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Professor of Chemistry

Profile

My education as a chemist started at Southwest Minnesota State University, a public liberal arts college, where I graduated in 1973 with a B.A. degree in chemistry. From there I obtained a Ph.D. in Inorganic Chemistry from the University of Minnesota and completed postdoctoral studies in organometallic chemistry at the University of Alberta (Canada). I joined the faculty at Creighton University in 1977 and over the years I have taught lecture and laboratory courses in General Chemistry, Inorganic Chemistry, Microscale Gas Chemistry and Organometallic Chemistry.

Throughout my 40 years at Creighton my research interests have all focused on inorganic chemistry, but they have evolved from synthetic organometallic chemistry of transition metals to science demonstrations and pedagogy with an emphasis on environmental chemistry finally to my current focus on microscale gas chemistry and gas-phase catalysis with nanoparticle palladium.

Over 20 years ago, my students and I developed a method of generating small samples of gases using 60-mL plastic syringes. Prior to this method, laboratory students and researchers generated gases by 18th Century methods using pneumatic troughs. Noxious and toxic gases were generated in Kipp's generators (19th Century) or by messy methods in fume cabinets. With in-syringe generation, teachers and researchers alike can generate small quantities of gases inexpensively and safely without unintentionally discharging the gas in the room. The first gases we produced were carbon dioxide, hydrogen and oxygen – gases of interest to high school chemistry teachers. We developed 8 – 10 interesting experiments for each of these gases that used as little as 5 mL of the gas per experiment. After that, and over the course of ten years, we developed methods for producing N_2, NH_3, NO_x, C_2H_2, H_2S, SO_2, Cl_2, HCl, CO, C_2H_4, SiH_4, CH_4, N_2O, and O_3. Eleven of these gases are made by the in-syringe method, and the others by other safe methods. Although the methods were developed as university/high school laboratory experiments, an unanticipated audience emerged: scientific and medical researchers, and forensics and fire departments and the like interested in producing small quantities of a certain gas and eliminating the need to purchasing a compressed cylinder of the gas at considerable expense. With undergraduate students performing the research with these gases, we have developed ~150 classroom demonstrations and laboratory activities suitable for use at a variety of levels ranging from the middle school and high school levels up through university-level first-year chemistry students and chemistry majors taking descriptive inorganic chemistry. The results of this work were published in a series of 30+ articles in the *Journal of Chemical Education* and *Chem13 News* and in our book "Microscale Gas Chemistry". The book provided step-by-step procedures for use by high school/university teachers and students and featured an excellent pedagogical section for each experiment, including teaching tips, questions and answers. The book had a companion website, which is how most people first encountered these methods. The newly updated website (2016) now features color photography, some YouTube movies and free downloads for each of the gas chapters formerly available in the book.

For the past decade, our focus has shifted to our "gas reaction catalyst tube", developed with students here at Creighton. The current version of the catalyst tube consists of a small glass tube (6 mm diameter x 10 cm) containing ~ 1 mg nanoparticle palladium on alumina support. Always with undergraduate research students, we designed, developed, and published a series of articles on gas-phase catalytic reactions. All along the way, the design of the catalyst tube improved and now can be constructed for about $2 and used indefinitely. In the past several years, my research students were first-years when they began the work. They started by working through a 10-lesson, 70-page booklet over a 10-week period during the summer to become familiar with the project. By August, they are ready for their first experiments and within two weeks they are at the frontier trying new experiments that have not been performed with our catalyst tube. Over the past two academic years we have worked extensively with the deuteration and hydrogenation of alkynes and will soon be ready for publication. In parallel, I have written a 3-part series for *Chem13 News* on nanoparticles titled "Function and importance of nanoparticles in catalysis". Part 1 appeared in December 2017 and Parts 2 and 3 will appear in the Spring of 2018.

Regarding how I view scholarship that improves teaching, I am motivated by and dedicated to this part of our Mission Statement: "Creighton faculty members conduct research to enhance teaching, to contribute to the betterment of society, and to discover new knowledge. Faculty and staff stimulate critical and creative thinking and provide ethical perspectives for dealing with an increasingly complex world." Coupling that to the Jesuit Charisms, I mention three major examples that span my four decades here:

(1) When I served as coordinator of the General Chemistry program from 1986 – 1995, I undertook the task of revamping the general chemistry laboratory program with the goal of making it environmentally responsible. I developed a simple scheme for removing toxic metal ions generated as laboratory wastes. Many of the more toxic chemicals formerly used in the laboratory program were replaced with earth-friendly alternatives. My "Laboratory for General Chemistry; An Environmentally Responsible Manual" (Forbes) was designed to teach decision-making skills regarding chemical disposal as well as general chemical responsibility. I continue to love contributing to the improvement of our General Chemistry lab program and have introduced numerous ideas for labs that have been adopted by the entire program including the kinetics lab and equilibrium lab and the use of personal laptops for data collection and analysis. Just this year I tested a modification to our electrochemistry experiment that will eliminate the toxic metals lead and cadmium – this modification debuts across all sections in Spring, 2018.

(2) I have always had an interest in chemical demonstrations and the power of visual learning. I developed, coordinated and taught a chemistry demonstrations workshop for high school chemistry teachers for a number of summers. I received a National Science Foundation grant ($348K) to expand this program and offer it as part of NSF's Teacher Enhancement program here at Creighton. I have received other external and internal grants to fund my scholarship. Three external grants supported my salary to perform research at other institutions and allowed me to be a Visiting Professor of Chemistry at Yale University (1986 and 1991).

(3) Our work with microscale gas chemistry and the catalyst tubes has been the most rewarding of my career. Many of the gas reaction experiments have made it into my General Chem demonstration repertoire, and some are now part of the Gen Chem laboratory program. I use the catalyst tube to demonstrate to my General Chemistry students how automobile catalytic converters work: passing reddish nitrogen dioxide and unburned hydrocarbon fuel through the catalyst results in colorless carbon dioxide, nitrogen and water. All of the work on gases and catalysts has been done with undergraduate students and done for the purpose of providing laboratory opportunities for learning. The catalyst tubes can be used for a large number of reactions. That's the easy part. Designing experiments to elucidate the molecular pathways involved with the nanoparticle catalyst is an incredibly enriching and satisfying endeavor for student and me alike. Ideas come to us all the time, in conversation or in quiet reflection. This is inquiry-based learning at its best and is a noble and gratifying pursuit.