GILLINGS SCHOOL OF GLOBAL PUBLIC HEALTH

THE UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL
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November, 2020

Educational Background

SUNY at Buffalo, -1963-1965 -B.A.-Chemistry.
Univ. of North Carolina at Chapel Hill -1970-71 MSPH -Air and Industrial Hygiene.

Professional Activities

Director of the UNC- Carolina Environmental Program Field Site in Thailand- 1999-present

Fulbright Scholar, ChiangMai University, Thailand, December 1997-Aug, 1998

Editorial Advisory Board for *Environmental Sciences and Technology* (*ES&T*) - January 1994 to January 2003

Professional History

2011-present Research Professor
1995-2010 Professor
1994-1996 Professor. Acting Director ESE Air Radiation and Industrial Hygiene Program Area
1991-1994 Research Professor. Principal investigator of combustion soot research program
1986-1991 Research Associate Professor
1984-1986 Research Assistant Professor. Principal Investigator of combustion soot research program.
1981-1984 Director and Principal investigator of UNC Combustion research group.
1972-1981 Research Assistant. Laboratory director of UNC smog chamber facility since 1977.
1971-1972 Technical Assistant. Consultant to Panel 1 Committee on Motor Vehicle Emissions - National Academy of Sciences.
1968-1970 Junior High School teacher, Snohomish Public Schools, Snohomish, WA and Monticello Public Schools, Monticello, NY.
1965-1967 Peace Corps Volunteer, Cholburi, Thailand., Peace Corps Representative. Motivating rural populations to build sanitary water systems, wells and privies.; also, taught health education in the local schools to support village health programs

Current UNC Classes

Undergraduate Environmental Chemistry: (ENVR and ENST 403, 3 credits, Spring, Bangkok) Highlight some important areas in environmental chemistry, and present some of the common techniques that environmental chemists use to quantify process that occur in the environment. General topics include: Fossil fuels and associated carbon emissions, stratospheric O_3, photochemical smog and atmospheric aerosols, chromatography, acid rain, fresh water chemistry, pesticides and heavy metals in the environment: We develop simple relationships used to quantify equilibrium and kinetic processes. It is assumed that everyone has courses in calculus and general chemistry. Three lecture hours per week-

Thai Language Thai culture Seminar: (ENST 241, 1 credit). This class is designed for UNC undergraduates going to the UNC-Thai study abroad filed site, where they spend 7 months taking classes, and conduct a significant research capstone in sustainable energy and the associated environmental issues. Thai culture is discussed and basic vocabulary is introduced each week. Verbs are covered first, then basic sentence structure, followed by adjectives, nouns and then simple dialogues. Each week a Thai dish is introduced along with associated Thai characters. This culminates and a mandatory Thai dinner where students have to order in Thai characters. We go over previous capstone reports that are published in the peer reviewed literature and review basic chemistry, kinetics and thermodynamics.

Previous UNC Classes

Environmental Physical Organic Chemistry: (Envr 725, 3 credits, Spring) The physical chemistry of the partitioning, exchange, and chemical transformation of organic contaminants in the water, air, and soil environments is addressed. Extensive use of activity coefficients, vapor pressures, Henry's law constants, octanol water coefficients, and linear free energy relationships. Text: Environmental Organic Chemistry by Schwarzenbach et al., 2003. Three lecture hours per week.

Atmospheric Organic Aerosol Chemistry: (Envr 890, 3 credits, Fall) Gas-Particle Interactions Prerequisites: Physical Chemistry. Selected topics, The atmospheric compartment, Global atmospheric processes, kinetics, the atmospheric chemistry of alkenes, aromatics and alkanes, reactions of the hydroxy radical, smog mechanisms in atmospheric chemistry, equilibrium theory of gas-particle partitioning, Langmurian and BET sorption, with examples from Yamasaki, Junge, and Pankow, and modeling gas-particle reactions. Three lecture hours per week.

Major Research Achievements

1. First to describe aerosol formation from isoprene + O_3 and propose that isoprene reaction products could contribute to the "aerocollodial mass" or what is not called secondary organic aerosols, *Int. J Chem. Kinet.*,14, pp. 955-975, **1982.**

2. Observed the bacterial mutagenic enhancement of wood soot particle extracts as particles aged in outdoor atmospheric chambers. *Environ. Sci. Technol.*, 18, 523-530, **1984.**

3. First to kinetically describe the decay of PAHs on atmospheric soot particles. *Environ. Sci. Technol.*, 22, 103-108, **1988**.

4. First to kinetically model the formation of NitroPAHs on atmospheric diesel soot particles. *Atmos, Environ.* 29, 1171-1181, **1995**.

5. First to implement a gas-particle kinetic model to describe the formation of secondary organic aerosols from α-pinene. *Environ. Sci. Technol*, 33, 1431-1438, **1999.**

6. First to describe the importance of acid catalysis in SOA formation. *Science*, 298, 814-817, October 25, 2002.

7. First to model the influence of the importance of water on aromatic SOA formation. *Atmos. Environ.*, 45, 2324-2334, **2011**

For over three decades, beginning in the early1980s, fine aerosol work at UNC under the direction of Richard Kamens has focused on the chemical transformations that occur on atmospheric particles. These studies initially addressed potentially toxic compounds like polynuclear aromatic hydrocarbons (PAH) and halogenated dibenzodioxins and furans, which are associated with different aerosol systems. His group initially investigated the extent to which O_3, NO_2, N_2O_5, and sunlight influence chemical changes of organics on soot particles as these particles age in the atmosphere. They reported that sunlight promotes the decay of polynuclear aromatic hydrocarbons (PAH) on soot particles as these particles age in the atmosphere, and is more important than oxidation by either O_3 or NO_2. MS student Glenn Reves and Ph.D student Douglas Bell reported how extracts from soot particles exhibited large increases in bacterial mutagenicity as soot particles aged in the atmosphere. Dr. Zhishi Guo then a Ph.D. student showed how to heterogeneously treat particle phase organics. From outdoor chamber experiments they were able to develop rate constants for these reactions as a function of sunlight, water vapor, and

Figure 1. UNC 270 m^3 dual outdoor smog chamber.

temperature. These rate constants and PAH source signatures were then used in chemical mass balance receptor models to estimate particle source apportionment by Cheng Kong Lee. This rate constant work led to the integration of gas phase smog kinetics with particle PAH and nitroPAH reactions and permitted the modeling of the daytime formation and decay of selected nitroPAH (like 2nitrofluoranthene) in both the gas and particle phases by Zhihua Fan. Much of this work is summarized in a 2002 text on aromatics by Cavert et al. The Kamens group via Parag Birla and Chris Lutz then goes on to employed these techniques to study the atmospheric stability of brominated and chlorinated dioxins and furans.

In the late 1980s Dr. Steven McDow joined the Kamens group and focused interest on organic aerosols. Over the next 20 years research concentrated on semi-volatile gas-particle partition. In the late 1990s Dr. Myosoen Jang implemented an equilibrium-gas-particle partitioning technique which took advantage of activity coefficient calculations. This provided a novel approach to estimate the partitioning of both polar and non-polar toxic semivolatiles. By the 2000s, his group was then able to develop a kinetics model to predict aerosol formation from biogenic hydrocarbons. Further aerosol work necessitated the building of a new 270 m^3 outdoor aerosol smog chamber (Figure 1) at the Pittsboro NC out door smog chamber site. The chamber provides a large volume with a low surface to volume ratio to permits long fine aerosol life-times. As with the UNC 300 m^3 dual chamber built in 1972, under the direction of Harvey Jefferies and Donal Fox, it afforded direct control comparisons. The new chamber had very short aerosol sampling lines and has unique ability to exchange contents of chambers and to mix and react dilute reactants. Last, in 2007, remote control of many of the chamber functions like venting, clean air purging, and data acquisition permitted remotely controlled experiments and provided a unique teaching tool for students who could operate the chambers as far away as Bangkok.

This new chamber was used to conduct experiments that would be used to integrate gas and particle phase chemistry and equilibrium partitioning thermodynamics. Along with Mohamed Jaoui, Myoseon Jang, Michael Strommen and Kerri Leach, a gas-particle model was successfully developed to predict smog chamber secondary aerosol formation (SOA) from α-pinene smog systems. Myosoen then in the early 2002s made her corner stone discovery that acid, catalyzed reactions are very important in SOA formation. This opened up an important vein of research that continues today. Sirakarn Leungsakulin the mid 2000s extended the semi-explicit kinetic partitioning approach to d-limonene +O_3 dark systems and NOx + light systems. This approach was then expanded to toluene by student, Di Hu and was later adapted in an engineered kinetic model by Kamens and Yang Zhou et al. to toluene and xylene SOA systems. The important discovery from the chamber experiments was that particle phase water could dramatically increase SOA formation from aromatics in the presence of background aerosols or ammonium sulfate seeds; the opposite was later observed for isoprene systems by Haofei Zhang . who went on to develop isoprene and gas and SOA kinetic mechanisms.

In 2001 Kamens implemented, through UNC Study Abroad, an undergraduate/graduate student exchange/research program in Thailand and currently serves as the UNC field site coordinator. UNC students spend 6 too 7 months in Thailand taking classes and working on research projects at King Mungut's University of Technology, Thonburi in Bangkok (KMUTT), For the past 13 years Professor Gheewala Shabbir at KMUTT, and also an adjunct professor in ESE, and Professor Savitri Garivait have directed much of the UNC student research and Professor Savitri Garivait administers the program. UNC students take classes in Environmental Chemistry, Life Cycle Assessment, Energy Management in Buildings, and Energy Technology. During and after completion of the classes, UNC student groups spend considerable effort addressing a significant environmental or sustainable energy issue. About 20 of these projects have found their way into the peer review literature. They include life cycle assessment (LCA) of biofuel use in S.E. Asia, ways to reduce BOD in Thai Rivers, impact of bioethanol use O_3 formation in the Bangkok atmosphere and associated economic impacts, and the efficacy of photovoltaics, electric busses, energy storage etc. in S.E. Asia. More than 150 UNC students and 20 Thai students have participated in this program and the academic and cultural experience has been axis shifting.

Grants and Contracts

"Transport and Behavior of Engineered Nanomaterials in Selected Environmental and Biological Matrices" Oct1 2010, NSF, Funded Sept 30, 2015, PI-Kamens, (2010-2013) $470,000

"A Kinetic Model for predicting Secondary Organic Aerosol Formation in Complex Hydrocarbon Mixtures" Aug 1 2007, -July 31,2011, NSF funded, PI-Kamens, $567,000

"Secondary Aerosol Formation from Gas and Particle Phase Reactions of Aromatic Hydrocarbons" USEPA STAR program, funded, August 2003 to August 2006, PI-Kamens, $400,000

"Atmospheric Secondary Aerosol Formation by Acid-catalyzed Heterogeneous Reactions of Carbonyls" NSF, funded, August, 2003 to August 20 06, PI-M. Jang, co-PI, R. Kamens, $500,000

"A Predictive Model for Biogenic Hydrocarbon Aerosol Formation Using a Gas Phase Kinetic-Aerosol Partitioning Approach" NSF; funded, July 2001-June 2004, PI- R. Kamens, $527,000

"Predicting Day and Nighttime Aerosol Yields from Biogenic Hydrocarbons with a Gas –Particle Phase Kinetic Model, EPA Star Program Sorting Code: 99-STAR-R2: PI- R. Kamens" funded: 09-01 to 08-03, $225, 000

"Partitioning of Semivolatile Organic Compounds: Organic and Inorganic Aerosols:" A unified Approach, USEAP-STAR Program, PI Kamens, PI, 9-15-98 to 9-14-2001 , $562, 536

"The partitioning of Semi-volatile Organics," NSF, PI, Kamens, 7-1-97 to-6-30-2000, $320,00.

"Continued Environmental Investigations of Organo-silicon compounds" PI R. Kamens, Dow Corning Corp. 1997, $30,000

"An Experimental Data Base and Modeling Effort to Describe the Atmospheric Gas-Aerosol Mass Transfer of Semi-volatile Organics, NSF, PI, Kamens ,9-15-94 to-14-97, 365,00.

"Environmental Investigations of Organo-silicon compounds" PI R. Kamens, Dow Corning Corp. 7- 94 to . 9-96 , $100,000

"Modeling the Transfer of Semi-volatles Organics in Combustion Aerosols" North Carolina Super computing Center, PI, Kamens1-1-94 to 12-31-95, $100,000

"Predicting Day and Nighttime Aerosol Yields from Biogenic Hydrocarbons with a Gas –Particle Phase Kinetic Model, EPA Star Program Sorting Code: 99-STAR-R2: PI- R. Kamens" funded, 09-01 to 08-02, 225K

"Cooperative Research Between the Chinese, USEPA & UNC Scientists" USEPA, P.I., -R. Kamens, 09/29/92 to 2/28/94. $94,000.

"Atmospheric Transformations of Halogenated Dibenzo-p-Dioxins and Dibenzofurans" 3/15/91 to 3/14/94. USEPA, Office of Exploratory Research PIs-M.J. Charles & R. Kamens. $438,000"

Heterogeneous Organic Reactions on Atmospheric Aerosols," 09/24/90 to 09/23/93. USEPA, Office of Exploratory Research PIs- S McDow & R. Kamens. $430,000

"Indoor and Outdoor Aerosols - Characterization Studies" 09/01/88 to 6/14/92. USEPA P.I. -R. Kamens. $343,000.

"A Methodology for Analyzing Hazardous Waste From Incineration and Other Treatment Alternatives", 03/0l/89 to 8/30/91. P.I. Kamens, Charles, Amaral. From EPA STAR Hazardous Substance Research Under North Carolina State University. $226,000.

"Cooperative Research Between the Chinese, USEPA & UNC Scientists" USEPA, P.I., -R. Kamens, 08/22/88 to 5/15/92. $374,000.

"UNC, Chapel Hill-China-US EPA Joint Research Program", PI- R. Kamens, Environmental Protection Agency, 10/1/85 to 9/30/88, $205,185.

"Atmospheric Behavior of PAH, Nitro PAH and Aromatic Carbonyls on Airborne Soot Particles," PI- R Kamens, Office of Exploratory Research, Environmental Protection Agency, 7/15/85 to 7/14/87, $246,773.

"Analysis of Benzo(l)aceanthrylene in Wood Soot Samples," PI- R Kamens, Environmental Protection Agency, 3/29/85 to 2/28/86, $9,999.

"Aging Emissions from Residential Coal Combustion in Environmental Chambers," PI- R Kamens, Environmental Protection Agency, 3/29/85 to 12/30/85, $9,605.

"OH Rate Constant Intercomparison Study," PI- R Kamens, Northrop Research Services, 5/17/85 to 9/30/85, $21,000

"Atmospheric Reactions and Atmospheric Mutagenic Changes in Emissions from Common Fuels," PI- R Kamens, Office of Exploratory Research, Environmental Protection Agency, 10/1/83 to 9/30/85, $149,991.

"The Atmospheric Transformation and Bioactivity of Combustion Products from Residential Wood Stoves," PI- R Kamens, Office of Exploratory Research, Environmental Protection Agency, 6/1/81 to 12/31/83, $220,030.

"The Atmospheric Transformation and Bioactivity of Combustion Products from Residential Wood Stoves," PI- R Kamens, State of North Carolina, 4/1/81 to 12/31/83, $28,110.

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Peer Reviewed Journal Publications

Kamens, R. M.; Stern, A.C. "Effects of Inclusion or Exclusion of Methane in the 1975 Automobile Standard for Hydrocarbons," *J. Air Pollut. Assoc.*, 23, 593-596, 1973.

Fox, D. L.; Kamens, R.M; Jeffries,H.E; "Photochemical Smog Systems: Effect of Dilution on Ozone Formation," *Science*, 118, 1113, 1975.

Jeffries, H. E.; Fox, D.L; Kamens, R.M. "Photochemical Conversion of NO to NO2 by Hydrocarbons in An Outdoor Chamber," *J. Air Pollut. Assoc.*, 10, 1006-1011, 1976.

Jeffries, H. E.; Fox, D.L.; Kamens, R.M. "Outdoor Smog Chamber Studies: Light Effects Relative to Indoor Chambers," *Environ. Sci. Technol.*, 10,1006-1011, 1976.

Kamens, R. M.; Jeffries, H.E.; Fox, D.L.;.Alexander, L. "Potential Effect of Emission Control Strategies on Nighttime NO_2 Concentrations," *Atmos. Environ.*, 11, p. 22, 1977..

Wright, R. S.; Kamens, R.M.; Sickles, J.E.; Jeffries, H.E.; Eaton, W.C. "Comparison Between Two Outdoor Smog Chamber Facilities: Matched Experiments," *J. Air Pollut. Assoc.*, 26, 249-250, 1978.

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Kamens, R. M.; Jeffries, H.E.; Sexton, K.G.; Wiener, R.W. "The Impact of Day-Old Dilute Smog on Fresh Smog Systems," *Atmos. Environ.*, 16, pp. 1027-1034, 1982.

Feigley, C. E.; Jeffries, H.E.; Kamens, R.M. "An Experimental Simulation of Los Angeles Reactive Pollutant Program (LARPP) Operation 33-Part I: Experimental Simulation in an Outdoor Smog Chamber," *Atmos. Environ.*, 16,1987-1986, 1982.

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Feigley, C. E.; Kamens, R.M.; Jeffries, H.E. "Experimental Simulation of Los Angeles Reactive Pollutant Program (LARPP) Operation 33-II. Evaluation of Simulation," *Atmos. Environ.*, 17, 103-109, 1983.

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Kamens, R. M.; Bell, D.A.; Perry, J.M.; Goodman, R.G.; Dietrich, A.; Tejada, S. "Airborne Mutagenic Transformations of Dilute Wood Smoke Systems: Analysis of Selected HPLC Fractions from Wood Smoke Particle Extracts," *Environ. Sci. Technol.*, 19, 63-70, 1985.

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Bell, D. A.; Kamens, R.M. "Photodegradation of Wood Smoke Mutagens," *Atmos. Environ.*, 20, 318-321, 1985.

Kamens, R. M., Fulcher, J.N.; Guo, Z. "Effects of Temperature on Wood Soot PAH Decay in Atmospheres with Sunlight and Low NOX," *Atmos. Environ.*, 20. 1579-1587, 1986.

Ackerman, T. P.; Guo, Z.; Kamens, R.M. "Equilibrium Temperatures of Aerosol Particles in Outdoor Exposure Chambers," *Atmos. Environ.* 20, 2473-2475, 1986.

Gery, M. W., Fox, D.L.; Kamens, R.M.; Stockburger, L. "Investigation of Hydroxyl Radical Reactions with o-xylene and m-xylene in a Continuous Stirred Tank Reactor," *Environ. Sci. Technol.*, 21, 339-348, 1987.

Kamens, R. M., Fulcher, J.N.; Ball, L.M.; Gold, A. "Analysis of Cyclopenta Fused Isomers of Benz(a)Anthracene in Wood Smoke," *Biomed. Environ. Mass Spect.*, 14, 369-374, 1987.

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Rodes, C., Kamens, R.; Wiener,R. "The Significance and Characteristics of Personal Cloud on Exposure Assessment Measurements for Indoor Contaminants," *Indoor Air*, 2, 123-145, 1991.

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Invited talks

1. Invited Plenary Lecture *"The Chemistry of SOA ."* Kinetics Mechanism Conference, UC Davis", December 13, 2008.
2. Invited Talk. *SOA formation from the Atmospheric Reactions of Toluene*, Kinetics Mechanism Conference, UC Davis", December 6-8, 2006.
3. Group leader and invited speaker, *Secondary Organic Aerosol Formation*: Chamber studies, NARSTO Workshop on Particulate Matter Modeling for Air Quality and Climate, Bolder Co. June 7, 2006.
4. AAAR-Super-Sites Meeting, STAR grant PIs, *Modeling Aromatic SOA Formation* Atlanta, February 3, 2005.
5. AAAR tutorial speaker on Secondary Aerosols , Atlanta, October 4, 2004.
6. Keynote Conference Speaker on *Organic Speciation*, Los Vegas, Nevada, April 2, 2004.
7. Invited Speaker, Gordon Conference on Biogenic Hydrocarbons, Italy, May 5, 2004.
8. Invited Session Key Note Speaker on *Secondary Aerosols*, European Geophysical Union and AGU, meeting, San Francisco December 10, 2003
9. Invited Speaker, "Organic Atmosphere Aerosols: *Are they important and what are some of the issues?",* Toxicology Forum, Aspen CO, July 16, 2003.
10. Invited Session Keynote speaker, Session on Organic Aerosols, European Geophysical Union, "*Secondary Organic Aerosol Formation; Some New and Exciting Insights*", Nice, France, April 4, 2003
11. Invited Speaker, *Secondary Organic Aerosol Formation,* New Your University Medical Center, April 23, 2003
12. Kamens, R *"Organic Atmospheric Aerosols: Are They Important and What are Some of the Issues?"* Ester and Bingham J. Humphrey Memorial Symposium, Chemistry Department, University of Vermont, September 27, 2003