STEFAN FRANZEN
Professor of Chemistry
North Carolina State University
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PROFESSIONAL EXPERIENCE

Professor
Department of Chemistry, North Carolina State University 2006-Present
Assistant and Associate Professor
Department of Chemistry, North Carolina State University 1997-2006
Fulbright Fellow and Visiting Professor
Department of Chemistry, Adam Mickiewicz University, Poznan, Poland 2014
Guangbiao Chaired Professor of Chemistry
Department of Chemistry, Zhejiang University, Hangzhou, China 2009-Present
Director's Office Post-Doctoral Fellow,
Los Alamos National Laboratory, Los Alamos, NM 1994-1997
European Molecular Biology Organization Post-doctoral Fellow,
Ecole Polytechnique, Palaiseau, France 1992-1994

EDUCATION

Stanford University, Stanford, CA
PhD in Physical Chemistry, Thesis Advisor: Steven G. Boxer 1992
University of California, Berkeley, CA
B.S. in Chemistry 1982

SERVICE

Member of the Biophysics Study Section, NIH (MSFB) 2004-2008

TEACHING EXPERIENCE

Full Professor of Chemistry
North Carolina State University 1997-Present
Liaison, NC State STEM Semester Study Abroad 2017-Present
Adam Mickiewicz University, Poznan, Poland
Visiting Professor, **Polish, Fulbright and Erasmus Mundus Programs**
Adam Mickiewicz University, Poznan, Poland 2001-Present
Visiting Professor, **Guangbiao Chaired Professor**
Zhejiang University, Hangzhou China 2009-2015
Director, NC State University Study Abroad,
Zhejiang University, Hangzhou China 2008-2016
Teaching Assistant, Chemistry Dept., Stanford University 1985-1986
Peace Corps Volunteer Science Teacher, Torongo, Kenya 1982-1985
Music Teacher, Stockholm, Sweden 1980-1981

OUTREACH

Mentor for Kenan Fellows Program
with Fellow Pat Ligon of Broughton High School, Raleigh, NC 2002-2005

RESEARCH DESCRIPTION

The Franzen group has pioneered research in plasmon resonance in conducting metal oxides. While the existence of a plasma absorption and surface plasmon polaritons is predicted by theory in all conductors, we have predicted and experimentally verified that that measurable optical resonances can be observed in a series of conducting metal oxides, including indium tin oxide (ITO), aluminum-doped zinc oxide (AZO), gallium-doped zinc oxide (GZO), and dysprosium-doped cadmium oxide. We have extended the measurement of plasmons to the mid-infrared beyond 10 microns in wavelength. Until the present almost all practical applications of surface plasmons have been made in the noble metals silver and gold. In 2006, we have described the basic physics and discovered that plasmons in degenerate semi-conductors such as ITO are free from interfering absorption bands such as those observed in silver and gold. We have recently shown novel hybrid plasmonic materials for the first type. These are composite layers of ITO and Au where the plasmon is actually resident in both layers. We have shown patterned surfaces are possible with conducting metal oxides. These are semi-conductor compatible materials that have the ability to develop a new field of integrated plasmonics in semi-conductors.

Dr. Franzen has created a world-class research effort in the study of a multi-function hemoglobin, which mas multiple enzymatic functions. We regard the protein known as dehaloperoxidase-hemoglobin (DHP) as a prototype for the study of multi-functional proteins. These proteins lead to an understanding of the evolution of protein function according to our hypothesis that primitive proteins were multi-functional, in contrast to the more specialized functions seen in many life forms today. DHP is an enzyme capable of degrading chlorinated and brominated phenols. In recent years we have discovered a hydrogen sulfide oxidase function and a peroxygenase function. We have studied the structure and function using x-ray crystallography, nuclear magnetic resonance, resonance Raman spectroscopy, electron paramagnetic resonance spectroscopy, Fourier-transform infrared spectroscopy, electrochemistry, stopped-flow kinetics, and site-directed mutagenesis. In 2010 we proposed a model known as two-site competitive inhibition to explain the observed inhibition kinetics. This mechanism is one of the few examples of a textbook mechanism known as non-classical competitive inhibition. The inhibitor binding site is directly above the heme and blocks the heme iron. This unusual behavior likely is an evolutionary response to the need to change function. Normally, the protein functions as an oxygen carrying protein (hemoglobin) until it encounters a toxic compound. In the presence of toxic halogenated phenols the protein switches function and becomes a dehaloperoxidase. In 2012, we proposed a resolution to the functional paradox presented by the apparent requirement for ferrous iron in oxygen transport function (globin) and ferric iron in the oxidation of substrates (peroxidase). The resolution is an enzymatic cycle that begins and ends with the ferrous iron. This mechanism had major input from collaborator, Prof. Ghiladi who has become a major player in the field. Our recent discovery of a new internal substrate binding site and concommitant peroxygenase activity is a completely novel observation in a hemoglobin.

Dr. Franzen has developed the concept of using plant viruses as nanoparticles. The research in the Franzen laboratory pioneered the infusion of small molecules into plant viruses as a method for creating a new type of drug delivery system. This idea has been patented and developed in a company called Nanovector, Inc. co-founded by Dr. Franzen and Dr. Lommel. The company received both phase I and phase II NIH funding and was successful at developing a targeting agent. Currently the scale-up of plant virus is taking place jointly with collaborators at Adam Mickiewicz University in Poznan, Poland.

INTERNATIONAL SCIENTIFIC COLLABORATION

Dr. Franzen has had a 13-year long relationship with the groups of Dr. Bohdan Skalski at Adam Mickiewicz University in Poznan, Poland. During this time Dr. Franzen has contributed to projects in nucleic acids photochemistry. These have been research collaborations with students, computational contributions based density functional theory (DFT) and molecule dynamics calculations carried out by Dr. Franzen and spectroscopy. Drs Skalski and Franzen patented the fluorescent crosslinking of 5-fluoro-4-thiouridine, which was observed in DNA for the first time in a 2014 in a publication in ChemBioChem.

Dr. Franzen has maintained a collaboration with several groups at Zhejiang University in Hangzhou, China. These are more recent and the first publications will be published in 2015. Dr. Franzen has contributed by mentoring summer research students for 5 years and thereby has become a collaborator. The contributions to the group of Dr. Haoran Li of Zhejiang University are mostly computational, although one graduate student from China spent 6 months in Dr. Franzen's laboratory learning Raman spectroscopy. Dr. Franzen has also conduct joint projects with Dr. Qi Wang and Dr. Tao Wu using molecular dynamics simulations to study dehaloperoxidase.

Dr. Franzen is a member of a NC State-Technical University of Berlin graduate student exchange program. Dr. Franzen has accepted 3 students from Berlin for research visits ranging from 6-9 months. The first of these has resulted in 2 publications in collaboration with Dr. Peter Hildebrandt.

INTERNATIONAL EDUCATIONAL MISSION

Driven by a strong personal experience in international education that includes High School education in the Netherlands for one year and Sweden for two years, teaching Music in Sweden for one year, teaching Science and Swahili in Kenya for two years and a post-doctoral fellowship in France for two years, Dr. Franzen has pursued numerous international activities. Study Abroad research experiences for undergraduates have been provided in Norway (2004), Sweden (2005), Poland (2006-2010), China (2010-present). These have increased in size each year so that the current program size in China ranges from 12-20 annually. Students can study General Chemistry, Physical Chemistry or conduct laboratory research in China at Zhejiang University. The program in Poland was funded by the NSF and supported research for 4 undergraduates and 1 graduate annually to do research for 3 months at Adam Mickiewicz University. Dr. Franzen has lived in Poland for more than one year since 2000 and has lived in China for more than one year since 2008. Graduate student research experiences have been provided in the United Kingdom, Italy, France, Germany and Poland.

The undergraduate programs for science majors are an ongoing project. The current focus is on a Summer Study abroad program in China and a Fall Semester program in Poznan, Poland. Together with partners in Poznan we can offer a significant sampling of science classes, including General Chemistry, Organic Chemistry (with laboratories), Physical Chemistry, Physics (semester courses in Mechanics and Electromagnetism), Biology (two semester sequence with laboratory), Mathematics (all calculus courses and differential equations). This concept is driven by a unique situation in Poland. Due to the depletion of the population the universities need students and the infrastructure is all brand new. The cost of education in Poland is among the cheapest in the world. The program can be run "at cost" for students. They would pay one semester of in-state tuition, room and board and this would cover all costs for a semester in Poland including the plane fare, housing, food all educational costs, in-country travel for one week. Affordable Study Abroad programs is the focus Dr. Franzen's current work as the College of Sciences Liaison for STEM International Programs.

TRANSLATIONAL RESEARCH

Dr. Franzen co-founded the company Nanovector, Inc. with partner Dr. Steven Lommel. In collaboration Dr. Bruce Oberhardt this company has worked to develop technology originally developed in the Franzen laboratory to use the loading of drug molecules into the plant virus *Red clover necrotic mosaic virus* (RCNMV). Infusion of doxorubicin has shown the greatest success. Preparations of ~1000 infused doxorubicin molecules per RCNMV have been used in laboratory experiments to demonstrate efficacy against melanoma tumors. It is understood that doxorubicin is not normally a drug that has efficacy against melanoma. However, the hypothesis of the research is that the particles are taken up by endocytosis and evade efflux pumps, which normally would remove doxorubicin and prevent them from reaching the nucleus which is the target for an effective treatment to inhibit the growth of cancer cells. This research has moved beyond the university has received both first and second phase funding from the National Institutes of Health. One of the major obstacles for the development of plant virus technology is scale up of production.

SCIENTIFIC WRITING COURSE AND SCIENTIFIC LANGUAGE BOOKS

Dr. Franzen has developed a short course in scientific writing and has written a book entitled "The Art of Scientific Writing" for non-native speakers of English. The current version is being published at Zhejiang University Press as a dual language book in Chinese and English targeted for Chinese audience with the help of Zheng Rui. A second book has been contracted by Zhejiang University Press with the "Cultural Contradictions: Dialogs in the International Conduct of Science". This book is also a dual-language text co-written with Xiaoyan Sun.

LANGUAGES

Swedish, Fluent, Secondary School Diploma, Trained Music Instructor
Dutch, Fluent, Passed Advanced Dutch Language and Literature (Atheneum level)
German, Fluent, Swedish Secondary School Exam as First Foreign Language
French, Fluent, Swedish Secondary School Exam as Second Foreign Language
Spanish, Fluent.
Polish, Fluent,
Chinese, Fluent
Swahili, Fluent, Foreign Service International Exam (4+), Kenya Secondary Exam (British "A level")
Kalenjin, Foreign Service International Exam (3+)
Latin, Reading, Swedish Secondary School Exam as Third Foreign Language
Italian, Conversant, Special language study during Secondary School
Russian, Conversant, Three Years University Study at UC Berkeley

REFEREED JOURNAL PUBLICATIONS AND BOOK CHAPTERS

1. **Boxer; S. G. Goldstein, R. A.; Franzen, S.** ¨The use of magnetic and electric fields to probe electron transfer reactions¨ in Photoinduced Electron Transfer Fox, M. A.; Chanon, M. Eds.; Elsevier Press; New York **1988**; Vol. B, pp. 163-215

2. **Boxer; S. G. Lockhart, D. J.; Franzen, S.** ¨Electric field effects on electron transfer reactions in isotropic systems¨ in Photochemical Energy Conversion J. R. Norris Jr.; Meisel, D. Eds.; Elsevier Press; New York **1989**; pp. 196-210

3. **Franzen, S; Goldstein, R. F.; Boxer, S. G.** ¨Electric field modulation of electron transfer rates: charge recombination in photosynthetic reaction centers¨ J. Phys. Chem. **1990**, 94, 5135-5149

4. **Lockhart, D. J.; Hammes, S. L.; Franzen S.; Boxer, S. G.** ¨Electric field effect on emission lineshapes when electron transfer competes with emission: an example from photosynthetic reaction centers¨ J. Phys. Chem. **1991**, 95, 2217-2226

5. **Hasegawa, T.; Franzen, S.; Lambright, D.; Oh, D.; Balasubramanian, S.; Hedman, B.; Hodgson, K.** ¨Inclusion of a small molecule in a big cage: preparation and structure of catena-(catena-α,ω-diaminooctane-μ-cadmium tetracyanonickelate)-toluene¨ Inorg. Chem. **1991**, 30, 1441-1444

6. **Shreve, A.; Cherepy, N.; Franzen, S.; Boxer, S. G.; Mathies, R. A.** ¨Rapid flow resonance Raman in bacterial photosynthetic reaction centers¨ Proc. Natl. Acad. Sci. **1991,** 88, 11207-11211

7. **Boxer, S. G.; Franzen, S.; Lao, K.; Lockhart, D. J; Stanley, R.; Steffen, M.; Stocker, J. W.** ¨Electric-field effects on the quantum yield and kinetics of fluorescence and transient intermediates in bacterial photosynthetic reaction centers¨ in The Photosynthetic Bacterial Reaction Center II **1992** Breton, J.; Vermeglio, A; Eds. NATO ASI Series vol. 237 Plenum Press

8. **Franzen, S.; Lao, K-Q.; Boxer, S. G.** ¨Electric field effects on kinetics of electron transfer reactions: connection between experiment and theory¨ Chem. Phys. Lett. **1992**, 197, 380-388

9. **Franzen, S. and Boxer, S. G.** ¨Temperature dependence of the electric field modulation of electron transfer rates: charge recombination in photosynthetic reaction centers¨ J. Phys. Chem. **1993**, 97, 6304-6318

10. **Franzen, S; Goldstein, R. F.; Boxer, S. G.** ¨Distance dependence of electron-transfer reactions in organized systems: the role of superexchange and non-Condon effects in photosynthetic reaction centers¨ J. Phys. Chem. **1993**, 97, 3040-3053

11. **Goldstein, R. F.; Franzen, S.; Bialek W.** ¨A non-perturbative approach to non-Condon effects: must a non-adiabatic transition always occur at the potential surface crossing?¨ J. Phys. Chem. **1993**, 97, 11168-11174

12. **Lao, K-Q.; Franzen, S.; Stanley, R. J.; Lambright, D. G.; Boxer, S. G.** ¨Effects of applied electric fields on the quantum yields of the initial electron transfer steps in bacterial photosynthesis: I. Quantum yield failure¨ J. Phys. Chem. **1993**, 97, 13165-13171

13. **Cherepy, N.; Shreve, A.; Franzen, S.; Boxer, S. G.; Mathies, R. A.** ¨A comparison of the excitation profile of the bacteriochlorophyll monomer and dimer in the bacterial photosynthetic reaction center¨ J. Phys. Chem. **1994**, 98, 6023-6029

14. **Franzen, S.; Lambry, J.-C.; Bohn, B.; Poyart, C.; Martin, J-L.** ¨Direct evidence for heme-iron doming as the primary event in the quaternary structure change of hemoglobin¨ Nature Structural Biology **1994**, 1, 230-233

15. **Franzen, S.; Bohn, B.; Poyart, C.; Martin, J-L.** ¨Evidence for sub-picosecond heme doming in hemoglobin and myoglobin: A time-resolved resonance Raman comparison of carbonmonoxy and deoxy species¨ Biochemistry **1995**, 34, 1224-1237

16. **Franzen, S.; Bohn, B.; Poyart, C.; DePillis, G. D; Boxer, S. G.; Martin, J-L.** ¨Functional Aspects of Ultra-Rapid heme Doming in Hemoglobin, Myoglobin, and the Myoglobin Mutant H93G¨ J. Biol. Chem. **1995**, 270, 1718-1720

17. **Franzen, S.; Martin, J-L.** ¨Design and Regulation of Efficient Photoinduced Electron Transfer in Photosynthetic and Macromolecular Model Systems¨ Ann. Rev. Phys. Chem., **1995**, 46, 453-487

18. **Lao, K-Q.; Franzen, S.; Stanley, R. J.; Lambright, D. G.; Boxer, S. G.** ¨Effects of applied electric fields on the quantum yields of the initial electron transfer steps in bacterial photosynthesis: II. Angle dependence of quantum yield failure¨ Chem. Phys. **1995**, 197, 259-275

19. **LeClerc, E.; Franzen, S.; Bohn, B.; Marden, M.; Poyart, C.; Martin, J-L.** ¨A Time-resolved Study of CO Recombination Dynamics in a Calmodulin-Heme Complex¨ Biochim. Biophys. Acta **1996**, 1293, 140-146

20. **Decatur, S.; Franzen, S.; Dyer, R. B.; Woodruff, W. H.; Boxer, S. G.** "Trans Effects in Nitric Oxide Binding to Myoglobin Cavity Mutant H93G" Biochemistry **1996**, 35, 4939-4944

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25. **Collman, J. P.; Harford, S. T.; Franzen, S.; Marchon, J.-C.; Maldivi, P.; Woodruff, W. H.** "Resonance Raman, X-Ray Crystallographic and Magnetic Susceptibility Studies of Metal-Metal Bonded MoRu and WOs Porphyrin Dimers: 1. Evidence For An Unusual MO Diagram" Inorg. Chem., **1999**, 38, 2085-2092

26. **Franzen, S.; Moore, L. J.; Woodruff, W. H.; Boxer, S. G.** "Stark Effect Spectroscopy of the Heme Charge Transfer Bands of Deoxymyoglobin" J. Phys. Chem. B, **1999**, 103, 3070-3072

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"Resonance Raman and X-ray crystallographic studies of intertriad metal-metal bonds. 2. WRu and MoOs porphyrin dimers" Inorg. Chem., **1999**, 38, 2093-2097

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34. **Franzen, S.; Miskowski, V. M.; Shreve, A. P.; Wallace-Williams, S. E.; Woodruff, W. H.; Ondrias, M. R.; Barr, M. E.; Moore, L.; Boxer S. G.** "Electrostatic and Conformational Effects on the Electronic Structures of Distortional Isomers of a Mixed-Valence Binuclear Cu Complex", Inorg. Chem. **2001**, 40, 6375-6382

35. **Franzen, S.; Bailey, J.; Dyer, R. B.; Woodruff, W. H.; Hu, R. B.; Thomas, M. R.; Boxer, S. G.** "A Photolysis-Triggered Heme Ligand Switch in H93G Myoglobin" Biochemistry, **2001**, 40, 5299 – 5305

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41. **Franzen, S.; Stanley, R. J.** "A Theoretical Explanation for Quantum Yield Failure in Bacterial Photosynthetic Reaction Centers" Chemical Physics, **2002**, 276, 115-127

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61. **Franzen, S.; Shultz, D. A.** "A New Paradigm for Design of High-Spin Organic Molecules: The Mechanism of Spin-dependent Delocalization in Exchange-Coupled Mixed-Valent Organic Species" J. Phys. Chem. A **2003**, 107, 4292-4299

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INVITED PRESENTATIONS

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Polish Chemical Society Meeting, Wroclaw, Poland, September 15, 2004
Federated Analytical Spectroscopy Society Meeting Portland, Oregon October 4, 2004
Fudan University, Shanghai, China October 14, 2004
Leiden University, Leiden Netherlands Dec. 8, 2004
Iowa State University Ames, Iowa March 25, 2005
Excited States Conference, Santa Fe, NM August 9, 2005
American Chemical Society Meeting, Washington, DC August 29, 2005
Spectroscopy of Biological Molecules, Santa Fe, NM September 1, 2005
Polish Chemical Society Meeting, Poznan, Poland September 22, 2005
Federated Analytical Chemistry and Spectroscopy Society Meeting, Quebec City, Oct. 4, 2005
Western Carolina University, Cullowee, NC, November 11, 2005
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Federated Analytical Chemistry and Spectroscopy Society Meeting, Orlando, Florida, September 25, 2006
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Biophysical Society, Meeting, March 7, 2007
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Conference on Green Technology, Linan, China October 13, 2007
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University of South Carolina, Nanotechnology Center, February 13, 2008
Biophysical Society Meeting, Boston, MA March 4, 2009
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