Magnetic Materials: Sonochemical Synthesis and Characterization", 1996.
T. S. Piper Thesis Research Prize, UIUC, 1996.
P.D. Res. Assoc. Northwestern Univ., 1996-97.
Assistant Professor, Seoul Natl. Univ., Korea.

Robert E. Johnson
B.Sc., Univ. of Wisconsin-Milwaukee, 1977.
Ph.D., Univ. of Wisconsin-Madison, 1981 (L. Dahl).
Postdoctoral Associate, UIUC, 1983-84.
Staff Scientist, HOECHST Celanese Inc.

Kathleen A. (Kemper) House
B.Sc., M.S., Illinois State Univ., 1989.
Ph.D., UIUC, "Sonoluminescence As a Probe of Cavitation", 1994.
Asst. Professor, Illinois Wesleyan Univ.

Keith S. Kostecka
B.Sc., Illinois Benedictine College, 1982.
M.S., UIUC, 1985.
D.Ed., UIUC at Chicago, 1990.
Associate Professor, Columbia College, Chicago.

Kenneth Kolbeck
B.S., Univ. of New Mexico, 1991.
Ph.D., UIUC, 1999; M.D., UIUC, 2000.
Radiology Resident, College of Medicine, Dartmouth.

Gregory Kufner
B.S., Illinois Wesleyan, 1995.
Ph.D., UIUC, "Surface Modification of Protein Microspheres" 2000.
Staff Scientist, Abbott Pharmaceuticals.

Dongkyu Lee
Professor, Chemical Engineering,
Chungbuk National University (Korea).

William B. McNamara, III
B.S., Univ. of California, Santa Barbara, 1992.
Ph.D., UIUC, "Multi- and Single Bubble Sonoluminescence," 2002.
Staff Scientist, ChemSensing, Inc.

Millan M. Mdleleni
B.Sc., Univ. of Fort Hare (S. Africa), 1987.
Ph.D., UCSB, 1995.
Postdoctoral Associate, UIUC, 1995-98.
Staff Scientist, Sasol Industries, S.A.

James D. Oxley
B.S., Texas Christian University, 1998.
Ph.D., UIUC, 2003; "Environmental Applications of Ultrasound."
Staff Scientist, Southwest Research Institute.

Christian Petrier
Ph.D., Univ. of Grenoble, 1982
Postdoctoral Associate, UIUC, 1988-89
Professor, ESIGEC/Universite de Savoie, France.

Tanya Prozorov
M.S., Bar-Ilan University, 1998.
Ph.D., UIUC, 2004.
Research Scientist, Univ. So. Carolina.

Paul F. Schubert
B.Sc., Univ. of Arkansas, 1978.
Ph.D., UIUC, "Sonochemistry of Some Metal Carbonyl Complexes," 1982.
Group Leader, Catalytica Res. and Development.
Vice-President for Research and Development, Syntroleum Corp.

Gregory Szewczyk
B.A., Northwestern Univ., 1995.
Ph.D., UIUC, "Disulfide Crosslinking in Protein Microspheres" 2000.
Staff Scientist, Colgate-Palmolive Corp.

Hau H. Wang
B.Sc., National Tsing Hua Univ., Taiwan, 1975.
Ph.D., Univ. of Minnesota, 1981, (L. Pignolet).
Postdoctoral Associate, UIUC, 1981-83.
Staff Scientist, Argonne National Laboratory.

Mike Wong
B.S., Univ. of Tulsa, 1991.
Ph.D., UIUC, "Sonochemically Produced Proteinaceous Microspheres," 1996.
Staff Scientist, Colgate-Palmolive, N.J.

PAST RESEARCH GROUP MEMBERS

Bioinorganic Chemistry

Francis V. Acholla
B.Sc., Univ. of Nairobi, Kenya.
Ph.D., Univ. of Kansas, 1985 (K. B. Mertes).
Postdoctoral Associate, UIUC, 1985-86.
Asst. Professor, Univ. of Nairobi, 1985-91.
Senior Research Chemist, Rohm & Haas.

Mark D. Ball
B.S., Purdue Univ., 1982.
Ph.D., Iowa State Univ., 1987 (J. A. Olson).
Postdoctoral Associate, UIUC, 1988-90.
Associate Professor, Rose-Hulman Inst. Tech.

Jie Bai
B.S., Beijing University, 2002.
M.S., UIUC, 2004.

David Benson
B. A., Goshen College, 1990.
Ph.D., UIUC, "New Intermediates of Cytochrome P450" 1997. (with Steve Sligar)
Postdoctoral Associate, Duke Univ.
Asst. Prof., Wayne State Univ.

Puttaiah Bhyrappa
B.S., M.S., Bangalore Univ., 1986
Ph.D., Indian Inst. of Science, Bangalore, 1991.
Postdoctoral Associate, UIUC, 1994-97.
Assistant Professor, Indian Institute of Technology, Madras.

Mala Bhyrappa
B.S., M.S., Bangalore Univ., 1991
Ph.D., Indian Inst. of Science, Bangalore, 1996.
Postdoctoral Associate, UIUC, 1997.

Chin-Ti Chen
B.S., Tamkang Univ., Taiwan, 1978.
M.S., National Taiwan Univ., 1982.
Ph.D., UIUC, "Porphyrins and Metalloporphyrins as Field Responsive Materials," 1992.
Postdoctoral Associate, S. Marder, Caltech.
Research Faculty, Institute of Chemistry, Academia Sinica, Taiwan.

Homer Chou
B.S. Univ. of Chicago, 1989.
Ph.D., UIUC, "Porphyrins as Second Order Nonlinear Optical Materials," 1995.
T. S. Piper Thesis Research Prize, UIUC, 1995.
Postdoc. Res. Fellow, Northwestern U., 1995-97.
Staff Scientist, Cabot Corporation.

Richard Jun-Hong Chou
B.S., National Cheng Kung Univ., Taiwan, 1982.
Ph.D., Michigan State Univ., 1995.
Staff Scientist, Merck Pharmaceuticals.

Bruce R. Cook
B.S., Hope College, 1981.
Ph.D., UIUC, "Shape Selective Oxidation of Hydrocarbons," 1986.
Staff Scientist, Exxon Corporate Res. & Engin.

Daniel R. English
B.S., Ohio State Univ., 1979.
Ph.D., UIUC, "Synth. Fe Porphyrins as Models for Heme Proteins", 1984.
Unit Director, Eastman Kodak Company.

Mary M. Fox
B.S., Indiana Univ.-Evansville, 1978.
Ph.D., UIUC, "A Bis-Pocket Porphyrin," 1983.
Staff Scientist, Procter & Gamble Corp.

Philip Gorlin (Joint with Greg Girolami)
B.S., Univ. of Texas at Austin, 1989.
Ph.D., UIUC, "Metalloporphyrin Sandwich Complexes," 1994.
Staff Scientist, Colgate Palmolive Corp.

Christopher L. Hein
B.S., Univ. of Colorado at Boulder, 1992.
Ph.D., UIUC, "Photosynthetic Reaction Center Analogs", 1997 (with Greg Girolami)
Staff Scientist, G. E. Plastics Corp.

David Huffman
B.S., M.S., Illinois State Univ., 1988.
Ph.D., UIUC, "Oligopeptide-Heme Complexes," 1993.
NIH Postdoctoral Fellow, T. O'Halloran, Northwestern Univ.
Asst. Prof., Univ. Western Michigan.

Vijay K. Joshi

PAST RESEARCH GROUP MEMBERS

B.Sc., Punjab Univ., 1969.
M.Sc., Univ. of Jodhpur, 1971.
Ph.D., SUNY Buffalo, 1987 (J. H. Wang).
Postdoctoral Associate, UIUC, 1987-8.
Staff Scientist, Reheis Chemical Co.

Warren A. Kaplan
B.S., Brandeis Univ., 1984.
Ph.D., UIUC, "Ligand Binding to Ni Porphyrins and F430," 1989.
Staff Scientist, Shell Corporate Research.
Research Chemist, Stepan Company.

Michael G. Kinnaird
B.S., Guilford College, 1979. Ph.D., Univ. of North Carolina, 1983 (D. Whitten).
Postdoctoral Associate, Univ. of Kyoto, 1984 (I. Tabushi).
Postdoctoral Associate, UIUC, 1984-86.
Staff Scientist, BASF Chemical Co.

Stanley N. Milam
B.S., Univ. of Texas at Austin, 1984.
Ph.D., UIUC "Actinide Porphyrin Chemistry," (with G. Girolami), 1989
Staff Scientist, Shell Chemical Co.

Margaret Kosal
B.S., University of Southern California, 1995.
Ph.D., UIUC, "Porphyrin Network Materials", 2001.
Staff Scientist, Monterey Institute.

Shirley Nakagaki
Sabbatical Associate, 2003.
Prof., Federal University of Paraná, Brazil.

Saad N. Nemeh
B.S., Univ. of Applied Chemistry, Syria, 1976.
Ph.D., Univ. of California, Santa Barbara, 1984 (W. Kaska).
Postdoctoral Associate, UIUC, 1984-5.
Staff Scientist, Englehardt Chemical Co.

Bimal Patel
A.B., Occidental College, 1990.
Ph.D., UIUC, "Porphyrin Liquid Crystals," 1996.
Staff Scientist, G.E. Plastics Corp.

Alicia Paterno
B.S., Ithaca College, 1996.
Ph.D., UIUC, "Supramolecular Porphyrin Assemblies", 2001.
Visiting Asst. Prof., Duquesne University

Jennifer Beck Ralph
B.S., Ph.D., Univ. of Queensland, Australia, 1983, 1987.
Postdoctoral Associate, UIUC, 1987-9 (joint with S. G. Sligar).
Research Scientist, Australian National Univ.

Neal Rakow
B.S., Colorado School of Mines, 1996.
Ph.D., UIUC, "Metalloporphyrin Based Colorimetric Nose: 'Smell-Seeing,'"2001.
T. S. Piper Thesis Research Prize, UIUC, 2001.
Research Scientist, 3M Corporate R&D Center.

Thomas J. Reinert
B.S., Iowa State Univ., 1979.
Ph.D., UIUC, "Mechanistic Probes of Heme Proteins" 1987.
Professor, Linfield College, Oregon.

Michael Rosenblatt
B.S., Towson State Univ., 1992.
Ph.D., UIUC, "Mb Microspheres and Metalloporphyrin-Peptide Complexes" 2000.
Postdoctoral Associate, Univ. of Pennsylvania (W. DeGrado)

Avijit Sen
B.S., Jadavpur University, Calcutta, 1989.
Ph.D., Indian Inst. of Science, Bangalore, 1998.
Postdoctoral Associate, UIUC, 1998-2001.
Staff Scientist, ChemSensing, Inc.

Cynthia A. Smith
B.Sc., Kenyon College, 1978.
M.S., UIUC, 1981.
Regulatory Officer, ICI Specialty Chemicals.

Dennis Smithenry
B.S., University of Illinois, 1999.
Ph.D., UIUC, 2004.
Postdoctoral Associate, Stanford University.

PAST RESEARCH GROUP MEMBERS

Shawne Van Deusen-Jeffries
A.B., Occidental College, 1987.
M.S., UIUC, 1991.
Research Scientist, Eli Lilly.
Chemist, AMTX Products, XEROX Inc.

Jiangyun Wang
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Ph.D., UIUC, 2003, “De Novo Heme Protein Design”

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