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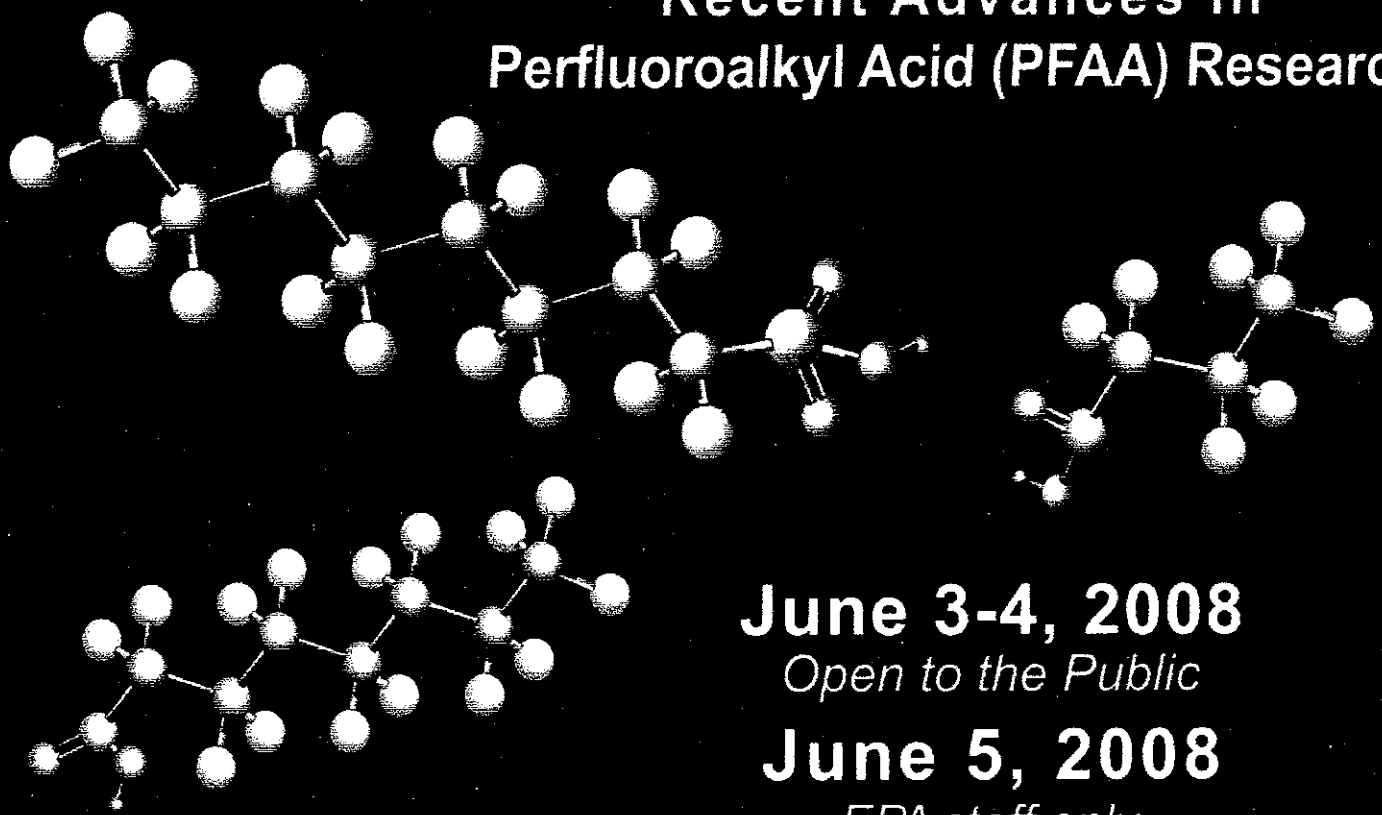
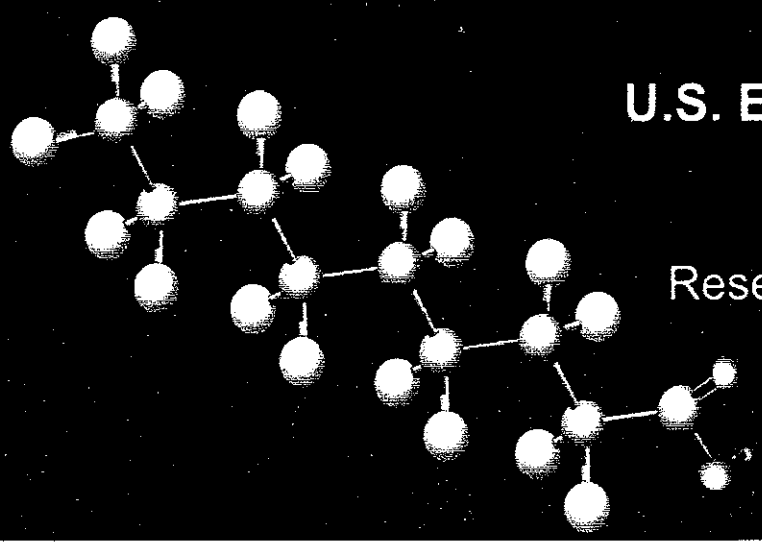
PFAA Days II

Recent Advances in Perfluoroalkyl Acid (PFAA) Research



June 3-4, 2008
Open to the Public

June 5, 2008
EPA staff only



U.S. EPA - Research Triangle Park
Auditorium C-111
109 T.W. Alexander Drive
Research Triangle Park, N.C. 27711

PFAA Days II

Background

The Perfluoroalkyl Acids (PFAAs), such as perflurooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS), are persistent environmental pollutants that are of considerable interest to the U.S. Environmental Protection Agency (US EPA) as well as the public. The Office of Pollution Prevention and Toxics (OPPT) of US EPA has been actively involved in the assessment of these chemicals, as well as potential replacements for PFOS and PFOA. In 2006, a draft human health risk assessment of PFOA (http://www.epa.gov/opptintr/pfoa/index.htm) was reviewed by the Agency's Science Advisory Board, and their report was released in May (http://yosemite.epa.gov/sab/SABPRODUCT.NSF/A3C83648E7725282852 5717F004B9099/$File/sab_06_006.pdf). It identified several informational gaps and recommended areas of critical research needs.

Over the past several years, investigators from the US EPA Office of Research and Development's (ORD's) National Health and Environmental Effects Research Laboratory (NHEERL), and more recently, from the National Exposure Research Laboratory (NERL) and the National Risk Management Research Laboratory (NRMRL) have developed research programs to characterize the toxicity of these chemicals, to explore their modes of actions, to develop analytical methods for their detection in various media, and to investigate the fate and transport of these chemicals in the environment. Collectively, they are making significant strides in these research areas.

In the summer of 2006, a "PFAA Days" workshop was held at the US EPA ORD's facility in Research Triangle Park, NC where scientists and managers from the Office of Prevention, Pesticides, and Toxic Substances (OPPTS), the Office of Water (OW), the EPA Regions, and various offices and laboratories within ORD assembled to learn of the research plans and activities of investigators in NHEERL, NERL and NRMRL, to exchange perspectives, and to identify research needs for risk assessment. The workshop was highly successful, in that valuable insights were gained by all participants.

Goals and Logistics

Since that workshop, significant research progress has been made by ORD and other scientists, and different scientific issues concerning PFAAs have emerged. It is, therefore, an appropriate time to hold another workshop, PFAA Days II, to review the progress, to share the recent discoveries, to address the current issues and to chart the future course for PFAA research at ORD. This informal workshop is open to scientists from other federal and state agencies, the chemical industry and academia for the sessions on June 3 and 4. Several prominent and active investigators working on exposure and toxicity issues of PFAAs have been invited to share their most recent findings.

In addition to the invited speakers, workshop participants are encouraged to present their own work at a poster session in the afternoon of June 3. Abstracts of platform and poster presentation, workshop proceedings and a brief report will be submitted to *Reproductive Toxicology* for consideration of publication. Posters will be displayed for June 3-4, 2008.

A separate session on June 5 will be reserved for EPA scientists and managers to determine remaining research needs and a path to address them.

Acknowledgments

The workshop was organized by a committee composed of the following members:

Christopher Lau, NHEERL/ORD (Chair)
John Rogers, NHEERL/ORD
Barbara Abbott, NHEERL/ORD
Douglas Wolf, NHEERL/ORD
Andrew Lindstrom, NERL/ORD
Marc Mills, NRMRL/ORD
Elaine Francis, ORD
Jennifer Seed, OPPT/OPPTS
Cathy Fehrenbacher, OPPT/OPPTS

The organizers wish to thank Ms. Teresa Wall and Mr. Stephen Thompson of RTD/NHEERL for their enormous efforts to support this workshop.

PFAA Days II Workshop
Auditorium C111A-C, EPA Main Campus,
Research Triangle Park, NC

Agenda

Tuesday, June 3, 2008

Introduction

8:30 a.m. – 8:40 a.m.:	Introduction – *Chris Lau*, RTD, NHEERL, ORD
8:40 a.m. – 8:50 a.m.:	Welcoming Remarks – *Julian Preston*, NHEERL, ORD
8:50 a.m. – 9:00 a.m.:	Charges of Workshop – *Elaine Francis*, IO, ORD

Environmental distribution, fate and transport of PFAA – Moderator: Andrew Lindstrom, HEASD, NERL, ORD

9:00 a.m. – 9:45 a.m.:	Historical perspective of PFAA and recent advances in environmental distribution, fate and transport of these chemicals – *Scott Mabury*, Department of Chemistry, University of Toronto, Canada
9:45 a.m. – 10:20 a.m.:	PFAA in environmental media – *Mark Strynar*, HEASD, NERL, ORD
10:20 a.m.– 10:40 a.m.:	Sorption of PFOA and PFOS to aquifer sediment *John T. Wilson*, GWERD-ADA, NRMRL, ORD
10:40 a.m. – 11:00 a.m.:	Break
11:00 a.m. – 11:40 a.m.:	Perfluorinated compounds: From frying pans to polar bears *Kurunthachalam Kannan*, Wadsworth Center, NY State Department of Health
11:40 a.m. – 12:15 p.m.:	Perfluorinated contaminant research at NIST: Value assigning Standard Reference Materials (SRMs) and measuring spatial and temporal trends from the marine animal specimen bank – *Jennifer Keller*, Hollings Marine Laboratory, National Institute of Standards and Technology, NOAA
12:15 p.m. – 1:20 p.m.:	Lunch

Bio-monitoring of PFAA – Moderator: Jennifer Seed, OPPT

1:20 p.m. – 1:55 p.m.:	Update of PFAA in the general population *Antonia Calafat*, National Center for Environmental Health, Centers for Disease Control and Prevention
1:55 p.m. – 2:30 p.m.:	Bio-monitoring of PFAA in adults and children exposed to contaminated drinking water – A European perspective *Jürgen Hölzer*, Department for Hygiene, Social and Environmental Medicine, University of Bochum, Germany
2:30 p.m. – 3:05 p.m.:	Community exposure to PFOA and health parameters *Edward Emmett*, Center of Excellence in Environmental Toxicology, University of Pennsylvania School of Medicine
3:05 p.m. – 3:25 p.m.:	Break
3:25 p.m. – 4:00 p.m.:	C8 Science Panel community study *Tony Fletcher*, London School of Hygiene and Tropical Medicine, UK
4:00 p.m. – 4:35 p.m.:	Simulation modeling of PFAA exposure and pharmacokinetics – *Harvey Clewell*, Center for Human Health Assessment, The Hamner Institute of Health Sciences
4:35 p.m. – 5:10 p.m.:	Pharmacokinetic modeling of PFAA – *Hugh Barton*, NCCT, ORD
5:10 p.m. – 5:15 p.m.:	Wrap up – *Chris Lau*, RTD, NHEERL, ORD
5:15 p.m. – 5:30 p.m.:	Break
5:30 p.m. – 7:00 p.m.:	Poster session in the B-wing atrium
7:30 p.m.:	Reservation for those who want to join a group dinner at Café Parizade in Durham

Wednesday, June 4, 2008

8:15 a.m. – 8:20 a.m.: Re-cap of workshop, house-keeping – *Chris Lau*, RTD, NHEERL, ORD

In vitro and in vivo effects of PFAA – Moderator: John Rogers, RTD, NHEERL, ORD

8:20 a.m. – 8:50 a.m.: In vitro screening of PFAA toxicities: the NTP efforts *Ron Melnick*, NTP

8:50 a.m. – 9:20 a.m.: Comparative description of PFAA developmental toxicity: an update – *Chris Lau*, RTD, NHEERL, ORD

9:20 a.m. – 9:55 a.m.: Latent effects of PFAA exposure during perinatal development – *Sue Fenton*, RTD, NHEERL, ORD

9:55 a.m. – 10:15 a.m.: Break

10:15 a.m. – 10:55 a.m.: Mechanisms of PFAA toxicity: involvement of PPAR molecular signals – *Barbara Abbott*, RTD, NHEERL, ORD

10:55 a.m. – 11:30 a.m.: Developmental toxicogenomic studies of PFOA and PFOS in mice – *Mitch Rosen*, RTD, NHEERL, ORD

11:30 a.m. – 12:05 p.m.: Evidence for involvement of other nuclear receptors in PFAA toxicity through genomic profiling – *Chris Corton*, NHEERL Toxicogenomics Core, ORD

12:05 p.m. – 1:10 p.m.: Lunch

1:10 p.m. – 1:45 p.m.: Evaluation of PFOA toxicity by the humanized PPARα transgenic mouse model – *Jeff Peters*, Department of Veterinary and Biomedical Sciences, Pennsylvania State University

1:45 p.m. – 2:20 p.m.: Immunotoxic potentials of PFOA – *Jaime DeWitt*, ETD, NHEERL, ORD

2:20 p.m. – 2:55 p.m.: Health effects of perfluorinated compounds – What are the wildlife telling us? – *Margie Peden-Adams*, Department of Pediatrics and Marine Biomedicine and Environmental Science Center, Medical University of South Carolina

2:55 p.m. – 3:15 p.m.: Break

Exposure issues of PFAA – Moderator: Andy Lindstrom, NERL, ORD

3:15 p.m. – 3:50 p.m.:	Method development for the determination of fluorotelomer alcohols in soils by gas chromatography mass spectrometry – *Jackson Ellington*, ERD, NERL, ORD
3:50 p.m. – 4:25 p.m.:	Testing of PFAA release from aged articles of commerce *Zhishi Guo*, APPCD, NRMRL, ORD
4:25 p.m. – 5:00 p.m.:	Issues and needs for PFAA exposure and health research: A state perspective – *Helen Goeden*, Minnesota Health Department
5:00 p.m. – 5:10 p.m.:	Wrap up – *Chris Lau*, RTD, NHEERL, ORD
5:10 p.m.:	Workshop adjourns

U.S. EPA PFAA Days II Workshop - Bios

Barbara Abbott

Dr. Barbara Abbott is a Senior Researcher in the Developmental Biology Branch of the Reproductive Toxicology Division, of the National Health and Environmental Effects Research Laboratory of the US Environmental Protection Agency. She received a Ph.D. and M.S. in Toxicology at NC State University in 1985 and was a post-doctoral fellow at NIEHS. Dr. Abbott studies the mechanisms of developmental toxicity with particular emphasis on receptor-mediated pathways. She has published over 70 peer-reviewed papers, 15 book chapters and reviews and received five EPA Scientific and Technological Achievement Awards for outstanding publications. Dr. Abbott is a member of the Teratology Society and the Society of Toxicology. She served as President of the North Carolina Chapter of the SOT in 2002 and as Councilor in 2002-2004 for the Reproductive and Developmental Specialty Section of the SOT. Dr. Abbott is an Associate Editor for Toxicological Sciences and serves on the Editorial Board of Reproductive Toxicology. Since 1990, Dr. Abbott has been a research advisor to numerous graduate and post-doctoral students in cooperation with the University of North Carolina at Chapel Hill and North Carolina Central University.

Hugh A. Barton

Dr. Barton is a toxicologist with the US EPA developing computational models for use in biologically based dose-response analyses for chemical risk assessment. He specializes in the use of physiologically based pharmacokinetic (PBPK) and pharmacodynamic modeling to address low dose, interspecies, and inter-route extrapolations that critically impact estimating risks. He has evaluated volatile organic compounds, endocrine disrupting chemicals, and perfluorinated alkyl compounds, most recently focusing on comparisons across lifestages. Dr. Barton received a B.S. in Life Sciences from the Massachusetts Institute of Technology, Cambridge, MA in 1982 and a Ph.D. from the Toxicology Program at MIT in 1988. After working for consulting companies for 10 years, he joined US EPA in 1999, where he is currently at the National Center for Computational Toxicology in Research Triangle Park, NC. He is adjunct Assistant Professor in the Curriculum in Toxicology at the University of North Carolina at Chapel Hill. He has published more than 40 articles in the scientific literature on xenobiotic metabolism, PBPK and PD modeling, endocrine disruption, dose response assessment, and risk assessment.

Antonia M. Calafat

Antonia M. Calafat, Ph.D., is a Lead Research Chemist at the Division of Laboratory Sciences, National Center for Environmental Health (NCEH) of the Centers of Disease Control and Prevention (CDC) in Atlanta, Georgia, USA, where she serves as Chief of the Personal Care Products Laboratory. Since starting her tenure at CDC in 1998, Dr. Calafat has been involved in developing, validating, and applying analytical methods for measuring in biological matrices environmental chemicals including volatile organic compounds, disinfection-byproducts, chemical warfare agents, and phytoestrogens. Dr. Calafat currently leads several active research programs for assessing human exposure to emerging chemicals such as phthalates, environmental phenols (e.g., bisphenol A, triclosan, parabens), and polyfluoroalkyl compounds. She has developed and maintained extensive collaborative research with leading scientists in exposure and health assessment. Her research has made relevant contributions to CDC's biomonitoring program including the CDC's National Report on Human Exposure to Environmental Chemicals. Dr. Calafat is the recipient of several awards at CDC, including the Excellence in Supervision Award, the NCEH Leadership in Science Award, NCEH Director's Award for Superior Mission Response (Science), and the CDC/ATSDR Public Health Epidemiology and Laboratory Research Award.

Harvey Clewell

Harvey Clewell is the Director of the Center for Human Health Assessment at the Hamner Institutes for Health Sciences. He received a Masters in Chemistry from Washington University and a PhD in Toxicology from the University of Utrecht. His current research interests include the application of physiologically based pharmacokinetic (PBPK) modeling to the interpretation of human biomonitoring data, the incorporation of genomic dose-response information in quantitative risk assessment, and the development of biologically based dose response modeling approaches.

Christopher Corton

Chris Corton is Leader of the NHEERL Toxicogenomics Core at the National Health and Environmental Effects Research Laboratory (NHEERL) of the US Environmental Protection Agency in Research Triangle Park, NC and Senior Research Biologist in the Environmental Carcinogenesis Division of NHEERL. His research interests include the application of genomic techniques to understand chemical mode of action, the role of nuclear receptors in chemical toxicity, the role of oxidative stress and the Nrf2 pathway in modulation of chemical toxicity and the use of transcript profiling to determine chemical sensitivity at different life stages (young or old).

Jamie DeWitt

Jamie DeWitt is a Postdoctoral Trainee in the Immunotoxicology Branch of the Experimental Toxicology Division, within the National Health and Environmental Effects Research Laboratory, under the Office of Research and Development of the U.S., Environmental Protection Agency, through a cooperative training agreement with the University of North Carolina. She received her Ph.D. in Environmental Science and Neural Science from Indiana University and completed a year of postdoctoral training in developmental toxicology at Indiana University before coming to the EPA. She is an active member in the Society of Toxicology and the Society for Environmental Toxicology and Chemistry. Her research interests include developmental immunotoxicolgy and neurotoxicology, environmental and ecotoxicology, and risk assessment.

J. Jackson Ellington

J. Jackson Ellington graduated from University of Georgia with a Ph.D. in medicinal chemistry. He worked for four years as a research chemist with ARS/USDA. He has worked for the past 24 years as a research chemist at the USEPA, National Exposure Research Laboratory in Athens, GA where his research included method development for organochlorines, organophosphates and perchlorate in soil, water, food. His research also included the determination of hydrolysis kinetics and octanol water partition coefficients important to model development and to the Office of Solid Waste.

Edward A. Emmett

Edward A. Emmett is Professor and Deputy Director of the Center of Excellence in Environmental Toxicology at the University Of Pennsylvania School Of Medicine in Philadelphia. He is active in clinical practice, research and education. Dr Emmett has been listed as one of Philadelphia's Top Doctors and one of America's Top Doctors. Dr. Emmett graduated in Medicine from the University of Sydney, completed residency training in Internal Medicine in Australia, and in Occupational and Environmental Medicine at the University of Cincinnati. After being Assistant and Associate Professor in Environmental Health, Medicine and Dermatology at the University of Cincinnati, Dr. Emmett was Professor and Director of the Center for Occupational and Environmental Health at the Johns Hopkins University from 1978 to 1988. From 1988 to 1996 he was Chief Executive of the National Occupational Health and Safety Commission in Australia, a body with functions partially corresponding with those of OSHA, NIOSH, the Bureau of Labor Statistics, and EPA in the United States. In addition to leading Australia's efforts to implement uniform health and safety standards, he oversaw the introduction of NICNAS, the Australian equivalent of TOSCA.

His research contributions have included occupational and environmental skin diseases, ultraviolet radiation effects on skin and eyes, the toxicity of polyaromatic hydrocarbons, PCBs, organometals, monomers used in plastics and resins, and more PFAAs. He is author of more than 150 original papers, book chapters and books in the field of Occupational and Environmental Medicine. He is certified by the American Board of Toxicology and by the American Board of Preventive Medicine in Occupational Medicine. Dr. Emmett has been a member of many national and international committees. He has been Vice Chairman of the Joint ILO/WHO Committee on Occupational Health; Chairman of the Regional Working Group on Occupational Health for WHO; a member the WHO Expert Advisory Panel on Occupational Health, Chair of the Implementation and Methodology Committee for the Institute for Health and Productivity, Chairman of the Governor's Council on Toxic Substances of the State of Maryland and Chairman of the State of Maryland Hazardous Toxic Substances Study Commission. He is the "Risk Communicator" for the UAW-General Motors Occupational Health Advisory Board. Dr. Emmett is a recipient of the Fight for Sight Citation for Clinical Research, the Kehoe Award of Merit from the American College of Occupational and Environmental Medicine. His studies of PFOA in Little Hocking received first place at the 2006 EPA Science Forum, the 2008 Adolph G. Kammer Merit in Authorship Award from the Journal of Occupational and Environmental Medicine, and the prestigious 2008 Community-Campus Partnership for Health Award.

Suzanne "Sue" Fenton

Dr. Suzanne "Sue" Fenton received her B.S., M.S., and Ph.D. from the University of WI-Madison. Her early research focused on artificial insemination and in vitro fertilization in dairy cattle, while her Ph.D. studies discerned novel signal transduction pathways used for differentiation of the mammary gland from a proliferative to a secretory tissue during pregnancy and early lactation. Her postdoctoral studies at the UNC-Chapel Hill Lineberger Cancer Center focused on the roles and regulation of epidermal growth factor receptor ligands in the mammary gland. Dr. Fenton has been a Research Biologist at the US EPA's Reproductive Toxicology Division since October of 1998. Her current research involves identification of the effects of environmental components on early development, pubertal timing and lactational function of the mammary gland. Her research efforts have three times been awarded a Level III EPA Scientific and Technical Achievement Award, a SOT Reproductive and Developmental Toxicology Specialty Section "Best Paper" in Toxicological Sciences award, and her work on the long-term effects of developmental exposure to a perfluorinated alkyl acid was highlighted in the May 2007 issue of Environmental Health Perspectives.

Tony Fletcher

Dr. Tony Fletcher, member of the Court-appointed C8 Science Panel, is a senior researcher and lecturer at the Public and Environmental Health Research Unit in the London School of Hygiene & Tropical Medicine (LSHTM) which he joined in 1992. Tony Fletcher has been active in environmental and occupational epidemiology and risk assessment, for over 25 years. He is Adjunct Research Professor in Environmental Health in the School of Public Health, Boston University, Massachusetts, USA. He has spent two periods working at the International Agency for Research in Cancer in Lyon, France. He has directed and recently completed multi-country European studies arsenic contamination and cancer, and particulate air pollution and children's respiratory disease. Other research includes occupational epidemiology studies in foundries and synthetic fiber manufacture, and risks related to pesticides and welding. He was President of the ISEE International Society for Environmental Epidemiology for two years 2004-5, and co-organizer of a number of conferences on health and the environment, including the "Big Smoke" commemorating the 50th anniversary of the 1952 London Smog.

Elaine Francis

Dr. Elaine Francis is the National Program Director for the U.S. Environmental Protection Agency's Pesticides and Toxics Research Program. She coordinates the development and implementation of multi-million dollar intramural and extramural research programs, working with scientists from across EPA, other federal agencies, governments of other countries, academia, and the regulated scientific community. The research programs she oversees include those on endocrine disruptors, agricultural biotechnology, and the development of testing, risk assessment, and risk management approaches for pesticides and toxic substances – including perfluorinated chemicals. Elaine has been at EPA for almost 28 years. She spent 1991 as a legislative fellow to Senator Joseph Lieberman of Connecticut working on pesticides, lead, and children's issues. She received her doctorate in Anatomy from Thomas Jefferson University in Philadelphia.

Helen Goeden

Dr. Goeden received her B.S. in Biology and Chemistry and her Ph.D. in Environmental Health and Toxicology. After spending a year and a half in a postdoctoral position at the University of Calgary researching developmental effects of low-level hydrogen sulfide exposure, Dr. Goeden moved to California. While in California, Dr. Goeden worked at a small environmental consulting firm and at the University of California at Berkeley. Her work involved development of toxicity values for California Office of Environmental Health Hazard Assessment and conducting risk assessments for waste combustion facilities. In 1992 Dr. Goeden took a position as a Research Scientist at the Minnesota Pollution Control Agency. While at the Pollution Control Agency her major responsibilities involved development and refinement of risk assessment methodologies (including methodology for the derivation of multi-duration soil criteria), chemical specific toxicity assessments, and site-specific risk assessments. In 2001 Dr. Goeden joined the Health Risk Assessment Unit of the Environmental Health Division of the Minnesota Department of Health (MDH). Currently, her main responsibilities are related to the evaluation of groundwater contaminants. Her role is to evaluate recent scientific research to identify the best science available and to determine its application in making public health policy decisions that are protective of susceptible (e.g., heightened sensitivity or highly exposed) populations potentially exposed to groundwater and drinking water contamination.

Zhishi Guo

Zhishi Guo is an Environmental Scientist in the Indoor Environment Management Branch, Air Pollution Prevention and Control Division, National Risk Management Research Laboratory, Office of Research and Development, U.S. EPA. He received his Ph.D. degree in Environmental Science and Engineering from University of North Carolina at Chapel Hill. Dr. Guo is specialized in characterization of indoor pollution sources and indoor environmental quality and exposure modeling.

Jürgen Hölzer

Jürgen Hölzer is a Medical Scientist in the Department of Hygiene, Social and Environmental Medicine, Ruhr-University Bochum, Germany. He is an active member of the Society of Hygiene, Environmental and Public Health Sciences (GHUP, Germany) and the German Society for Medical Informatics, Biometry and Epidemiology (GMDS). His research interests include bio-monitoring of ETS, PAH, PCDD/F, PFAA in epidemiological studies, evaluation of DNA damage and repair and risk assessment.

Kurunthachalam Kannan

Dr. Kurunthachalam Kannan is a Research Scientist at Wadsworth Center, New York State Department of Health in Albany, New York. He is the Chief of the Organic Analytical Laboratory at the Center and also holds a joint appointment as a Professor at the Department of Environmental Health Sciences, School of Public Health, SUNY at Albany. Dr. Kannan's research interests are in understanding sources, pathways and distribution of persistent organic pollutants in the environment. Dr. Kannan has published more than 225 research articles in peer-reviewed journals, 11 book chapters and edited a book and is one of the top 10 most highly cited researchers (ISI) in Ecology/Environment in the world. Dr. Kannan is a receipt of several awards and honors through his career and SETAC's Weston F Roy Environmental Chemistry award in 1999. He received his PhD from Ehime University, Japan and a Bachelor's degree from Tamil Nadu Agricultural University in India. He is an editor of Environmental Chemistry section of Chemosphere.

Jennifer Keller

After becoming SCUBA certified at age 14, Jennifer Keller, embarked upon an unwavering pursuit into a career in marine biology. She received her Bachelor's of Science in Biology with a minor in Environmental Science at Indiana University. During her undergraduate studies, she performed three independent research projects, one of which at the Woods Hole Oceanographic Institution. All three projects focused on toxicology, which steered her towards a Ph.D. at Duke University in Marine Environmental Toxicology. Her dissertation stemmed from a collaboration among the Duke Marine Laboratory, National Marine Fisheries Service, and National Institute of Standards and Technology (NIST) to measure the concentrations of persistent organic pollutants (POPs) accumulated by sea turtles and further investigate their health effects in these endangered marine creatures. Dr. Keller received a National Research Council post-doctoral fellowship to work at NIST in 2003 and has continued to work for NIST as a Biologist since. She is responsible for developing analytical methods to measure environmental contaminants that are of an emerging concern, like brominated flame retardants and perfluoro alkyl stain-resistant compounds. She is also an Adjunct Professor at the College of Charleston's Grice Marine Laboratory and the Vice President of a non-profit marine science education and research organization, Marine Science and Nautical Training Academy (MANTA). In her free-time, she enjoys traveling, boating with her family, yellow lab and friends, photography, and boogie boarding.

Christopher Lau

Christopher Lau is a Lead Research Biologist in the Developmental Biology Branch of the Reproductive Toxicology Division, within the National Health and Environmental Effects Research Laboratory, under the Office of Research and Development of the U.S, Environmental Protection Agency. He received his Ph.D. degree in Pharmacology from Duke University, and postdoctoral training in Neuroanatomy from the Medical College of Pennsylvania. He is an active member of the Society for Neuroscience, Society of Toxicology, Teratology Society, International Society for Developmental Origins of Heath and Diseases, and Fetal and Neonatal Physiology Society. His research interests include developmental toxicology, teratology, and risk assessment modeling.

Andrew B. Lindstrom

Andrew B. Lindstrom is an environmental scientist with the United States Environmental Protection Agency's (USEPA) National Exposure Research Laboratory (NERL) in Research Triangle Park, North Carolina. He is currently conducting biomarker methods development research for the Exposure Measurements and Analysis Branch where his areas of expertise include: measurement of persistent perfluorinated compounds (PFCs), use of protein adducts as indicators of exposure to carcinogens, and analysis of exhaled alveolar breath to determine exposure and dose of volatile organic compounds (VOCs). He has considerable experience with gas chromatography/mass spectrometry (GC/MS) and liquid chromatography/mass spectrometry

(LC/MS) analysis to measure trace level contaminants in biological matrices and environmental media.

Scott A. Mabury

Mabury received his undergraduate chemistry degree from Northland College (1984) after which he spent a few years as a Peace Corps Volunteer on the island of Mindoro in the Philippines. Environmental photochemistry focused on aqueous hydroxyl radical took him to the University of California-Davis where he completed a PhD (1993) in Environmental Chemistry under the mentorship of Prof. Donald Crosby. Following a short PDF he took up an assistant professorship in chemistry at the University of Toronto to build an environmental chemistry undergraduate and graduate program. UofT Chemistry now has 7 full-time environmental chemistry faculty with a vibrant and impressive complement of PhD and MSc students. Undergraduate courses are well populated and received at all levels with Mabury focusing on a third year environmental chemistry (150 enrolled annually) and a fourth year advanced analytical environmental course with an advanced laboratory. While maintaining interest in aquatic photochemistry, the main thrust of the Mabury group has focused on the role the fluorine atom plays in the fate, disposition, and persistence of fluorinated pesticides, pharmaceuticals, consumer and industrial products. Significant effort has focused on the PFCA class of chemical pollutants with some success elucidating the sources of these contaminates and the processes at play in their global dissemination. His group has discovered a number of new contaminants, has determined the mechanism and kinetics for multiple environmental processes, and has worked to influence industry and regulators towards developing friendlier chemical architectures. The Mabury group has ~125 publications, with roughly 85 in the area of fluorinated chemicals, and has delivered ~90 invited talks. The group currently has 5 MSc and 4 PhD students, having graduated 10 MSc and 9 PhD students; four former Mabury group students are currently faculty members. Mabury has been honored with four teaching awards, a Premier's Research Excellence Award and an Alumni Award from his alma mater. Currently, Mabury is winding up a stint as Chair of Chemistry having lead the hiring of 10 new faculty, massive expansion of the graduate program, and the renovation of over $15M of teaching and research laboratories.

Ron Melnick

Dr. Ron Melnick is senior toxicologist and director of special programs in the Environmental Toxicology Program at the National Institute of Environmental Health. He has worked at the National Institute of Environmental Health since 1980, where he has been involved in the design, monitoring and interpretation of toxicity and carcinogenesis studies, as well as research on the health effects of environmental and occupational agents. He spent a year as an agency representative to the White House Office of Science and Technology Policy to work on interagency assessments of health risks of environmental agents and on risk assessment research needs in the federal government. Dr. Melnick's research has advanced the understanding of the toxicity of such widely used industrial chemicals as butadiene, isoprene, glycol esters and drinking water disinfection by-products such as chloroform, and the cancer-causing potentials of DEHP and MTBE. The author or co-author of more than 140 journal articles, book chapters and technical reports related to the potential health effects of environmental agents, Dr. Melnick has organized several national and international symposiums and workshops on health risks associated with exposure to toxins. He has served on numerous scientific review boards and advisory panels, including those of the North Carolina Department of Environment and Natural Resources and the U.S. Environmental Protection Agency.

Margie Peden-Adams

Margie Peden-Adams completed her Ph.D in Environmental Toxicology from Clemson University in 1999. Following graduation, she finished a post-doctoral fellowship in Rheumatology and Immunology at the Medical University of South Carolina, which was followed by a faculty position in the Department of Clinical Laboratory Services. She is currently faculty in the Department of Pediatrics and the Marine Biomedicine and Environmental Science Center at MUSC and holds adjunct faculty appointments at the College of Charleston and Mystic Aquarium. Her research focuses on the sublethal toxic effects of environmental contaminants and utilizes various laboratory, wildlife, and in vitro models to assess effects on immune, reproductive, developmental, and endocrine endpoints.

Jeffrey Peters

Jeffrey Peters is associate professor of molecular toxicology at the Pennsylvania State University. His research interests include the roles of the peroxisome proliferator -activated receptors (PPARs) in the regulation of homeostasis, toxicology, and carcinogenesis with extensive application of null and transgenic mouse models. The goal of his research is to identify functional roles of the PPARs in the etiology and prevention of carcinogenesis. Dr. Peters is also conducting research to delineate the role of the PPARs in the regulation of homeostasis, including body composition, tissue specific gene expression, serum lipid biochemistry, and atherosclerosis. Results from this research will determine mechanisms that PPARs regulate physiological lipid metabolism using different activators reported to interact through PPARs. He earned a Ph.D. in nutrition science from the University of California at Davis and did his postdoctoral training at the University of California at Davis and the National Cancer Institute.

R. Julian Preston

R. Julian Preston, Ph.D. is currently serving as Acting Associate Director for Health for the National Health and Environmental Effects Research Laboratory of the U.S. EPA. He served as Director of the Environmental Carcinogenesis Division at the EPA from 1999 until August 2005. Prior to this appointment, he served as the Senior Science Advisor at the Chemical Industry Institute of Toxicology in Research Triangle Park, North Carolina from 1991-1999. He was employed at the Biology Division of the Oak Ridge National Laboratory in Oak Ridge, Tennessee from 1970-1991 where he was appointed Section Head, Human Genetics in 1987. He also served as Associate Director for the Oak Ridge – University of Tennessee Graduate School for Biomedical Sciences. He is currently Adjunct Professor at Duke University and North Carolina State University. Dr. Preston received his BA and MA from Peterhouse, Cambridge University, England in genetics and his Ph.D. from Reading University, England in radiation genetics. Dr Preston is an Editorial Board Member of Mutation Research, Environmental and Molecular Mutagenesis, Environmental Health Perspectives, Chemico-Biological Interactions and Health Physics. Dr. Preston's research and current activities have focused on the mechanisms of radiation and chemical carcinogenesis and the approaches for incorporating these types of data into cancer risk assessments. In particular, he is developing approaches for addressing how key events for tumorigensis can be used to select informative bioindicators of response.

John M. Rogers

Dr. John M. Rogers is Chief of the Developmental Biology Branch in the Reproductive Toxicology Division at NHEERL/ORD. He earned a Ph.D. in Biology from the University of Miami, and received a National Research Service Award from the National Eye Institute for postdoctoral work at the University of California at Davis. He joined the EPA after his postdoctoral fellowship. His research interests include developmental biology, mechanisms of abnormal development, developmental nutrition, and risk assessment. Dr. Rogers has authored over 90 journal articles and chapters, and has been an invited speaker or participant at EPA, NIEHS, FDA and EPRI workshops. He serves on research grant review panels for numerous organizations. He is a member of the Society of Toxicology, the Teratology Society and the Society for Experimental Biology and Medicine. He has taught courses in cell and developmental zoology at North Carolina

State University and is an Adjunct Associate Professor in the Curriculum in Toxicology at the University of North Carolina, Chapel Hill.

Mitchell B. Rosen

Mitchell Rosen is a Research Biologist at the U.S. Environmental Protection Agency in the Research Triangle Park, North Carolina. His position is affiliated with the Gamete and Early Embryo Biology Branch of the Reproductive Toxicology Division, part of the National Health and Environmental Effects Research Laboratory under the Office of Research and Development. He received his Ph.D. degree in Physiology from North Carolina State University. He is a member of the Society of Toxicology and the Society of Developmental Biology. His research involves the use of molecular technology to understand the potential mechanisms associated with reproductive toxicants.

Jennifer Seed

Dr. Jennifer Seed is a Branch Chief with the Office of Pollution Prevention and Toxics, Risk Assessment Division, Existing Chemicals Assessment Branch of the U.S. EPA. Jennifer has been the lead for the Agency's hazard and risk assessment activities of PFOA and other perfluorinated compounds for the last 9 years. She has also been the lead for the international assessments of PFOS and PFOA under the auspices of the OECD. In addition, she is actively involved in a number of activities, both within the EPA as well as with other organizations that have focused on risk assessment issues. She is the chair of the human health effects subgroup of the Agency's Risk Assessment Forum and has been involved in Agency efforts to harmonize cancer and noncancer approaches for risk assessment. She has been involved in Agency and OECD efforts to develop and harmonize test guidelines and risk assessment guidelines for developmental and reproductive toxicity. Jennifer received a PhD in developmental biology from the University of Washington.

Mark Strynar

Mark Strynar is a Physical Scientist in the Methods Development and Application Branch of the Human Exposure and Atmospheric Sciences Division, within the National Exposure Research Laboratory, under the Office of Research and Development of the U.S, Environmental Protection Agency. He received his Ph.D. degree in Soil Science from The Pennsylvania State University, his Masters degree from Texas A&M University and his Bachelors degree from The University of Rhode Island. His research interests include analytical chemistry and fate and transport of perfluorinated compounds environmental media.

John Wilson

John Wilson is a research microbiologist in GWERD's Subsurface Remediation Branch. He has a B.S. in Biology from Baylor University, an M.A. in Microbiology from the University of California at Berkeley, and a Ph.D. in Microbiology from Cornell University. He has worked at the R.S. Kerr Environmental Research Center in Ada, Oklahoma since 1978. Dr. Wilson conducts research on in-situ bioremediation of fuel spills in the subsurface, and on natural attenuation of BTEX compounds and chlorinated solvents in ground water. In addition to his research activities, Dr. Wilson provides training and technical assistance to the EPA regions and to state agencies on natural attenuation of chlorinated solvents and BTEX compounds in ground water.

U.S. EPA PFAA Days II Workshop - Abstracts

Author: Scott A. Mabury

Title: Historical Perspectives of PFAAs and Recent Advances in Environmental Distribution, Fate and Transport

Affiliation: Department of Chemistry, University of Toronto

Abstract:
Perfluorinated acids (PFCAs and PFOS) are widely disseminated in the global environment and appear at high concentrations in humans and in Arctic mammals; a new PFA, the perfluorophosphonic acid or PFPAs, was recently discovered in our lab. We have developed the 'precursor alcohol atmospheric reaction and transport' or PAART theory to potentially explain these observations. Residual fluoro-alcohols are significant in fluorinated polymers and surfactants (food contact paper coatings) and may contribute significantly to the global burden, though we know little about the stability of the linkage chemistry within the fluorinated materials. Recent experiments have shown the ester and phosphate esters in monomers and surfactants are readily hydrolyzed through microbial and mammalian metabolism. The fluoroalcohols (e.g. FTOHs) are readily oxidized, via reactive intermediates, to the resulting PFCAs. Some of these intermediates have been shown to be highly toxic to D. Magna (ie 10:2 FTCA) or readily react with GSH (the acrylic aldehydes). These fluoroalcohols are also readily found in the atmosphere and have been shown to undergo atmospheric transport and OH driven transformation reactions to yield the observed perfluorinated acids. Model studies suggest significant production of these acids in remote Arctic regions have been confirmed by flux measurements into the ice cap. Temporal studies of biota contamination yield body burdens that appear to closely match production changes by industry. Human contamination is suggestive of an indirect source of exposure through metabolism of the fluorinated alcohols, which would indicate attention to the reactive intermediates is prudent.

Author: Mark Strynar[1], Andy Lindstrom[1], Shoji Nakayama[2], Amy Delinsky[1], Jessica Reiner[2] and Laurence Helfant[3]

Title: PFAAs in Environmental Media

Affiliation: [1]U.S. Environmental Protection Agency, Research Triangle Park, NC. [2]Oak Ridge Institute for Science and Education, Oak Ridge, TN. [3]National Caucus & Center on Black Aged Inc., Washington D.C.

Abstract:
Perfluorinated Alkyl Acids (PFAAs) are a globally distributed class of compounds that are found in humans, wildlife, and environmental samples. Determination of PFAAs in environmental media is a first step in assessing baseline concentrations for the evaluation of transport and fate issues and to help characterize sources that may lead to human exposures. To ensure adequate confidence in resulting data and study conclusions, it is necessary to establish robust methods with well defined performance characteristics. Our laboratory has developed a wide range of PFAA methods that have been used in a number of different studies. In general, PFAAs are extracted from environmental media (surface water, fish, soil, house-dust) using an organic solvent suitable for each specific application. Primary extractions are then generally followed by an optimized solid phase extraction (SPE) cleanup process prior to analysis by LC-MS/MS or GC-MS. To obtain optimal assay performance, standard curves and QA/QC samples are prepared in matrix-matched blank material when available. Current methods being used for selected environmental media will be discussed and results from recent studies will be presented.

Author: Ferrey, M.L.[1], Adair,C[2], and Wilson, J.T.[2]

Title: Sorption of PFOA and PFOS to Aquifer Sediment

Affiliation: [1]Minnesota Pollution Control Agency, St. Paul, Minnesota, [2]U.S. EPA, R.S. Kerr Research Laboratory, Ada, Oklahoma

Abstract:
During its years of operation, the Washington County Sanitary Landfill near St. Paul, Minnesota accepted both municipal and industrial solid waste. Several years of ground water monitoring performed by the MPCA indicates that, some of the waste disposed of at this landfill contained PFOA. The PFOA has leached into the ground water and moved with the ground-water flow. It has also moved deeper, affecting the bedrock aquifer where it was found at low levels.

As part of a risk evaluation, a microcosm study was performed to predict transport and fate of perfluorooctanoic acid (PFOA) and perfluorooctanesulfonate (PFOS) in leachate from the landfill. Realistic concentrations of PFOA and PFOS were added to microcosms constructed with sediment that was collected from beneath the water table at the Washington County Landfill. Microcosms were then sealed and incubated in the laboratory. Three microcosms of each treatment were sacrificed at quarterly intervals for analysis.

Aqueous concentrations of PFOA and PFOS increased in the microcosms over the incubation period. Shortly after the addition of PFOS and PFOA, the adsorption constant, Kd, averaged 0.9748 L Kg-1 for PFOA and 1.1503 L Kg-1 for PFOS. At 574 days, the Kd averaged 0.0690 L Kg-1 and 0.1973 L Kg-1 for PFOA and PFOS, respectively. Linear regression of the data generated slopes of -0.002 L Kg-1day-1 for PFOA and -0.0014 L Kg-1day-1 for PFOS. Corresponding retardation constants were 2.3 and 10.2 for PFOA and PFOS at the beginning of the study, which decreased to 1.55 and 2.58, respectively, after 574 days.

The fraction organic carbon in the sediments was 0.034%. The Koc after 574 days of incubation was 203 L Kg-1 and 580 L Kg-1 for PFOA and PFOS, respectively. Higgins and Luthy (ES&T 40: 7251-7256, 2006) determined values of Koc for PFOA and PFOS for freshwater sediments of 130 L Kg-1 and 480 L Kg-1 for PFOA and PFOS, respectively. After 574 days of incubation, there was good agreement between Koc for sediment and Koc for aquifer material. At the concentrations of organic material found in water supply aquifers, both PFOA and PFOS should be highly mobile.

The change in the extent of sorption was not expected. The decrease in the adsorptive properties of PFOA and PFOS observed in this study may be due to changing redox conditions over time in the microcosms. It can be rationalized as follows: The sediment as collected was impacted with leachate, but had a red color, indicating the presence of iron(III) minerals. The PFOA and PFOS may have initially sorbed to the iron(III) minerals, and then were released back into pore water as the iron(III) minerals were consumed or modified by iron reducing bacteria.

No evidence of degradation of PFOA or PFOS was observed.

Author: Kurunthachalam Kannan

Title: Perfluorinated Compounds: From Frying Pans to Polar Bears

Affiliation: Wadsworth Center, New York State Department of Health, & School of Public Health, SUNY at Albany, USA

Abstract:
Perfluoroalkyl surfactants (PASs) are class of fluorochemicals manufactured for their unique chemical stability and surface-tension lowering properties. Following several decades of commercial use, PASs have been discovered to be globally distributed, persistent environmental contaminants. Evidence of in vivo toxicity, and the occurrence of PASs in the blood of general populations, has created public health concern.

Our current research interests are in the areas of identifying sources, pathways and distribution of PASs in the environment. PASs and related fluorinated compounds are used in a variety of consumer products including non-stick cookware and microwave popcorn bags. We identified and measured PASs released from non-stick coated cookware into the gas phase under normal cooking temperatures. Our results indicate that PFOA and telomer alcohols are not completely removed during the fabrication process of the non-stick coating for cookware. Rather, they remain residual in the surface and may be off-gassed when heated to normal cooking temperatures, and contribute to a source of human and environmental exposures.

PASs are ionic and highly mobile in the aqueous environment. PASs present in several consumer products can ultimately be released into wastewaters from domestic, commercial and industrial sources and be directed to wastewater treatment plants (WWTPs). We measured concentrations and fate of several PASs in six WWTPs in New York State. Primary treatment was found to have no effect on the mass flows of PASs. Secondary treatment by activated sludge significantly increased the mass flows of perfluorooctanesulfonate (PFOS), perfluorooctanoate (PFOA), and a few long-chain PFCAs.

PASs have been found at higher concentrations in predators, than in their diet. We measured the occurrence of PASs in natural waters, lower trophic organisms, sport fish, birds, and aquatic mammals. PFOS and PFOA are ubiquitous in New York waters. Overall, average concentrations of PFOS in fish were 8850 –fold greater than those in surface water. An average biomagnification factor of 8.9 was estimated for PFOS in birds relative to that in fish. Significance of dietary fish in food chain accumulation of PFOS is documented.

Our current studies focus on human and wildlife biomonitoring on a global scale as well as oceanic survey of PASs to understand their pathways and distribution in the environment.

Perfluorinated contaminant research at NIST: Value assigning Standard Reference Materials (SRMs) and measuring spatial and temporal trends from the Marine Environmental Specimen Bank .

Author: Jennifer M. Keller

Title: Perfluorinated Contaminant Research at NIST: Value Assigning Standard Reference Materials (SRMs) and Measuring Spatial and Temporal Trends from the Marine Environmental Specimen Bank

Affiliation: Hollings Marine Laboratory, Analytical Chemistry Division, National Institute of Standards and Technology (NIST)

Abstract:
Some of the members of the Analytical Chemistry Division of NIST are located in the Hollings Marine Laboratory (HML). Within HML, NIST maintains an organic and inorganic chemistry laboratory, a nuclear magnetic resonance core facility, and the Marine Environmental Specimen Bank (www.hml.nist.gov). The research presented today will focus on the quantification of perfluorinated contaminants (PFCs) in Standard Reference Materials (SRMs) and in specimen bank samples.. Standard Reference Materials (SRMs) are homogeneous, well-characterized materials that may be used to validate measurement methods (www.nist.gov/srm). NIST, in collaboration with the Centers for Disease Control and Prevention and the 3M Corporation, are measuring background concentrations of 12 PFCs in a variety of environmental and biological reference materials, including human serum (SRMs 1957, 1958), human milk (SRMs 1953, 1954), fish tissue (SRMs 1946, 1947), mussel tissue (SRMs 1974b, 2977), sediments and sludge (SRMs 1941b, 1944, 2781), house dust (SRM 2585), and marine mammal liver. Preliminary data will be presented for selected SRMs. In addition, we utilized samples from the Marine Environmental Specimen Bank to monitor temporal trends and sex differences of three PFCs in a marine mammal species. Liver samples from 49 adult white-sided dolphins (Lagenorhynchus acutus) that stranded in Massachusetts from 1993-2005 were analyzed by the 3M Corporation. Perfluorooctane sulfonate (PFOS) was the most abundant PFC, and males had higher PFOS

concentrations than females. Considering only males, PFOS concentrations were stable over the entire time period, but declined from 1999-2005. Perfluorooctanoic acid (PFOA) was below the detection limit (≈3 ng/g) in most samples. Perfluorononanoic acid (PFNA) showed an increasing temporal trend in males with a doubling time of ≈8 y. The possible reasons for these sex differences and temporal trends will be discussed. Through the tools available at NIST, we anticipate that use of our SRMs will improve analytical PFC measurements and that support for the Specimen Bank will continue to allow retrospective studies that can capture the emergence and trends of environmental contaminants.

Author: Antonia M. Calafat, Lee-Yang Wong, Kayoko Kato, Larry L. Needham

Title: Update of PFAA in the General Population

Affiliation: Division of Laboratory Sciences, National Center for Environmental Health, Centers for Disease Control and Prevention, Atlanta, GA 30341

Abstract:
Polyfluoroalkyl compounds (PFCs) can be used in multiple commercial applications, including surfactants, lubricants, paints, polishes, food packaging, and fire-retardant foams. The Centers for Disease Control and Prevention's National Health and Nutrition Examination Survey (NHANES), which includes exposure assessment to selected environmental chemicals of the US population at various life stages, has confirmed that exposure to PFCs is widespread among the general population 6 years of age an older. Also of interest, compared to data from NHANES 1999–2000, data from NHANES 2003–2004 are consistent with reduced population exposure to several PFCs, most likely because of recent efforts of industry and government. However, despite the important advances in our knowledge of human exposure to PFCs in the United States, little is known about the extent of this exposure of pre-adolescent children, because the amount of serum collected from young children in NHANES is limited. To fill these data gaps, we have analyzed pooled serum samples from 3–11-year-old children who were participants of NHANES 2001–2002. The concentrations of 9 PFCs were estimated by use of on-line solid-phase extraction coupled to isotope dilution-high performance liquid chromatography-tandem mass spectrometry. Perfluorooctane sulfonate (PFOS), perfluorooctanoate, perfluorohexane sulfonate (PFHxS), perfluorononanoic acid, 2-(N-ethyl-perfluorooctane sulfonamido) acetate, and 2-(N-methyl-perfluorooctane sulfonamido) acetate (Me-PFOSA-AcOH) were detected in all pools. The unweighted mean concentrations were higher for PFOS than for the other PFCs. The concentrations of some PFCs differed by race/ethnicity. The measurements of PFCs in these samples will complement the measurements previously conducted on the 2001–2002 NHANES participants aged 12 years and older.

Author: Jürgen Hölzer

Title: Bio-Monitoring of PFAA in Adults and Children Exposed to Contaminated Drinking Water – An European Perspective

Abstract:
Background: In 2006, contamination of drinking water with Perfluoroalkyl Acids (PFAAs) was reported from Arnsberg, Germany (Σ PFAAs: 598 ng/L, PFOA: 0.519 µg/L; Skutlarek et al. 2006). 40,000 residents were affected. Immediately after the increased PFOA-levels were observed, German Drinking Water Commission of the German Ministry of Health at the Federal

Environment Agency established guide values for human health protection for composite PFOA and PFOS-concentrations: health based precautionary value (long term minimum quality goal) for non-genotoxic substances: 0.1 µg/L, strictly health based guide value for safe lifelong exposure of all population groups: 0.3 µg/L; precautionary action value for infants: 0.5 µg/L; precautionary action value for adults: 5.0 µg/L (DWC 2006). Based on the results of an extensive environmental monitoring program, Federal health authorities concluded, that PFAA-contamination of

agricultural land occurred by the wide-ranging use of soil conditioner, which has been mingled with industrial waste (Wilhelm et al. in press).

Objective: A biomonitoring study was performed to assess the internal exposure of Arnsberg's residents to PFAAs in comparison to reference areas.

Study population: 170 children (5-6 years old), 317 mothers (23-49 years) and 204 men (18-69 years) were included in the cross-sectional study.

Methods: Individual consumption of drinking water and personal characteristics were assessed by questionnaire and interview. Perfluorooctanoate (PFOA), perfluorooctanesulfonate (PFOS), perfluorohexanoate (PFHxA), perfluorohexanesulfonate (PFHxS), perfluoropentanoate (PFPA) and perfluorobutanesulfonate (PFBS) in blood plasma and PFOA/PFOS in drinking water samples were measured by solid phase extraction, HPLC and MS/MS detection.

Results:

PFOA-levels in blood plasma of residents living in Arnsberg were 4.4-8.3 times higher compared to the reference population (ratios based on geometric means: children 22.1/4.8 µg/L, mothers 23.4/2.8 µg/L, men 25.3/5.8 µg/L). Consumption of tap water at home was associated with PFOA-blood-concentrations in Arnsberg ($P < 0.01$). PFHxS-concentrations were significantly increased in Arnsberg compared with controls ($P < 0.05$). PFBS was detected in 33 % (4 %, 13 %) of the children (women, men) in Arnsberg compared to 5 % (0.7 %, 3 %) in the reference areas ($P < 0.05$). Further details are reported in Hölzer et al. (2008).

Conclusions: PFOA-concentrations in blood plasma of children and adults exposed to PFOA-contaminated drinking water were 4-8fold increased compared with controls.

References:

DWC. 2006. (Drinking Water Commission of the German Ministry of Health at the Federal Environment Agency). 2006.Provisional evaluation of PFT in drinking water with the guide substances perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) as examples. Available: http://www.umweltbundesamt.de/uba-info-presse-e/hintergrund/pft-in-drinking-water.pdf) [accessed 29.4.2008].

Hölzer J, Midasch O, Rauchfuss K, Kraft M, Reupert R, Angerer J, Kleeschulte P, Marschall N, Wilhelm M. Biomonitoring of Perfluorinated Compounds in Children and Adults Exposed to Perfluorooctanoate-Contaminated Drinking Water. Environ Health Perspect 116(5): 651-657.

Skutlarek D, Exner M, Farber H. 2006. Perfluorinated surfactants in surface and drinking waters. Environmental science and pollution research international 13(5): 299-307.

Wilhelm M, Kraft M, Rauchfuss K, Hölzer J. in press. Assessment and management of the first German case of a contamination with perfluorinated compounds (PFC) in the region Sauerland, North Rhine-Westphalia. J Toxicol Environ Health A.

Author: Edward A. Emmett, MD, MS

Title: Community Exposure to PFOA and Health Parameters

Affiliation: University of Pennsylvania, School of Medicine

Abstract:
We have studied Perfluorooctanoate (PFOA) in the vicinity of Little Hocking, a contaminated community in Southeastern Ohio. PFOA is persistent in humans and the environment and is ubiquitous at low levels in human serum. The reported half-life of PFOA in human serum is about 4 years. At the time our study was initiated the sources(s) of general population exposure were unknown and no studies of PFOA effects on the health of the general population had been reported. The toxicokinetics of PFOA in experimental animals and humans are so different that extrapolations from animals, without human data, can have little or no validity. PFOA is a potent hepatotoxin and carcinogen in rodents but the mechanism of action may not be relevant to humans. PFOA has been reported to cause developmental delays in rats.

Residents of the Little Hocking Water Association (LHWA) reticulation area have potential water and air PFOA exposure from nearby fluoropolymer production. We formed an environmental justice partnership with the community to: (1) determine the levels of PFOA in the blood of residents in the Little Hocking water service area and compare these with levels in other populations, (2) determine the major sources of exposure (water, air, other) influencing the blood C8 levels, and (3) determine whether there is an association between blood C8 levels and levels of markers of health effects.

We measured serum PFOA and administered questionnaires to a stratified random sample of 324 subjects from 161 households, plus 54 individuals from 35 volunteer households selected by lottery. These residents were selected from two areas, one with higher potential air exposure, the other with negligible air exposure, both sharing the same water supply. PFOA was measured by high performance liquid chromatography (HPLC)/tandem MS, confirmed using C13 labeled standards. The levels of PFOA in residents of the Little Hocking water district greatly exceeded US general population medians of ~5ng/mL. Control individuals from Philadelphia had values in the normal population range.

Occupational exposure from production processes using PFOA and residence in the water district made additive contributions to serum PFOA; no other occupations made discernable contributions. Median serum PFOA for residents with both air and water exposure was 326ng/mL and 367ng/mL for water exposure alone, indicating no contribution from air exposure. Median PFOA was 55ng/mL for current consumers of bottled/spring/cistern water. In well water users, serum PFOA reflected well water PFOA. The median serum/water PFOA ratio for LHWA water users was 105. Serum PFOA was significantly higher in children aged <6 years and those aged >60. No gender differences were observed. For residents whose sole water source was Little Hocking water, we used the General Estimating Equation to assess the contribution of other variables: the model of best-fit included age, tap water drinks per day, servings per week of homegrown fruit and vegetables, and carbon filter use. Eating locally harvested meat and game was not significant. The association with eating homegrown fruits and vegetables may reflect water use in cooking, cleaning, and canning. Serum PFOS values did not show the same association with water source.

We also explored the relationship between serum PFOA and disease biomarkers. Serum PFOA was not significantly associated with biomarkers of potential liver, renal, hematologic, or thyroid disease or with serum cholesterol. There was no significant association between serum PFOA and a history of diagnosis or treatment for liver or thyroid disease. We did not initially study potential cancer or developmental effects, some studies are continuing. We are also studying the distribution of PFOA to breast milk in mothers in the area.

The results of our findings were made available to the community. As a result of the findings of high serum PFOA, bottled water was made available to residents in the community, Over 77% of LHWA customers accepted the offer. We performed a follow-up study of 64% of the participants in the original study, approximately 15 months after the release of our original findings. Of those previously drinking unfiltered LHWA water 86% had changed to bottled water, and over 95% had made some change in their residential drinking water. The median reduction in serum PFOA levels was 26%. We observed age-related differences in the changes in blood PFOA. The LHWA has now installed an advance filtration system which appears to be eliminating PFOA from the reticulated water.

Our findings have raised a number of additional research questions such as: the relationship of PFOA to fruit and vegetable consumption, age and gender effects on effective PFOA half-lives, and the relative effectiveness of different drinking water interventions.

These studies to date indicate the usefulness of a community-investigator partnership, with independent funding from government agencies, in answering important questions relevant to humans about environmental exposure and effects in unique exposure circumstances.

Author: Tony Fletcher

Title: C8 Science Panel Community Study

Affiliation: London School of Hygiene and Tropical Medicine, UK

Abstract:
In February 2005, West Virginia Circuit Court approved a class action settlement in a lawsuit concerning releases of PFOA (or "C8"), from DuPont's Washington Works in West Virginia. The settlement, among other provisions, established a "Science Panel" of three epidemiologists: Dr. Tony Fletcher (London School of Hygiene and Tropical Medicine), Dr. David Savitz (Mt. Sinai School of Medicine, New York) and Dr. Kyle Steenland (Emory University, Atlanta). Our role is to conduct a Community Study, and subsequently evaluate whether there is a "probable link" between C8 exposure and any human disease. (www.c8ciencepanel.org)

After an initial review of the evidence we established the C8 Community Study as a set of interlinked studies, addressing a number of health outcomes and encompassing several epidemiological designs and data sources. Some draw on a baseline set of blood analyses and questionnaire data from 69030 community participants - the C8 Health Project - set up under the settlement in parallel with the Science Panel.

Cross sectional analyses of the C8 Health Project data, principally analyses of associations between clinical chemistry and C8 measured at the same time in serum samples;

Health event data (including births, and self reported disease) in the C8 Health Project population in relation to the reconstructed historical exposure profile;

Longitudinal studies of the C8 Health Project population in subgroups of those with additional consent to Science Panel studies – multiple repeated sampling of C8 for studying the half life of C8; repeat sampling of C8 and clinical parameters to assess response to changes in C8 levels; examination of neurobehavioral development in relation to C8 in a sample of children; follow up of 40000 in the exposed community to assess morbidity and mortality in relation to the history of C8 exposure.

Longitudinal study of workers in the plant.

Ecologic studies of routine data: studies of reproductive and cancer outcomes, with exposure classification to C8 in water supplies by area of residence at birth/cancer registration.

The first phase of work is under way, including data checking, QA and analyses of the cross sectional data; reconstruction of C8 exposures and repeat sampling of individuals in the half life study. Associations of interest are being assessed for a number of outcomes in the cross sectional study including lipids, uric acid, immune biomarkers, liver and thyroid function and self reported disease. The population of 69030 participants had a range of concentrations up to 22000 µg/l of PFOA in serum, with a median of 28.2 µg/l (interquartile range 13.4-70.6 µg/l). For PFOS the median was 20.2 µg/l (interquartile range 13.9-29.0 µg/l).

Author: Harvey Clewell, Yu-Mei Tan, and Melvin Andersen

Title: Simulation Modeling of PFAA Exposure and Pharmacokinetics

Affiliation: The Hamner Institutes for Health Sciences, 6 Davis Drive, RTP, NC 27709

Abstract:
Determining the relationship between exposure to PFOA and measured concentrations in plasma has been hindered by the lack of pharmacokinetic data in humans. For convenience, the pharmacokinetics of PFOA has been described with one-compartment, first-order models; however, the observed kinetics in animals is clearly more complicated. During studies with daily oral dosing and extended post-exposure observation periods, cynomolgus monkeys have a rapid approach to steady-state plasma concentrations together with a very much slower terminal half-life. Moreover, changes in apparent elimination rates with increasing dose suggest that capacity

limited, saturable processes must be involved in the kinetic behavior of these compounds. We have developed a biologically motivated model for PFOA in the monkey and rat, and have performed an initial extrapolation of this model to the human. This presentation will describe the alternative approaches for modeling PFOA (simple and biologically motivated) and discuss their relative strengths and weaknesses for estimating the exposures likely to be associated with blood levels of PFOA measured in a population, and for comparing these exposures with health benchmarks from animal studies.

Author: Hugh A. Barton

Title: Pharmacokinetic Modeling of PFAA

Affiliation: US EPA, ORD, National Center for Computational Toxicology
Research Triangle Park, NC 27711

Abstract:
Perfluorooctanoic acid (PFOA) has pharmacokinetic properties that appear consistent with a number of processes that are currently not well understood. Studies in mice exposed orally at lower doses (1 and 10 mg/kg) demonstrated blood, liver, and kidney concentration time courses consistent with a one-compartment model, although the tissue distribution is clearly not uniform. Blood time course concentrations following a single 60 mg/kg oral dose were consistent with a two-compartment model. Repeated exposures (20 mg/kg/day for 7 and 17 days) produced exposures inconsistent with the one-compartment predictions, but reasonably predicted by the two compartment fit based upon the single high dose. The three-compartment saturable resorption model can be parameterized to fit all the blood time course data. A more complex physiologically based pharmacokinetic model would be required to predict the tissue distribution characteristics. Improved knowledge of the biological processes controlling the pharmacokinetics of these compounds will better inform cross-species extrapolation and understanding of mode of action. (This abstract does not present Agency policy).

Author: Christopher Lau, Kaberi Das, Julie Thibodeaux, Brian Grey and John Rogers

Title: Comparative Description of PFAA Developmental Toxicity: An update

Affiliation: RTD, NHEERL, ORD, US EPA, Research Triangle Park, NC

Abstract:
The perfluoroalkyl acids (PFAAs) are a family of fluorocarbons consisting of a perfluorinated carbon tail (typically 4-12 carbons in length) and an acidic functional moiety, usually carboxylate or sulfonate. These compounds have excellent surface tension reducing properties and have numerous industrial and consumer applications. The rates of PFAA elimination and their body burden accumulation appear to be dependent on carbon-chain length, functional moieties, and animal species. For instance, in rodents, the serum half-life for the C-8 compounds perfluorooctane sulfonate (PFOS) was estimated as 7 days (rats) and perfluorooctanoate (PFOA) as 17-19 days (mice), but that for the C-4 compound perfluorobutyrate (PFBA) was only 2-17 hours (rats and mice). Correspondingly, a slightly longer half-life for the C-9 compound perfluorononanoate (PFNA), than that of PFOA has been reported in the rat. When laboratory rodents were exposed to some PFAAs during pregnancy, adverse developmental effects were noted. Generally, *in utero* exposure to PFAAs did not produce anatomical defects, except at high doses where maternal toxicity was observed. However, newborn rats and mice exposed to PFOS showed labored breathing and died within hours to days, in a dose-dependent manner. Neonatal mortality was also observed in mice exposed to PFOA, but the rate of loss was less abrupt than that seen with PFOS, with death reported as late as 3-5 postnatal days of age. Deficits of growth and development were evident in the neonates exposed to lower doses of the chemical. Preliminary results from a recent study indicated that mouse neonates exposed to PFNA displayed a similar pattern of mortality as that seen with PFOA. However, pup loss was much more gradual, with pups dying until weaning at postnatal day 24. Significant growth deficits

and developmental delays were noted among survivors, and significant increases in liver weight were observed up to 6 weeks postnatally. In contrast to the C-8 and C-9 compounds, *in utero* exposure to PFBA did not lead to any neonatal death or growth deficits, although slight developmental delay and transient liver enlargement were seen in the pups. Thus, developmental toxicity of PFAAs appears to be correlated to the carbon-chain length (with a potency ranking of PFNA > PFOA ≈ PFOS >> PFBA), and is, to a large extent, related to the rate of elimination of the chemical. *This abstract does not necessarily reflect US EPA policy.*

Author: Suzanne E. Fenton, Jason P. Stanko, Sally S. White, and Erin P. Hines

Title: Latent Effects of PFAA Exposure During Perinatal Development.

Affiliation: US EPA, ORD, NHEERL, Reproductive Toxicology Division, RTP, NC 27711

Abstract:
Developmental exposure to PFOA is associated with decreased body weight, as well as increased mortality of newborn mice. These studies address whether prenatal exposure to PFOA also leads to altered adult weight gain, changes in organ weights, altered reproductive tissue development, or other adverse latent health effects in mice. The mouse model was chosen for its similarity to human PFOA elimination by gender. Time-pregnant CD-1 mice were exposed to a wide dose range of PFOA for these studies (0.01, 0.1, 0.3, and 1 or 5 mg/kg/day). Exposure was via gavage over multiple days during gestation or via their water supply (5 ppb) pre- and postnatally. Male and female offspring were evaluated for numerous health related endpoints. Males were weighed at numerous ages and preputial separation timing was determined. Females were assessed for timing of vaginal opening, mammary gland development, estrous cyclicity, and were weighed on a regular basis. Offspring were necropsied at 18 mo. Whole body, liver, spleen, white abdominal and intrascapular brown fat were collected and weighed. Mammary glands, various masses or abnormal tissues, and thymuses were collected and fixed in 10% buffered formalin.

Significant effects on female weight gain were noted. At postnatal day 1 (PND1), the 5 mg/kg litters weighed significantly less than control animals while animals of all other dose groups were similar to controls. There were significant increases in both body weight (0.1, 0.3, and 1 mg/kg) at 20-29 weeks of age and intrascapular brown fat weight (1 and 3 mg/kg at 18 months of age) in the PFOA group when compared to control animals. Liver, spleen, abdominal white fat and liver to body weight ratio were not significantly different in any of the treatment groups at 18 months. A subset of the prenatally exposed females was ovariectomized (ovx) at PND21 and followed concomitantly with the intact animals. The body weights of these ovx animals showed no significant difference versus intact animals when compared within dose groups. A final group of age-matched females were gavage dosed as adults (0, 1, 5 mg/kg PFOA) at 8 weeks of age for 17 days and followed out to 18 months. These adult exposed animals showed no significant increase in body weight and no significant changes in organ or fat weight at 18 months when compared to controls. Excessive body or tissue weight gain was not noted in males at any life stage measured. These data demonstrate a low dose and gender-specific effect of developmental exposure to PFOA on adult weight.

Effects of developmental exposure to PFOA were noted in the mammary gland. Early development was abnormal in female offspring and full lactational patency was significantly delayed in dams. Evaluation of mammary gland sections and whole mounts from late life indicate lesions that appear to be inflammatory in nature and as well as permanent effects of the early epithelial stunting. Whether the mammary gland and fat deposition have related modes of action is currently under investigation. (This abstract does not necessarily reflect EPA policy; SSW funded by EPA CR833237, NIH T32 ES007126.)

Author: Barbara D. Abbott

Title: Mechanisms of PFAA Toxicity: Involvement of Peroxisome Proliferator Activator Receptor Alpha (PPARα) Molecular Signals.

Affiliation: Reproductive Toxicology Division, NHEERL, ORD, US Environmental Protection Agency, Research Triangle Park, NC 27511

Abstract:
Perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) are members of a family of environmentally persistent perfluorinated compounds and are found in the serum of wildlife and humans. PFOS and PFOA are developmentally toxic in rats and mice. Exposure in utero reduces postnatal survival and growth and delays development. PFOS and PFOA are weak agonists of PPARα, a causal pathway for induction of hepatocellular carcinoma in rodents. This presentation addresses the question of whether PPARα is involved in the mode-of-action for PFOA and PFOS-induced developmental toxicity and discusses the potential for PFAA to activate PPARα in an in vitro model. In in vivo studies, WT and PPARα KO mice were exposed to PFOA at 0 – 20 mg/kg/day from GD1-17 or PFOS at 0-10.5 mg/kg/day from GD15-17. These studies demonstrated that PFOA-induced postnatal lethality, growth effects, and delayed eye opening were dependent on expression of PPARα, but that the effects on early pregnancy loss were independent of PPARα. However, PFOS-induced neonatal lethality and delayed eye opening were not dependent on activation of PPARα. Additional studies are required to further define the modes-of-action for PFOA and PFOS-induced developmental toxicity. In vitro transfected cell assays were used to evaluate the ability of PFAA of various carbon chain lengths, (both perfluoroalkyl and sulfonic acids), to activate the ligand binding domain (LBD) of mouse or human PPARα. Cos-1 cells were transfected with a plasmid containing either the mouse or human PPARα LBD and a luciferase reporter and incubated with perfluoroalkyl acids of 4, 6, 8, 9 or 10 carbon chain length or perfluorosulfonic acids of 4, 6, or 8 carbon chain length. The perfluoroalkyl acids were more active than the sulfonic acids. The activity generally increased with increasing chain length, and PFAAs generally activated plasmid containing the mouse LBD to a greater degree than the human LBD. While this model is useful for determining the potential for PFAA to activate mouse or human PPARα, it cannot address whether these compounds would activate PPARα in a physiological system. In summary, our in vitro studies indicate that the PFAAs examined have the potential to act via a PPARα mode-of-action and the in vivo studies confirmed that PFOA, but not PFOS, has a PPARα-dependent mode-of-action for developmental toxicity in the mouse. Thus, PFAAs with the ability to activate PPARα and produce similar outcomes, may or may not have the same mode-of-action. It may be necessary to determine for each PFAA, and possibly for each outcome, whether a PPARα mode-of-action exists. This abstract does not necessarily reflect US EPA policy.

Author: M.B. Rosen, D.C. Wolf, B.D. Abbott, J.C. Corton, J.E. Schmid, C. R.Wood, K.P. Das, R.D. Zehr and C. Lau

Title: Developmental Toxicogenomic Studies of PFOA and PFOS in Mice

Affiliation: NHEERL, ORD, US EPA, Research Triangle Park, NC

Abstract:
Perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) are developmentally toxic in rodents. To better understand the mechanism(s) associated with this toxicity, we have conducted transcript profiling in mice. In an initial study, pregnant animals were dosed throughout gestation with 1-10 mg/kg PFOA. The expression of genes related to fatty acid catabolism was altered in both the fetal liver and lung. The effects of PFOA were more pronounced in the fetal liver and included genes associated with a variety of signaling pathways known to be regulated by PPARα, although non-PPARα-related effects were suggested as well. In a second study, wild-type (WT) and PPARα-null adult male mice were dosed for 7 days with either 1-3 mg/kg PFOA or

50 mg/kg WY-14,643 (WY), a known PPARα agonist. In WT mice, PFOA and WY induced changes consistent with activation of PPARα. PFOA-treated WT mice deviated from those exposed to WY with respect to genes involved in xenobiotic metabolism, including up-regulation of Cyp2b10, a gene regulated by the constitutive androstane receptor (CAR). Few changes were induced by WY in PPARα-null mice, whereas a moderate number of changes were found in null mice treated with PFOA, including transcripts related to fatty acid metabolism, inflammation, xenobiotic metabolism, and cell cycle progression. Regulation by other PPAR isoforms could account for altered expression of genes involved in fatty acid metabolism and inflammation, while regulation of xenobiotic metabolizing genes was suggestive of CAR activation. Although a dose-dependent increase in liver weight was evident in both WT and PPARα-null mice exposed to PFOA, histological evaluation indicated that this increase was not related to hepatocyte proliferation in null mice. Instead, nonmembrane-bound cytoplasmic vacuoles were observed which may be evidence of hepatic PFOA accumulation. A third study focused on the effects of PFOS in the fetal mouse liver and lung since, unlike PFOA, PPARα is not required for neonatal mortality in PFOS-treated mice. Pregnant mice were dosed with 5 or 10 mg/kg PFOS throughout gestation. Transcript profiling was conducted on the fetal liver and lung at term, and results compared to our previous PFOA study. PFOS-dependent changes were primarily related to activation of PPARα but also included up-regulation of Cyp2b10. No remarkable differences were found between PFOS and PFOA, although the effects mediated by PFOS were less robust. PFOA specifically altered the expression of genes related to inflammation and proteasome biogenesis in the fetal liver, which may reflect greater activation of PPARα by PFOA. These data do suggest divergent transcriptional responses for PFOS and PFOA. Therefore, PFOS-induced neonatal mortality may reflect functional deficits related to the physical properties of the chemical rather than to transcript alterations. In conclusion, the effects of PFOA are predominately mediated via PPARα, although activation of CAR as well as other nuclear receptors may be involved. PFOS is also an agonist of PPARα, although the transcriptional response of PFOS at developmentally toxic doses is less robust than that observed for PFOA. No apparent differences in transcript profiling were observed to explain the differences in developmental toxicity between these two compounds. This abstract does not necessarily reflect EPA policy.

Author: Corton JC[1], Rosen MB[1], Lee JS[1], Ren H[1], Vallanat B[1], Liu J[2], Waalkes MP[2], Abbott BD[1], Lau C[1],.

Title: Evidence for Involvement of Other Nuclear Receptors in PFAA Toxicity Through Genomic Profiling

Affiliation: [1]NHEERL, ORD, US EPA, Research Triangle Park, NC; [2]National Cancer Institute, Research Triangle Park, NC.

Abstract: A number of perfluorinated alkyl acids including perfluorooctanoic acid (PFOA) elicit effects similar to peroxisome proliferator chemicals (PPC) in mouse and rat liver. There is strong evidence that PPC cause many of their effects linked to liver cancer through the nuclear receptor peroxisome proliferator-activated receptor alpha (PPARalpha). To determine the role of PPARalpha in mediating PFOA transcriptional events, we compared the transcript profiles of the livers of wild-type or PPARalpha-null mice exposed to PFOA or the PPARalpha agonist WY-14,643 (WY). After 7 days of exposure, 85% or 99.7% of the genes altered by PFOA or WY exposure, respectively were dependent on PPARalpha. The PPARalpha-independent genes regulated by PFOA included those involved in lipid homeostasis and xenobiotic metabolism. Many of the lipid homeostasis genes including acyl-CoA oxidase (Acox1) were also regulated by WY in a PPARalpha-dependent manner. The increased expression of these genes in PPARalpha-null mice may be partly due to increases in PPARgamma expression upon PFOA exposure. Many of the identified xenobiotic metabolism genes are known to be under control of the nuclear receptor CAR (constitutive activated/androstane receptor) and the transcription factor Nrf2 (nuclear factor erythroid 2-related factor 2). There was excellent correlation between the transcript profile of PPARalpha-independent PFOA genes and those of activators of CAR including phenobarbital and 1,4-bis[2-(3,5-dichloropyridyloxy)] benzene (TCPOBOP) but not

those regulated by the Nrf2 activator, dithiol-3-thione. These results indicate that PFOA alters most genes in wild-type mouse liver through PPARalpha, but that a subset of genes are regulated by CAR and possibly PPARgamma in the PPARalpha-null mouse. The implications of these studies to the mode of action of PFOA-induced liver tumors will be discussed. This abstract does not necessarily reflect EPA policy.

Author: Jennifer E. Foreman, Prajakta Palkar and Jeffrey M. Peters

Title: Evaluation of PFOA Toxicity by the Humanized PPARα Transgenic Mouse Model

Affiliation: Center for Molecular Toxicology & Carcinogenesis, The Pennsylvania State University, University Park, PA.

Abstract:
Previous studies have shown that perfluorooctanoic acid (PFOA) can activate peroxisome proliferator-activated receptor-a (PPARa). However, significant species differences in the effect of ligand activation of PPARa are also known to exist. Two humanized PPARa transgenic mouse lines have been generated; one that expresses the human PPARa in the liver and another that expresses human PPARa in all tissues. Our laboratory has used these mouse models to examine the effect of PFOA and perfluorobutryate (PFBA) in the liver. Wild-type, PPARa-null and PPARa-hTg were treated with either PFOA or PFBA for up to 14 days. After 24 hours, significant changes in gene expression associated with increased lipid catabolism and activation of PPARa were observed in clofibrate-treated wild-type mice and PPARa-hTg mice, but not in PPARa-null mice. These changes were not found in mice treated with PFOA. Serum levels of PFOA were 2-3X lower after 14 days of treatment in the Sv/129 mice used for this study as compared to CD1 mice used in other studies. After 14 days of administration, a PPARa-dependent increase in liver weight was observed in PFOA-treated wild-type mice at high dose (1.0 mg/kg), but did not occur in similarly treated PPARa-null or PPARa-hTg mice. Interestingly, an increase in liver weight was observed in PFBA-treated wild-type mice and was modestly attenuated in PPARa-hTg mice, but did not occur in similarly treated PPARa-null mice. A PPARa-dependent increase in mRNAs encoding enzymes involved in fatty acid catabolism was detected by microarray analysis and confirmed by qPCR in wild-type and PPARa-hTg mice treated with PFOA. Increased expression of CYP3A4 and CYP2B10 were also observed in PFOA-treated mouse liver from all genotypes. Results from this work demonstrate that PFOA can modulate similar changes in gene expression required to facilitate fatty acid catabolism via activation of both the mouse and human PPARa. In contrast, the mild hepatomegaly induced by PFOA is differentially modulated by mouse versus human PPARa. These results also suggest that other receptors including CAR and PXR may also be important in modulating liver-specific effects resulting from PFOA exposure.
Recent work has also established that PPARa is required to mediate PFOA-induced post-natal lethality. Studies are currently underway to examine whether Wy-14,643 and clofibrate can cause similar post-natal lethality, and whether there is a difference in this response when the human PPARa is expressed rather than the mouse PPARa. Preliminary results from these studies will be summarized.

Author: JC DeWitt,[1] CB Copeland,[2] MJ Strynar[3], and RW Luebke[2]

Title: Immunotoxic Potentials of PFOA

Affiliation: [1]Curriculum in Toxicology, UNC Chapel Hill, NC; [2]Immunotoxicology Branch, ETD/NHEERL/ORD, US EPA, RTP, NC; [3]Methods Development and Application Branch, HEASD/NERL/ORD, US EPA

Abstract:
Reports of immunomodulation by perfluorooctanoic acid (PFOA) suggest that adaptive immunity and lymphoid organ weights are susceptible to PFOA exposure. Spleen weights, thymus weights, and primary antibody responses to a T cell-dependent antigen were suppressed in mice exposed to PFOA for 15 days in the diet or in drinking water at 30 mg/kg body weight (bw). Additional

studies identified a LOAEL for suppression of primary antibody responses of 3.75 mg PFOA /kg bw after 15 days of exposure via drinking water. The LOAEL was associated with a PFOA serum concentration of 7.5 x 104 ng/mL, which is a concentration approximately 150-fold higher than those measured in environmentally and occupationally exposed humans. PFOA immunotoxicity may be mediated by the peroxisome proliferator activated receptor alpha (PPARα) as lymphoid tissues of mice deficient in PPARα (KO) were reported to be less susceptible to PFOA than wild-type (WT) mice. However, our recent work has demonstrated that changes in adaptive immunity following PFOA exposure are not exclusively dependent on the presence of PPARα and are influenced by host phenotype. Primary antibody responses to a T-dependent antigen were suppressed approximately 15% compared with controls in C57BL/6 WT and PPARα KO female mice given 30 mg PFOA/kg bw in drinking water for 15 days. Conversely, primary antibody responses to a T-dependent antigen were not altered compared with controls in Sv129 WT and PPARα KO female mice exposed at the same dose and for the same duration. In addition to the influence of PPARα and host phenotype, it has been suggested that primary antibody suppression from PFOA exposure is mediated by stress-induced corticosterone release. However, adrenalectomized C57BL/6 WT female mice given 15 mg PFOA/kg for 10 days in drinking water had suppressed primary antibody responses to a T-dependent antigen that were statistically equivalent to the suppression observed in sham-operated mice exposed to the same dose and for the same duration. These studies suggest that adaptive immunity is susceptible to PFOA exposure, but that the mechanisms by which PFOA affects adaptive immunity are not directly mediated by receptor activation nor by corticosterone release.

Author: M.M. Peden-Adams[1,2,3,4,11], D.E. Keil[5],T. Romano[4], M.A.M. Mollenhauer [1,3], D.J. Fort[6]. P.D. Guiney[7], M. Houde[8], K. Kannan[9], D.C. Muir[8], C.D. Rice[10], J. Stuckey[11], A.L. Segars[12], T. Scott[13], L. Talent[14], G.D. Bossart[15], P.A. Fair[16], J.M. Keller[17]

Title: Health Effects of Perfluorinated Compounds- What are the Wildlife Telling Us?

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Abstract:
It has long been said that wildlife often give us the first indication of problems in the environment that may, if left unchecked, lead to deleterious effects in various species with subsequent impacts on human health. From examples with pesticides and raptors to alligators and endocrine disruption, wildlife has often heralded a problem in an ecosystem. Much work over the last 7 years has documented levels of perfluorinated compounds (PFCs) from multiple species worldwide. Few studies have, however, assessed the effects of perfluorinated compounds on health or toxicity in species other than traditional laboratory models. Several studies began assessing health effects of PFCs in wildlife and lab models in 2003. These models include field studies with loggerhead turtles and bottlenose dolphins and lab studies with the Western fence lizard (as a surrogate for sea turtles), white leghorn chickens (as a surrogate for coastal waterfowl) and rodent models (as a surrogate for bottlenose dolphins and humans). Lab studies utilized environmentally relevant concentrations that were reported in the literature or measured

in the field. Previously available studies that assessed only gross toxicological effects such as weight loss and death, reported effects only at exposure levels above what is documented in humans and wildlife suggesting that there would likely be no adverse effects from environmentally relevant exposures. These new studies, however, indicate that PFCs can cause sublethal effects at environmental concentrations. In relation to clinical health parameters, studies with loggerhead sea turtles (Caretta caretta) demonstrated positive correlations between the liver enzyme aspartate aminotransferase (AST) and both perfluorooctane sulfonate (PFOS) and sum total PFCs. This suggests that these compounds may contribute, either directly or indirectly, to increased plasma AST levels; thereby, indicating liver dysfunction. Similar increases in AST as well as alanine aminotranferease (ALT) were observed in the fence lizard (Sceloporus occidentalis) at PFOS exposure levels comparable to the sea turtles (0.00357 mg/kg/day = 0.1 mg/kg total dose). The correlation and trends in liver enzymes in the two reptile species were not completely unexpected as previous studies reported increased plasma AST levels in rats following exposure to 20 ppm PFOS. But these observations were surprising given the PFOS exposure range of 10 to 100 ppb. Additionally, dosing studies in the lizards confirmed correlative associations in the loggerhead turtles between PFOS and markers of immune function such as lysozyme activity and T-cell proliferation. In bottlenose dolphins (Tursiops truncatus) studied in the summer of 2003, absolute numbers of lymphocytes, numbers of CD4+, CD21+ and CD19+ cells, B-cell proliferation, and C-reactive protein levels were positively correlated with plasma concentrations of PFOS. However, plasma lysozyme activity and cortisol was negatively correlated with PFOS levels. NK cell activity, T-cell proliferation, AST, and ALT did not correlated with PFOS concentrations in the dolphins. In B6C3F1 mice exposed to PFOS concentrations measured in dolphins, these effects were not observed nor were alterations in liver enzymes as has been reported at much higher doses in mammalian models. In ovo chicken (Gallus gallus) studies resulted in no decrease in hatch rate, while chicks exhibited increased liver (2.5 and 5 mg PFOS/kg egg wt) and spleen weights (1, 2.5 and 5 mg PFOS/kg egg wt). At the 5 mg PFOS/kg treatment, body length (crown-rump length) was increased compared to control. For all three treatment groups lysozyme activity was increased while no significant effect was seen in antibody titers, or thymic or splenic T-cell populations. In utero PFOS exposure in mice resulted in decreased NK-cell activity and antibody production. In adult mice, decreases in IgM antibody production were seen at plasma PFOS levels similar to those found in wildlife and humans. Studies in the South African clawed frog (Xenopus laevis) indicate that PFOS may be anti-estrogenic which appears to be supported by rodent PFOS exposure studies. Although much still needs to be understood about the mechanism by which these effects occur and how that mechanism differs between species, these studies clearly indicate that PFCs can alter health parameters at environmentally relevant levels.

Author: J. Jackson Ellington[a], John W. Washington[b,a], John J. Evans[b,a], Thomas M. Jenkins[b,a], Sarah Hafner[c]

Title: Method Development for the Determination of Fluorotelomer Alcohols in Soils by Gas Chromatography Mass Spectrometry

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960 College Station Road, Athens, GA 30605, [b]Senior Service America, Inc., [c]Student Service Authority,

Abstract: Fluorotelomer alcohols (FTOHs) have been widely studied as precursors to perfluorocarboxylates, e.g. 8:2 FTOH degrades to perfluorooctanoic acid (PFOA). This presentation describes an analytical method for the extraction and analysis of 6:2, 8:2, and 10:2 FTOHs. Gas chromatograph/chemical ionization-mass spectrometry (GC/CI-MS) was used for sensitive determination of the fluortelomer alcohols. The best selectivity and sensitivity was observed when the detector was operated in the positive mode (GC/PCI-MS). Alcohol levels in the methyl tertiary butyl ether (MTBE) extracts of soils were determined based on the retention times of standards and the response of the protonated molecular ions $[M + H]^+$. In fortified soils the peaks in the PCI chromatogram assigned to FTOHs were confirmed by treatment of the extract with a silylation reagent through observing the loss of the FTOH peaks and the

appearance of trimethylsilyl (O-TMS) peaks. The instrument detection limit (IDL) was 0.016, 0.010, and 0.014 pg/uL for 6:2, 8:2, and 10:2 FTOH, respectively. The method detection limit (MDL) depended on the soil matrix but was as low as 0.05 pg/g.

Author: Zhishi Guo[1], Xiaoyu Liu[1], Kenneth A. Krebs[1], and Nancy F. Roache[2]

Title: Testing of PFAA Release from Aged Articles of Commerce

Affiliation: [1]APPCD, NRMRL, ORD, U.S. EPA, Research Triangle Park, NC and [2]Arcadis, Research Triangle Park, NC

Abstract:
Products such as fluoropolymer-coated cookware, plenum cable, thread sealant tape, membranes for apparel, surface protective coatings for paper, textile, and carpet may contain PFOA or its precursors (e.g., fluorotelomers). OPPT needs to understand whether these products play a significant role in human exposure to PFOA in the indoor environment. Although progress has been made in some areas including toxicity, sources, transport, transformation, and distribution in the environment, it is not fully understood how the general public gets exposed to these chemicals. It is known that consumer articles containing or treated with fluorinated chemicals can be a source of PFOA. Given that consumer articles are used in either close vicinity of or direct contact with humans, it is important to evaluate the source strengths and ways by which PFAAs are released. The main goals of this project are to characterize the source and transport of PFAA in the indoor environment and the factors that may affect PFAA release from consumer articles.

In the source study, over 100 consumer articles were collected from the open market. They were analyzed for the content of eight (C5 to C12) perfluoroalkyl acids (PFCAs). The results are used to identify the PFAA sources potentially important to human exposure. It was observed that the market has been in a transition period. While consumer articles with high PFAA content are still on the market, some manufacturers of fluorinated chemicals have re-formulated their products to reduce the PFAA content, and in some applications, fluorinated chemicals have been replaced by non-fluorinated chemicals. The trends are uneven, however. Furthermore, given that the consumer articles are made in many countries, an international collaboration is needed to further reduce the PFAA content.

In the currently on-going transport study, accelerated aging tests will be conducted to determine whether PFAA release from the source through gas-phase transfer is significant. Tests will be conducted based on the principles of ASTM standard guide 5116. Additional tests will be conducted in large environmental chamber (ASTM standard guide 6670) or research house to determine whether particle re-suspension plays any role in human exposure. PFAA release under normal use conditions for certain types of articles, such as apparel and dental floss will also be tested.

The results of this research project will help better understand the sources of PFAAs to which the general population is exposed and the potentially important exposure routes in the indoor environment. The findings will help reduce the uncertainty in PFAA assessments and development of risk management solutions.

Author: Helen Goeden

Title: Issues and Needs for PFAA Exposure and Health Research: A State Perspective

Affiliation: Minnesota Department of Health, St. Paul, MN

Abstract:
The 3M Company (3M) produced perfluorochemicals (PFCs) at its Cottage Grove facility in Washington County, Minnesota from the late 1940's until 2002. For a time, wastes from the production process were disposed on site. The water treatment plant on site that processed water from production activities did not remove PFCs, so PFCs were in the waste water that went into the Mississippi River. Some sludge left over from the water treatment process also contained PFCs and was disposed on site. Firefighting foams containing PFCs were also used in training exercises on-site.

PFCs-containing wastes were also disposed of by 3M off-site at three disposal sites located within Washington County. A variety of PFCs released from the disposal sites have contaminated groundwater and drinking water wells in 7 communities, covering an area of nearly 100 square miles.

In 2004 the Minnesota Pollution Control Agency (MPCA) began evaluating closed and active landfills that may have accepted PFC containing waste, directed 3M to investigate and cleanup the various PFC waste disposal sites, and initiated sampling of Mississippi River sediment and discharge from outfalls at the 3M Cottage Grove facility. MPCA is also investigating PFCs in the wider environment through statewide sampling of ambient groundwater and surface water, fish tissue, wastewater treatment plants, and landfills that did not accept 3M waste.

Perfluorobutanoic acid (PFBA) was the most frequently detected PFC in ambient groundwater and surface water. A wider range of PFCs (perfluorobutane sulfonate (PFBS), perflurohexane sulfonate (PFHxS), perfluorooctanesulfonate (PFOS) and perfluorooctanoic acid (PFOA)) were frequently detected at waste water treatment plants. PFCs, mainly PFBA, PFOA and PFOS, were detected in the leachate and/or condensate gas at all landfills sampled, including those that did not accept 3M waste. PFC concentrations in the non-3M related landfills were between one to three orders of magnitude lower than at sites that accepted 3M waste.

In late 2004 the Minnesota Department of Health (MDH) began sampling public and private water supplies to investigate possible exposures from past PFC waste disposal. PFBA, PFOA and PFOS were the most commonly detected PFCs, reaching maximum concentrations in drinking water of 11.8, 3.2 and 3.4 ug/L, respectively.

Over the last few years the MDH and MPCA have derived health based criteria for a limited number of PFCs:

Groundwater and Drinking Water
7 ug/L PFBA, 0.3 ug/L PFOA, and 0.3 ug/L PFOS
Surface Water
Mississippi River Pool 3
0.72 ug/L PFOA and 0.006 ug/L PFOS
Lake Calhoun
0.61 ug/L PFOA and 0.0122 ug/L PFOS
Fish Advisory
1 meal/week
> 40 ng/g PFOS
1 meal/month
> 200 ng/g PFOS
Soil Screening Values
Residential Land Use
77 mg/kg PFBA, 2 mg/kg PFOA, and 2 mg/kg PFOS
Industrial Land Use
500 mg/kg PFBA, 13 mg/kg PFOA, and 14 mg/kg PFOS

The MDH and MPCA are continuing to expend resources on evaluating PFCs in the environment. On-going activities include expansion of environmental media sampling, air and precipitation monitoring, foodweb study, source identification study, PFC product substitution, and treatability studies. EPA is assisting Minnesota in evaluating the extent and magnitude of PFC contamination in fish throughout the state.

Health based criteria for additional PFCs (such as PFBS, PFHxS and PFHxA) are needed in order to provide health based advice to citizens who are exposed to contaminated environmental media. Derivation of these values is based on knowledge regarding toxicity and exposure. Data identifying relevant adverse health effects, life stage sensitivities, and toxicokinetic are essential to evaluate toxicity potential. Understanding potential sources and routes of exposure are critical for risk management decisions. The generation of this type of data is typically beyond the resources of individual state agencies. Increased communication and cooperation between EPA and state agencies can improve our ability to deal with emerging contaminant situations such as PFCs and meet our common goal of protecting human health and the environment.

U.S. EPA PFAA Days II Workshop - Posters

P-1 Elevated Levels of Perfluorochemicals in Plasma of New York State Personnel Responding to the World Trade Center Disaster

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The collapse of the World Trade Center (WTC) on September 11, 2001 resulted in the release of several airborne pollutants in and around the site. Perfluorochemicals including perfluorooctanesulfonate (PFOS) and perfluorooctanoic acid (PFOA), which are used in soil and stain resistant coatings on upholstery, carpets, leather, floor waxes, polishes, and fire-fighting foams were potentially released during the collapse of the WTC. In this pilot study, we analyzed 457 plasma samples of New York State (NYS) employees and National Guard personnel assigned to work in the vicinity of the WTC between September 11 and December 23, 2001, to assess exposure to perfluorochemicals released in dust and smoke. The plasma samples collected from NYS WTC responders were grouped based on estimated levels of exposure to dust and smoke, as: more dust exposure (MDE), less dust exposure (LDE), more smoke exposure (MSE), and less smoke exposure (LSE). Furthermore, samples were grouped, based on self-reported symptoms at the time of sampling, as: symptomatic and asymptomatic. Eight perfluorochemicals were measured in 457 plasma samples. PFOS, PFOA, perfluorohexanesulfonate (PFHxS), and perfluorononanoic acid (PFNA), were consistently detected in almost all samples. PFOA and PFHxS concentrations were approximately two fold higher in WTC responders than the concentrations reported for the US general population. No significant difference was observed in the concentrations of perfluorochemicals between symptomatic and asymptomatic groups. Concentrations of PFHxS were significantly ($p \leq 0.05$) higher in the MDE group than in the LDE group. Concentrations of PFNA were significantly higher in the MSE group than in the LSE group. Significantly higher concentrations of PFOA and PFHxS were found in individuals exposed to smoke than in individuals exposed to dust. A significant negative correlation existed between plasma lipid content and concentrations of certain perfluorochemicals. Our initial findings suggest that WTC responders were exposed to perfluorochemicals, especially PFOA, PFNA, and PFHxS, through inhalation of dust and smoke released during and after the collapse of the WTC. The potential health implications of these results are unknown at this time. Expansion of testing to include all archived samples will be critical to help confirm these findings. In doing so, it may be possible to identify biological markers of WTC exposure and to improve our understanding of the health impacts of these compounds.

P-2 Pilot Study of Serum Biomarkers of Polyfluoroalkyl Compounds in Young Girls

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Background: Polyfluoroalkyl compounds (PFCs) and their salts, such as perfluorooctanoate (PFOA) and perfluorooctane sulfonate (PFOS), are chemicals that have wide consumer and industrial applications and known environmental persistence. PFCs have been detected in humans and wildlife, and health effects have been noted in laboratory animals, including changes in mammary gland structure and function.

Objective/Hypothesis: Within the NIH Breast Cancer and the Environment Research Centers (BCERC), we conducted a pilot study of multiple environmental biomarkers in young girls (age 6-8 years), including PFCs, followed by a second study at the Ohio site where elevated levels of PFOA had been detected in the pilot study.

Methods: Participants for the pilot study were recruited from area schools in Cincinnati and Northern Kentucky (n=27) and membership of the Kaiser Permanente health maintenance organization in the San Francisco Bay area (N=28). Blood was collected using a standard protocol and materials provided by the Centers for Disease Control and Prevention (CDC), and assayed for the perfluoroalkyl acids using high-performance liquid chromatography-tandem mass spectrometry.

Results: Four of the seven PFCs, including PFOA and PFOS, were detected in all samples, and only one was detected in less than 70%. The median values for PFOA differed by site (PFOA - 12.9 ng/ml for California and 20.2 ng/ml for Greater Cincinnati), an unexpected finding. Within the Ohio site, 14 of the 15 girls in one community had PFOA values above the NHANES 1999-2000 95th percentile value for children 12-19 years (11.2 ng/ml, Calafat, 2007). In the follow-up study of 42 girls from the community with higher values, the elevation in serum PFOA persisted (median 17.4 ng/ml, range 6.9-42.6 ng/ml serum), with 31 having values above the NHANES 95th percentile. For the subset of girls from greater Cincinnati who were in both the pilot and second study, the pilot serum samples were reanalyzed with the second study samples. The difference between PFOA measures for each girl, one year apart, was a median decrease of 7.9 ng/ml for girls in the community with the higher values ($p<0.0001$ under a one sample t-test with $H_0=0$) and a median decrease of 1.6 ng/ml ($p<0.001$) for the girls from the community with the lower values.

Conclusions: Sufficient between-person variation in PFC levels exists to enable an investigation of association with age of onset of pubertal maturation. The elevated serum PFOA levels in one community in the greater Cincinnati areas appear to be decreasing, but cannot be linked to a source at this time. Further research is required to identify the source and potential health effects.

Calafat A., Kuklenyik Z., Reidy J., Caudill S., et al. Serum concentrations of 11 polyfluoroalkyl compounds in the US population: Data from the National Health and Nutrition Survey (NHANES) 1999-2000. Environ. Sci. Technol. 2007; 41(7):2237 – 2242.

Support for this project provided by the National Institute of Environmental Health Sciences and the National Cancer Institute, to the University of Cincinnati/Cincinnati Children's Hospital Medical Center, Breast Cancer & the Environment Research Center (U01 ES12770), and Center for Environmental Genetics (P30-ES06096), and to the University of California San Francisco Bay Area Breast Cancer and the Environment Research Center (U01 ES012801). We also acknowledge the biostatistical expertise of Paul Succop, and geocoding assistance of Patrick Ryan.

The findings and conclusions in this presentation have not been formally disseminated by the Centers for Disease Control and Prevention and should not be construed to represent any agency determination or policy.

P-3 **PFOS and PFOSA in Bottlenose Dolphins: An Investigation Into Two Unusually High Mortality Epizootics**

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Along the Atlantic coast of the United States during 1987 and 1988, bottlenose dolphins (Tursiops truncatus) suffered one of this country's largest marine mammal mass mortality events. An estimated 50% of all near-shore bottlenose died during this short period. Two years later a second, although less dramatic, event occurred along the United States coastline of the Gulf of Mexico. The cause of these mortalities is not known for certain; however, morbilliviral infection seemed to have spread rapidly throughout the dolphins. Suppression of the animal's immune system by high concentrations of chemical contaminants was suggested as a contributing factor. In order to investigate this hypothesis, we determined by GC/MS the concentration of many polychlorinated and polybrominated chemicals, such as PCBs, chlorinated pesticides, and brominated flame retardants, as well as mercury, determined by AA, in the affected animals. The development of electrospray ionization LC/MS has now allowed us to re-examine these same dolphin tissues (liver) for the presence of PFOS and a metabolic precursor of PFOS, PFOSA. Concentrations of PFOS in the affected bottlenose were found to be greater than, and statistically different from those found in other species not affected during the epizootics, and to other bottlenose dolphin populations. PFOS concentrations were found to be as great as, or greater than, concentrations of PCBs, thirteen chlorinated pesticides, and PBDPEs. PFOS concentrations were generally less than mercury residues. PFOS was found to be readily transferred in utero from mother to fetus.

P-4 **Identification of a Major Source of Perfluorooctane Sulfonate (PFOS) at a Wastewater Treatment Plant in Brainerd, Minnesota**

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Perfluorooctane sulfonate (PFOS) is a globally distributed persistent contaminant in environmental and biological media. Due to the history of perfluorochemical (PFC) manufacture and waste disposal in the state, the state of Minnesota has been evaluating the presence of PFCs in drinking water and fish. PFOS has been shown to bioaccumulate in fish tissue, and the detection of elevated concentrations of PFOS in fish in a number of lakes and rivers in Minnesota has resulted in the issuance of PFOS-based fish consumption advice in some instances. While PFC waste disposal sites have been identified as one potential source, currently, little is known about other source(s) of PFOS in lakes and rivers in Minnesota.

In 2007, the Minnesota Pollution Control Agency (MPCA) conducted a study of PFCs in influent, effluent, and sludge at 28 public and private wastewater treatment plants (WWTPs) throughout Minnesota. Samples of influent (n=32), effluent (n=28), and sludge (n=23) were analyzed for 13 PFCs by Axys Analytical Services, British Columbia, Canada.

Several WWTPs, mainly in urban areas, had elevated levels of individual or multiple PFCs that could reasonably be attributed to local sources, including known PFC contamination in drinking water sources or the use of PFC containing products at an industrial facility or airport. A notable

exception was PFOS in the influent, effluent, and sludge from the City of Brainerd WWTP, operated by Brainerd Public Utilities (BPU). The plant is located about 135 miles northwest of St. Paul, and discharges to the Mississippi River. This plant had the highest detections of PFOS in all three media of any of the wastewater treatment plants tested, with an effluent PFOS level of 1.51 micrograms per liter (µg/L). Samples from wells supplying drinking water to the city of Brainerd showed no PFCs.

BPU conducted an investigation of the wastewater collection system to identify the source(s) of the PFOS contamination. The main source (~95%) of the PFOS was identified as a large chrome plating operation in the city who reported using a legal surfactant product to control hexavalent chromium emissions. The product reportedly contained "organic fluorosulfonate" between 1% and 7% by weight.

Samples collected within the plating facility by BPU staff identified the specific points where PFOS remains in the plating solution tanks. An alternate surfactant product that does not contain PFOS is currently being used by the facility and levels of PFOS in wastewater from the facility and the BPU WWTP are expected to drop over time.
The findings of the Brainerd investigation represent the first comprehensive look at PFOS inputs to a WWTP, and the first documentation of the importance of chrome plating as a possible source of PFOS in WWTP effluent. Little is currently known about levels of PFOS in agricultural fields where PFOS-containing sludge from such facilities is applied, and the uptake of PFOS by crops has not been extensively studied.

P-5 **Determination of Perfluorocarboxylic Acids in Sludge**

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Methods were developed for the extraction from wastewater-treatment sludge and quantitation by LC/MS/MS of perfluorocarboxylic acids (PFCAs, C6 to C12), 7-3 fluorotelomer carboxylic acid (7-3 FTCA) and 8-2 fluorotelomer 2-unsaturated carboxylic acid (8-2 FTUCA) using LC/MS/MS. In the last 10 years, advances in analytical instrumentation and techniques have enabled monitoring studies aimed at documenting the presence of PFCAs in various matrices including human serums, biological tissues and water bodies. Although these studies have documented the widespread distribution of PFCAs in numerous environmental matrices, exposure routes of the PFCAs to the receptors remain unclear. To help address this uncertainty, researchers now have begun looking for PFCA precursors, such as 8-2 FTUCA, in these matrices as well. Unlike many organo-chlorine contaminants, which primarily sorb to abiotic solid matrices, PFCAs commonly tend to partition to the water column in part because of their low dissociation constants and high water solubility. In sludge, mostly anaerobic bacteria decompose organic contaminants via enzymatic processes including hydrolysis, oxidation and reduction. In part because of this, concentrations of PFCAs in sludge, which are considered to be recalcitrant, are expected to be elevated compared to soils and sediments. In addition, biosolids, the treated form of sewage sludge, have been permitted for use in land-application programs. This raises concerns over the impact of bioavailability of PFCAs in land-applied sludge to in-situ vegetation or live-stock. For these reasons, there is a need to develop protocols for the extraction and determination of PFCAs and related compounds from sludge and biosolids.

Three extractants were tested to evaluate their efficacies to recover PFCAs and telomer acids from sludge; 60:40/ACN:H_2O, 90:10/MeOH:H_2O, and MTBE. Test sludge from a New York City wastewater-treatment plant was settled overnight and supernatant was decanted. Briefly, 1g wet sludge in a 16-mL PPCO centrifuge tube was spiked with 1ng of $^{13}C_5$-PFNA as a recovery internal standard and sonicated in a hot water bath with an addition of 200uL of 2M NaOH for an hour. Then, an equivalent volume of 2M HCl was added to neutralize the solution. The sludge was shaken in 7.5mL of 60:40/ACN:H_2O or 90:10/MeOH:H_2O for an hour. This slurry was

separated by centrifugation at 10,000rpm and this extraction step was repeated three times. Conventional MTBE ion-pairing extraction also was conducted wherein 1g of sludge was mixed with an ion-pairing agent (2mL TBA mix) and 5mL of MTBE. This mixture was shaken for 30min. This extraction step was repeated three times and all extractions were combined. In addition, the effect of an overnight oxidation pretreatment on PFCA extraction from sludge was tested using NaOH, HCl, and $K_2S_2O_8$. Upon completion of the pretreatments, the sludge was extracted with 60:40/ACN:H_2O as described above. The extract was dried under an SPE assembly and reconstituted with 1mL of 60:40/ACN:H_2O containing $^{13}C_4$-PFOA as a matrix internal standard.

Among the extractants tested, 60:40/ACN:H_2O extracted the greatest concentrations of PFCAs from test sludge, followed by 90:10/MeOH:H_2O and MTBE. Pretreatment of NaOH effectively extracted PFCAs in sludge, but HCl and $K_2S_2O_8$ were less effective. A NaOH pretreatment yielded at least three times greater PFCA concentrations than the sludge without a pretreatment.

Disclaimer: Although this work was reviewed by EPA and approved for publication, it may not necessarily reflect official Agency policy. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

P-6 Results from a Study on the Biodegradation Behaviour of a Clariant Fluorotelomer-Based Acrylate Polymer Coated on Polyester and Cotton Fabric Under Landfill Simulation Conditions

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Fluorotelomer-based substances like 8-2 Fluorotelomer alcohol (2-Perfluorooctylethanol) are speciality chemicals being used to synthesize e.g. high molecular weight Fluorotelomer-based acrylate polymers (FBAPs). FBAPs are used for coating of textiles, paper and carpet to achieve oil, stain and water repellency properties. Concerns that fluorotelomer-based polymers may be a source for low molecular Fluorotelomer-based substances which could be transformed to perfluorinated carboxylic acids like PFOA have triggered investigations on the biodegradation potential of a commercial FBAP coated on Polyester and Cotton Fabric under landfill conditions. Due to the long residence time of waste in a landfill and the unknown sources of the waste the degradation behaviour of FBAPs in a municipal landfill is difficult to study. Instead a Landfill Simulation Study has been set up using artificial waste which is representative for the waste composition of municipal solid waste being dumped on American landfills today. Experimental set up of the Landfill Simulation and results are reported.

P-7 Biodegradation Kinetic and Estimated Half-Life of a Clariant Fluorotelomer-Based Acrylate Polymer – Results from a Test on Aerobic Transformation in Soil

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Fluorotelomer-based substances like 8-2 Fluorotelomer alcohol (2-Perfluorooctylethanol) are speciality chemicals being used to synthesize e.g. high molecular weight Fluorotelomer-based acrylate polymers (FBAPs). FBAPs are used for coating of textiles, paper and carpet to achieve oil, stain and water repellency properties. Concerns that fluorotelomer-based polymers may be a source for low molecular Fluorotelomer-based substances which could be transformed to perfluorinated carboxylic acids like PFOA have triggered investigations on the biodegradation potential of a purified FBAP in aerobic soil. The PFOA measured in soil during this test on Aerobic Transformation may be residual PFOA in the FBAP and PFOA formed from degradation

of the FBAP as well as from degradation of 8-2 Fluorotelomer alcohol. A three component 1st order kinetic model allows to attribute the origin of PFOA in the soil and the estimation of the half-life of 8-2 Fluorotelomer alcohol as well as the half-life of the Fluorotelomer-based acrylate polymer (FBAP).

P-8 **Determination of Perfluorinated Compounds in Surface Soils**

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Much attention has recently been focused on the investigation of perfluorinated compounds (PFCs), including perfluorooctanoic acid (PFOA), perfluorooctane sulfonate (PFOS), and other related homologues. A growing number of studies have demonstrated the widespread presence of PFCs in environmental and biological matrices. However, little has been done to date to characterize the environmental distributions of these compounds at the local, regional, or world-wide scales. Surface soils are an easily acquired matrix that can be used to evaluate patterns of PFC contamination. Moreover, soils are intricately linked with hydrologic and atmospheric cycling, both of which have been shown to be important factors in the distribution and fate of the PFCs. Recent evidence for transport of PFCs from a manufacturing facility to nearby soil and water has been demonstrated. In addition, consumption of PFC contaminated water has been shown to increase the body burden of individuals drinking that water. The net negative charge of soils and negative charge of the more common PFCs acids and sulfonates may lead to mobility through soils to ground water. Little to no information exists concerning the translocation of PFCs from contaminated soils into plant matter. Few studies have investigated the analysis of PFCs in soils, but given the central role that soil is likely to play in the contamination of water and food supplies, a well characterized analytical method for PFCs in soils is a very high priority. A new method has been developed for the analysis of 10 related PFCs in surface soils at the sub ng/g concentration range. This method involves ultrasonic extraction of soils in methanol followed by a graphitized carbon SPE cleanup and LC/MS-MS analysis.

Surface soils were obtained from various sources world-wide and stored at 4°C prior to being sieved to 2 mm at field moisture before analysis. Sub-samples were extracted with methanol via shaking and sonication. Extracts were then subjected to cleanup using SPE (graphitized carbon). The final sample eluate was reduced in volume under N_2 gas and then injected on a high-performance liquid chromatography coupled with quadrupole tandem mass spectrometer (LC/MS/MS) for quantitation. Quantitation was carried out using surface soil/solvents fortified with a series of PFC standards (6 points). Recoveries were calculated using matrix matched solutions.

Methanolic extracts of soils are inherently dirty due to co-extraction of matrix interferences. The SPE cleanup with graphitized carbon (GL Sciences, Carbograph) with no modifiers removed much of the matrix interference and allowed the extracts to be reduced in volume enough to provide sensitivity and precision in the sub ng/g range. Recovery experiments using solvent based standards and soils spiked with methanolic PFC standards indicated that SPE cleanup with graphitized carbon generally lead to recoveries in the range of 70-130%. Duplicate analysis of soils resulted in coefficients of variation ranging between 2.2 – 15.1% at spike levels of 50 and 200 pg/g soil. Extraction of between 2-5 grams of soils appeared to be adequate for determination of low level (sub ng/g) contamination. Application of the method to a soil sub-set indicates a wide range in concentrations and composition of PFC in these samples. An assessment of the performance characteristics of this method and application to an international collection of soils (USA, Japan, China) for PFC analysis will be presented.

P-9 **Analysis of Fish Homogenates for Perfluorinated Compounds**

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Perfluorinated compounds (PFCs) have been manufactured and used in industrial and consumer applications for more than 50 years. Recent studies have demonstrated that PFCs are widespread in wildlife and environmental matrices. Due to the toxicity, persistence, and bioaccumulation of some PFCs, interest in these compounds is increasing. However, little is known about the ecological or human exposure effects of PFCs. A pilot scale study was undertaken to assess PFCs in whole fish homogenates collected as part of the Environmental Monitoring and Assessment Program (EMAP)-Great Rivers Ecosystem (GRE) project. The EMAP GRE fish tissue indicator was developed as a means to assess the bioaccumulation of persistent toxic substances in the environment and to estimate potential exposures at higher trophic levels. Although whole fish contamination is primarily an indicator of exposures in piscivorous wildlife, these data are also useful for estimating potential human exposures via this route. In brief, a subset of 60 whole fish homogenates from 10 sites on each of three major river systems in the United States (Upper Mississippi, Missouri and Ohio Rivers) were analyzed for PFCs. This subset was subjectively chosen from the EMAP-GRE probabilistic design of fish homogenates to get a spatially representative sample from each of the three rivers. Methods development, validation data, and preliminary study results will be discussed.

Disclaimer: Although this work was reviewed by EPA and approved for publication, it may not necessarily reflect official Agency policy.

P-10 **Method Development for the Determination of Perfluorinated Organic Compounds (PFCs) in Surface Water**

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Perfluorinated organic compounds (PFCs) have been manufactured world wide and used for more than 50 years. Concern over these compounds is due to recent studies showing some PFCs are toxic, carcinogenic, bioaccumulative, and persistent. Perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) are the best known PFCs, but there are a number of other PFCs that have been produced. Little information has been published about the distribution of these compounds in the environment or how humans are exposed. The most comprehensive research is a series of studies from Japan that suggest contamination of surface waters and related drinking water supplies may contribute to exposure. To determine the environmental distributions of these materials in the U.S., a method for the determination of the PFCs has been developed and used to characterise surface water samples from the Cape Fear River Basin in North Carolina, USA, in the spring of 2006. One litre water samples were collected, spiked with internal standards, and run through Oasis HLB using a positive pressure loading pump. The PFCs were then eluted with methanol, concentrated, and analysed via LC/MS/MS equipped with Wakopak Fluofix column. Quantification for C6–C12 perfluorinated carboxylic acids and C4–C8 sulfonates was performed using a 6-point standard curve prepared with deionised water. To ensure method precision and accuracy, quality control samples and travel blanks were analysed simultaneously. The method detection limit was 1 ng/L for all compounds with precision and accuracy being ±16% and within 100±15%, respectively. These PFCs were found in most samples with total PFC concentrations ranging from 1.64 to 942 ng/L. The variations in

concentration and distinctive patterns of the different PFCs found in various parts of the basin will be discussed.

P-11 **Method Development for the Determination of Perfluorinated Compounds in Human Urine**

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There is increasing research focusing on and public interest in perfluorinated compounds (PFCs), including perfluorooctanoic acid (PFOA), perfluorooctane sulfonate (PFOS), and other structurally related analogues, primarily because they are bioaccumulative, persistent, and toxic. To explore the possibility of a non-invasive way to assess human exposures to these materials, a new method has been developed and evaluated for the quantitation of trace levels of 10 PFCs in human urine. In preliminary studies using a synthetic human urine analogue, the limit of quantitation (LOQ) was determined as 1–2 ng/L with precision and accuracy ranging from 5%–16% and 75%–125%, respectively, for all compounds. The application of this method using human urine samples will be presented at the conference. The ability to detect and quantify these compounds in human samples may be a significant new tool for the non-invasive biological monitoring of PFC exposure. Application of this method in human studies will be of great interest for physiologically-based pharmacokinetic modelling efforts which are intended to describe the disposition of these materials in humans. This study is the first report of a method for the measurement of PFCs in human urine. The lower limit of quantitation (LLOQ) was determined to be 1–2 ng/L for all targeted compounds by computing the standard deviation of a series of injections of the lowest possible standard in synthetic urine and multiplying the standard deviation by ten. The matrix matched recoveries ranged from 55%–105% with less than 10% of relative standard deviation (RSD) for all compounds. Method accuracy, based on the nominal values of the QC samples, ranged between 75%–125%. The coefficient of correlation of each calibration curve was greater than or equal to 0.99 for all compounds, with a linear range from 1 or 2 ng/L to 200 ng/L (compound specific). These method performance characteristics indicate that the method provides sufficient reliability for use in the analysis of perfluorinated alkyl compounds in human urine.

P-12 **Method Development for the Analysis of PFOA in Gestationally Exposed Mice – Serum, Urine, Amniotic Fluid, and Whole Pups**

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Perfluoroalkyl acids (PFAAs) have received growing attention because of their widespread environmental and biological presence. One PFAA, perfluorooctanoic acid (PFOA), has been subject to increased scrutiny because of its detection in human blood samples from around the world. Recent studies with mice have shown that dosing pregnant dams with PFOA during gestation gives rise to a dose-dependent mortality in the litters, reduction in neonatal body weight for the surviving pups, and subsequent deficits in mammary gland development in comparison to controls. The actual body burdens of PFOA in dams and pups that are associated with these endpoints have not been determined, in part due to lack of robust analytical methods for these matrices. Such information would be very helpful in reducing the uncertainties of the risk assessment process. In order to do a more thorough evaluation of the pharmacokinetics in utero, pregnant CD-1 mice were dosed with PFOA at concentrations of 0.1 mg/kg, 1.0 mg/kg, and 5.0 mg/kg body weight on gestation day 17, with dam and pup serum, urine, amniotic fluid, and whole mouse pups being isolated for method development and analysis. The analytical methods and performance data are presented here. Preparation of mouse serum and amniotic fluid involved

the addition of formic acid, followed by the addition of acetonitrile to precipitate proteins. Mouse urine was diluted with formic acid and extracted using solid-phase extraction (SPE) with Waters™ weak anion exchange (WAX) cartridges. For whole pup samples, the weighed pups were homogenized and digested with 0.01 M NaOH in methanol. Cleanup was preformed by SPE with WAX cartridges using methods previously established for other biological matrices. Extracted samples were analyzed using Waters Acquity™ Ultra Performance LC interfaced with a Waters Quattro Premier XE triple quadrupole mass spectrometer (UPLC-MS/MS). The resulting methods provide excellent accuracy (100 ± 10%) and reproducibility (coefficient of variance between 2 and 15%) and will be used for future measurements. Tissue specific measurements of PFOA in serum, urine, amniotic fluid, and whole pup homogenate will be used to more completely describe the dose-response relationships for the most sensitive health outcomes and inform pharmacokinetic models that are being developed and evaluated.

P-13 **Interrogating the Interactions of Perfluorinated Carboxylic Acids in Human Blood Using Nuclear Magnetic Resonance (NMR) Spectroscopy**

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Unlike traditional organic pollutants that accumulate in lipid-rich adipose tissue, perfluorinated sulfonic acids (PFSAs) and perfluorinated carboxylic acids (PFCAs) accumulate in proteineous tissues such as the blood, liver and kidneys. Human PFCA contamination is relevant as perfluorooctanoic acid (PFOA) is detected in sera from the North American population at about 5 ng/mL (1). At concentrations of about 40 mM, serum albumin is the most prevalent protein in blood and the most likely site for PFCA interactions in blood. Previous studies have characterized interactions between PFSAs and PFCAs with serum albumin using mass spectrometry and binding assays (2, 3). In this study we wanted to expand upon this understanding using nuclear magnetic resonance (NMR) spectroscopy to observe the interaction PFCAs in human sera without isolation or prior treatment of the sample. We used saturation transfer difference NMR (STD-NMR) to determine the major site of interaction for perfluorohexanoic acid (PFHxA) and perfluorooctanoic acid (PFOA) in human sera. This technique works by irradiating a component of the mixture, this component then becomes saturated and transfers some of this energy to species in close contact, which are subsequently detected. Using STD-NMR we were able to identify serum albumin as the major site of interaction for PFHxA and PFOA in human sera. We were also able to identify the orientation of PFHxA and PFOA in the serum albumin binding sites. Both PFCAs were positioned with their fluorinated tails in the binding site and their carboxylate heads pointed towards the surface. This position suggests that PFCAs are interacting with the fatty acid binding sites on serum albumin, which x-ray crystallography has shown contain hydrophobic pockets with cationic surface sites (4). The interactions described here may help understand the pharmacokinetics of PFCA accumulation in human sera.

(1) Calafat, A. M.; Kuklenyik, Z.; Caudill, S. P.; Reidy, J. A.; Needham, L. L. Perfluorochemicals in pooled serum samples from United States residents in 2001 and 2002. Environ. Sci. Technol. 2006, 40, 2128-2134.

(2) Jones, J. D.; Hu, W.; De Coen, W.; Newsted, J. L.; Giesy, J. P. Binding of perfluorinated fatty acids to serum proteins. Evnviron. Toxicol. Chem. 2003, 22, 26392649.

(3) Han, X.; Snow, T. A.; Kemper, R. A.; Jepson, G. W. Binding of perfluorooctanoic acid to rat and human plasma proteins. Chem. Res. Toxicol. 2003, 16, 775-781.

(4) Bhattacharya, A. A.; Grune, T.; Curry, S. Crystallographic analysis reveals common modes of binding of medium and long-chain fatty acids to human serum albumin. J. Mol. Biol. 2003, 303, 721-732.

P-14 Bioaccumulation and Biortransformation of 8:2 FTOH Acrylate

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In recent years perfluorinated carboxylates (PFCAs) and sulfonates (PFSAs) have received a great deal of scientific and regulatory attention. This is due, in part, to their apparently ubiquitous global presence in wildlife, including those from remote regions. However, the source of PFCAs and PFSAs is not fully understood. Recent studies have shown that precursor compounds can be biotransformed by rats and microbes to yield PFCAs and PFSAs. One potential precursor is the 8:2 fluorotelomer acrylate (8:2 FTOH acrylate), a common monomer used in fluorotelomer based polymers. Fluorotelomer based polymers are incorporated into many commercial products for their hydrophobic and lipophobic properties. The present study investigated whether the 8:2 FTOH acrylate could be bioaccumulated and subsequently biotransformed to PFCAs by rainbow trout. Juvenile rainbow trout were purchased from a local hatchery and exposed to the 8:2 FTOH acrylate via commercial fish food dosed at a concentration of 93 μg/g. Fish were fed the dosed food during the five day uptake phase and fed clean food during the 8 day depuration phase. Tissues were analyzed for the parent compound as well as suspected metabolites. The intermediate metabolites, 8:2 saturated and unsaturated telomer acids (8:2 FTCA & 8:2 FTUCA) and 7:3 FTCA, were observed within 1hr of dosing. Perfluorooctanoate (PFOA), the terminal metabolite was observed with 4hrs of dosing. These results indicate that 8:2 FTOH acrylate was rapidly taken up and biotransformed by the fish. In an additional experiment, fish were dosed with the intermediate metabolites, separately, in order to elucidate the metabolism mechanism.

P-15 Biodegradation of Polyfluoroalkyl Phosphate Surfactants as a Source of Perfluorinated Carboxylic Acids and Fluorotelomer Acids

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The widespread occurrence of perfluorinated carboxylic acids (PFCAs) has raised public awareness due to their bioaccumulative properties, potential toxicity in humans and animals, and environmental persistence. In addition to production plants as direct sources, an alternative route of exposure is the release of PFCA precursors, such as fluorotelomer alcohols (FTOHs), that are either present as residuals or as degradation products from the breakdown of fluorotelomer-based products. One example of these fluorotelomer-based compounds is the polyfluoroalkyl phosphate surfactant (PAPS)[1], commonly used as grease resistants in food packaging paper and as anti-foaming additives in pesticides. Concern for these compounds as potential PFCA sources via degradation is implied in the recent U.S. EPA revocation of the tolerance for perfluoroalkyl phosphates as inert ingredients in pesticide formulations in 2006.[2] To date, knowledge of PAPS degradation is limited to one study where rat metabolism of the 8:2 FTOH mono- and diPAPs showed that their phosphate ester linkages are biologically labile and hence, both congeners may be biotransformed into 8:2 FTOH, and ultimately, to PFCAs and other FTOH metabolites.[3] What has not yet been fully explored is the potential for PAPS to be microbially degraded and the current investigation demonstrated the biodegradation of 8:2 monoPAPS using activated sewage sludge from a local wastewater treatment facility. A purge-and-trap system coupled to gas chromatography-mass spectrometry was employed to monitor the production of 8:2 FTOH which leveled off at day 44, resulting in 19% transformation of 8:2 monoPAPS in the 72-day experiment. The effect of the length of the singly-chained monoPAPS on the lability of the ester linkage was also probed in which 4:2, 6:2, 8:2, and 10:2 monoPAPS were simultaneously subjected to microbial hydrolysis as in the previous experiment. Results showed that the 4:2 congener was produced the fastest and at the highest level, followed by 6:2 FTOH, then 8:2 FTOH, and finally 10:2 FTOH, suggesting that the microbial cleavage of the P-O bond in monoPAPS was sterically controlled by chain length. As FTOH has been shown to be a prevalent source of PFCAs,[4] the

biodegradability of PAPS to FTOH shown here confirms the compound as a likely contributor to the load of PFCAs in the environment.

1. General structure of PAPS: $(R_fCH_2CH_2O)_xP(O)(OH)_y$ where R_f is a perfluorinated chain containing 1-10 carbons; x = 1 or 2; y = 1 or 2; and x + y = 3
2. U.S. EPA. Mono- and bis-(1H, 1H, 2H, 2H-perfluoroalkyl) phosphates where the alkyl group is even numbered and in the C6-C12 range; Proposed Revocation of Pesticide Inert Ingredient Tolerance Exemption; U.S. EPA public Docket OPP-2006-0253; Washington, DC, 2006.
3. D'eon, J.; Mabury, S.A. Production of perfluorinated carboxylic acids (PFCAs) from the biotransformation of polyfluoroalkyl surfactants (PAPS): Exploring routes of human contamination. Environ. Sci. Technol. 2007, 41, 4799-4805.
4. Dinglasan, M.J.A.; Ye, Y.; Edwards, E.A.; Mabury, S.A. Fluorotelomer alcohol biodegradation yields poly- and perfluorinated acids. Environ. Sci.

P-16 **Modeling Single and Repeated Dose Pharmacokinetics of PFOA in Mice**

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Perfluorooctanoic acid (PFOA) displays complicated pharmacokinetics in that plasma serum concentration indicates a long half life – 3.8 years in humans (Olsen et al. 2007) – but also rapidly achieves steady-state (Lau et al., 2006). Attempts to address this have included using different pharmacokinetic parameters for different doses (Washburn et al., 2005, Trudel et al., 2008) as well as biologically-based models such as the saturable resorption model of Andersen et al. (2006). We examined plasma concentration time-courses for female CD1 mice after single, oral doses of 1, 10, and 60 mg/kg of PFOA. We found that the pharmacokinetics for the two lower doses are well-described by an empirical, one-compartment model. The predictions for that model are not, however, consistent with the 60 mg/kg data which was instead found to be consistent with a two-compartment model that was in turn inconsistent with the two lower doses. We then examined plasma concentrations observed after 7 and 17 daily doses of 20 mg/kg PFOA from Lau et al. (2006) as well as additional 17-day studies. The 1 and 10 mg/kg one-compartment fit was not consistent with repeated dose concentrations while the 60 mg/kg two-compartment was. We found that some level of consistency between low and high doses could be achieved using the saturable resorption model of Andersen et al. (2006) in which PFOA is cleared from the plasma into a filtrate compartment from which it is either excreted or resorbed into the plasma by a process with a Michaelis-Menten form. A maximum likelihood estimate found a transport maximum of T_m = 860.9 (1298.3) mg/L/h and half-maximum concentration of K_T = 0.0015 (0.0022) mg/L where the estimated standard errors (in parentheses) indicated large uncertainty. The estimated rate of flow into and out of the filtrate compartment, 0.6830 (1.0131) L/h was too large to be consistent with a biological interpretation of the filtrate. For these model parameters we estimated that a single dose greater than 40 mg/kg, or a daily dose in excess of 5 mg/kg were necessary to observe non-linear pharmacokinetics for PFOA in female CD1 mice. This work was reviewed by EPA and approved for publication but does not necessarily reflect official Agency policy.

P-17 **Modeling the Pharmacokinetics of Perfluorooctanoic Acid During Gestation and Lactation in Mice**

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Perfluorooctanoic acid (PFOA) is used as a processing aid for the production of commercially valuable fluoropolymers and fluoroelastomers. It has been widely detected in biological organisms including humans whose estimated blood levels are in the low ppb levels for the general US population. PFOA is metabolically stable and exhibits a plasma half-life of 3-5 years in humans. In mice, PFOA induces developmental toxicity in the form of full litter resorption, compromised postnatal survival, delayed growth and development, and altered pubertal maturation. While some postnatally observed developmental effects have been attributed to gestational exposure, it remains to be elucidated whether these result from a higher internal dose (pharmacokinetics) and/or exposure during a developmentally sensitive period (pharmacodynamics). To address the pharmacokinetics of PFOA during gestation and lactation, a biologically-supported dynamic model was developed. A two compartment system linked via placental blood flow described gestation, while milk production linked the dam to a pup litter compartment during lactation. Mathematical functions described the growth of the dam, conceptus, placental blood flow, and nursing pups. Serum:fetal and serum:milk partition coefficients and milk production were estimated from published literature. Absorption and elimination were described as 1st order processes. The model reasonably simulated reported serum levels in non-lactating and lactating dams as well as nursing pups. Lactation is predicted to be an important clearance pathway for the dam and correspondingly a major source of exposure for the nursing pups. However, developmentally sensitive periods may render gestation more important toxicologically. The incorporation of renal resorption was necessary to simulate the non-linear behavior of serum levels in the adult non-pregnant mouse, especially at doses > 1mg/kg/day at which full-litter resorption occurs in the pregnant mouse.

These analyses indicate that a linear pharmacokinetic model may be appropriate in the analysis of gestational and lactational exposures to doses of PFOA ≤ 1 mg/kg/day, though this may be dependent on strain and toxicological endpoint.

These modeling efforts provide an initial template for further explorations of the pharmacokinetics of PFOA relevant to one-generation toxicity studies.
(This work does not reflect official Agency policy).

P-18 **8-2 Fluorotelomer Alcohol: Liver Glutathione Status, Metabolite Kinetics in Tissues, and Excretion and Metabolism with Daily Oral Dosing**

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Male and female rats were administered 8-2 Fluorotelomer Alcohol (8-2 FTOH) by oral gavage for 45 days and livers collected periodically to evaluate glutathione status, and samples of liver, kidney, fat, thyroid, bone marrow, thymus, skin and plasma were analyzed for 8-2 FTOH and perfluorinated metabolites. On day 46, conditioned and naïve rats were administered [^{14}C]8-2 FTOH and sacrificed 1-2 hours post dose to determine the percent of covalently bound radioactivity in liver, kidney and plasma. Also, conditioned rats were administered [^{14}C]8-2 FTOH, maintained for 7 days, sacrificed and a complete material balance performed along with metabolite identification in excreta and tissues. Lastly, selected tissues and excreta were processed with DNPH and screened by LC/MS for aldehyde and ketone metabolites. Overall, liver glutathione was unaffected by daily oral 8-2 FTOH administration. The most ubiquitous metabolites in tissues were 7-3 Acid and PFO; 8-2 FTOH had the greatest concentration in fat and most metabolites exhibited steady-state concentration by day 25. There were no differences in the percent of covalently bound radioactivity in naïve and conditioned rats. Following a single

oral dose of [^{14}C]8-2 FTOH, ≥74% was eliminated in the feces, which contained primarily 8-2 FTOH. Urine was a minor elimination pathway and contained PFO, 7-2 secondary FTOH-glucuronide and 8-2 unsaturated FTOH N-acetyl cysteine (females only). The greatest percentage of the administered dose was found in the liver, fat and skin; in liver, the principle metabolites were PFO, PFN, 8-2 FTOH-sulfate and 7-3 Acid (males only). In the kidney, PFO (males only) and 8-2 FTOH-sulfate (females only) was observed, and in plasma, 7-3 Acid, PFO and 8-2 FTOH-sulfate (females only) was detected. DNPH-derivatized tissues/excreta confirmed the presence of 7-2 Ketone, 7-3 aldehyde and 7-3 unsaturated aldehyde. These results provide a comprehensive evaluation of 8-2 FTOH pharmacokinetics and metabolism following sub-chronic exposure in the rat.

P-19 **Comparative in silico modeling of environmental and therapeutic classes of Perfluorinated Chemicals (PFCs): ADME properties, virtual receptor profiling and generalized PBPK models**

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Perfluorinated chemicals (PFC) have unique physicochemical/biological properties that have historically made them amenable to numerous industrial and biomedical applications. Therapeutic class PFCs used in prosthetics, contrasting agents, artificial blood replacements and partial liquid ventilation have low toxicity (NOEL > g/kg), resist metabolic degradation and form stable micelles that remain intact in vivo with short serum half-lives. Furthermore, the pharmacokinetic behavior, elimination routes, and benign histopathology of various tissues exposed to these chemicals are well documented. On the other hand, the environmentally persistent PFCs that are by-products of perfluorotelomer industries have significantly higher potencies (i.e., NOEL < mg/kg) longer serum half-life, and have been implicated with multiple adverse effects endpoints with attributable risk down to the molecular level. Yet, despite the multitude of in vivo and in vitro studies revolving primarily around PFOA/PFOS (C8/C7), much remains to be learned from studying congeneric PFAAs so that the biological disposition and effects may be extrapolated on a molecular structural level: In silico methods are ideal candidates to explore receptor binding, PBPK and ADME property relationships on such a basis.

Using both established 2D-physicochemical descriptors in addition to predicted ADME properties generated by 3D-QSAR models in Epiwin (US-EPA) and QikProp (Schrodinger Inc.) respectively, we built generalized PBPK models (Cahill et al Env Tox & Chem, 22(1): 26-34) to compare and contrast the differences in biological disposition and elimination profiles of "environmental" (~20 chemicals) and "therapeutic" (14 chemicals) classes of PFCs on the basis of molecular structure. In addition we performed multiple-target molecular docking profiles using eHiTS (Simbiosys Inc.) whereby the 3D structure of the PFCs and an additional 135 PPAR-□□ high affinity ligands from kibank (http://kibank.iis.u-tokyo.ac.jp/) were independently docked into 151 unique biological targets (comprised of nuclear receptors, oxidoreductases, kinases, phosphatases, lipid carrier proteins and serum proteins). Docking provides 3D coordinates of the ligand molecules bound to a given receptor and the scores are surrogates for the magnitude of their mutual interaction. The multiple-target scores were subsequently analyzed using (1) PCA and (2) hierarchical cluster analysis in Partek. In addition chemical-receptor linkage maps were generated in CytoScape. These analyses have provided additional insight on target selectivity and specificity (a) in comparison to other known chemicals (b) as a function of chain length and (c) as a result of structural features.

Both the data and analyses provide alternative (in silico) approaches to deal with multi-dimensional data on a comparative basis and how in turn such studies may be used in rapid and rational hypothesis generation, development of new structure-activity relationships and discovery

toxicology in general for PFCs.[This work was reviewed by EPA and approved for publication but does not necessarily reflect official Agency policy.]

P-20 **Consequences of Prenatal PFOA Exposure on Mouse Mammary Gland Growth and Development in F1 and F2 Offspring**

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Perfluorooctanoic acid (PFOA) is a known developmental toxicant with ubiquitous presence in industrial applications and the ambient environment. We previously reported that prenatal PFOA exposure results in delayed development of the mouse mammary gland (MG) in F1 female offspring. To determine consequences of this delayed MG development on lactational function and subsequent development of F2 offspring, F1 females exposed transplacentally to 0, 1 or 5 mg PFOA/kg/day (control, 1P, 5P; gestation days 1-17), were bred to generate F2 offspring (no direct exposure to PFOA). F2 offspring were monitored for growth and development from postnatal day (PND) 1-22, and F1 dam MG function was assessed on PND10 by lactational challenge. MG tissue was isolated from both F1 and F2 females at necropsy on PND10 and 22, and scored for age-appropriate development on a 1-4 scale. As hypothesized, MG morphological scores were lower ($p<0.05$) in 1P and 5P F1 dams evaluated on PND10, and in 5P F1 dams on PND22. However, no effect of treatment on milk production (volume after 30-min nursing) or maternal behavior (time to initiate nursing) was detected on PND10. Body weight of F2 pups was similar between groups on PND1-10, however, starting on PND14 and persisting through PND22 body weight of 1P F2 offspring was significantly higher than controls. MG developmental scores in F2 pups were similar to control at PND10, but lower among P5 F2 offspring on PND22. The time of eye-opening was similar in all groups. These findings confirm previous PFOA-induced delays in lactating mammary gland differentiation, with a current LOEL for these effects at 1 mg/kg/d, and suggest that these delays have little, if any, deleterious effects on the F2 offspring early in life; further evaluation of F2 offspring will illuminate whether adverse health effects may result in adult life. (This abstract does not necessarily reflect EPA policy; SSW funded by EPA CR833237, NIH T32 ES007126.)

P-21 **Differential Effect of Peripubertal Exposure to Perfluorooctanoic Acid on Mammary Gland Development in C57Bl/6 and Balb/c Mouse Strains**

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Perfluorooctanoic acid (PFOA) is a chemical widely used in the production of fluoropolymers for making numerous industrial and consumer products. PFOA is one of the most common persistent organic pollutants in environment, and its presence in humans and wildlife has raised considerable health concerns. Toxicological studies have found that PFOA is an agonist for peroxisome proliferator-activated receptor (PPAR) and causes Leydig cell adenomas, mammary fibroadenomas and liver cancer in rats. While exposure to PFOA throughout gestation induces general developmental toxicity in rats and mice, offspring of mice exposed during gestation to low dose PFOA display a defect in mammary gland development resulting in stunted mammary ductal growth and branching at postnatal day 10 and 20. The peripubertal period is an important window of susceptibility to environmental exposures that may predispose humans to increased breast cancer risk later in life. Nothing is known about the effect of peripubertal PFOA exposure on mammary gland development. Thus, our current studies have examined PFOA-induced effects on pubertal mouse mammary gland development in Balb/c and C57Bl/6 mice. We found that the effects of PFOA exposure differed significantly between the two mouse strains.

Three-week old female Balb/c and C57Bl/6 mice were given PFOA by oral gavage 5 times per week for 4 weeks. The dosages were 0 (vehicle control), 1, 5, or 10 mg PFOA/kg BW. Mammary glands, livers and uteri were collected for histological examination. A significant decrease in BW was observed only at 10 mg/kg dose. Dose dependent increases of relative liver weight were detected in both strains of mice and increased to a greater extent in C57Bl/6 mice. Liver histopathology revealed that the principal morphologic alteration in the livers of both strains of mice was a dose-dependent hepatocellular hypertrophy. However, at each dose the extent and severity of the lesions were greater in C57Bl/6 mice. PFOA treatment caused a significant and dose-dependent decrease of relative uterine weight in Balb/c mice. In contrast, the 1 mg/kg PFOA dose significantly increased the relative uterine weight in the C57Bl/6 mouse strain whereas the 10 mg/kg PFOA dose caused a significant decrease in relative uterine weight. PFOA treatment inhibited mammary gland growth in a dose dependent manner, as evidenced by reduced duct length and decreased numbers of end buds, in the Balb/c strain. However, in striking contrast, PFOA treatment in the C57Bl/6 strain resulted in a significant increase in end bud number, generalized mammary gland stimulation and no inhibition of ductal growth. This effect was maximal at the 5 mg/kg dose. An inhibitory effect on mammary gland development was seen at the 10 mg/kg dose. A dose dependent effect causing delayed vaginal opening was also observed in both strains.

In summary, pubertal PFOA exposure causes hepatocellular hypertrophy and delayed vaginal opening in both mouse strains. However, the effects of PFOA on the uterus and mammary gland were significantly different between the two mouse strains. In the Balb/c mice there was a dose dependent inhibitory effect whereas in the C57Bl/6 strain there was a stimulatory effect on the mammary gland and uterus at low doses and an inhibitory effect of a high dose. The molecular basis for the differential responses of two mouse strains to pubertal PFOA exposure is not known. Whether PFOA affects mouse mammary gland development through a direct or indirect mechanism remains to be determined. Importantly, the finding of the striking differences in the effect of pubertal PFOA exposure on mammary gland and uterus in two genetic backgrounds in the same species suggest that caution should be used when drawing conclusions about the effects of PFOA on a given target tissue on the basis of studies in a single mouse strain. (This study was supported by the Breast Cancer and the Environment Research Center Grant 1-UO1 ESO12800 01 from National Institute of Environmental Health Sciences).

P-22 **Prenatal Exposure to Perfluorooctane Sulfonate or Perfluorononanoic Acid Increases Blood Pressure in Adult Sprague Dawley Rat Offspring**

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The long term health effects of exposure to environmental chemicals during pregnancy have been identified as a significant data gap by several reproductive and developmental toxicology working groups over the past decade. In response, we have established a program to investigate the long-term adult health effects of adverse intrauterine environments induced by environmental chemical exposure. We have incorporated perfluorooctane sulfonate (PFOS) and perfluorononanoic acid (PFNA) as chemicals in this program due to their considerable interest to the U.S. EPA and/or their well defined toxicological effects following developmental exposures. Through the program's broad investigation into adverse adult health effects following prenatal exposures to environmental chemicals, an increase in systolic blood pressure has emerged as a consistent response with the majority of test chemicals. In this poster we will present systolic blood pressure findings in offspring of pregnant rats exposed to PFOS or PFNA, and investigations into potential modes of action.

Timed-pregnant Sprague Dawley rats were treated by oral gavage with either PFOS (18.75 mg/kg in 0.5% Tween-20, gestation day (GD) 2-6) or PFNA (5 mg/kg in water, GD 1-20). Exposure concentration, duration and gestational periods were selected based upon previous research demonstrating either some maternal toxicity and/or a decrease in offspring birth weight.

Corresponding vehicle and Dexamethasone (Dex) (subcutaneous injection of 0.6 mg/kg in water, GD 16-20) exposures were included as negative and positive controls, respectively. At birth, PFOS, PFNA and Dex treated pups were fostered to untreated control dams, while pups from vehicle-treated control dams were cross-fostered within this group. Systolic blood pressure was measured at several timepoints between 7-54 weeks of age using non-invasive tail cuff photoplethysmography.

Exposure to either of the perfluouroalkyl acids or Dex caused a reduction in maternal body weight gain during their respective exposure periods. A reduction in birth weight was evident in all treatment groups, reaching statistical significance in offspring of PFNA- and Dex-exposed dams. Catchup growth occurred and by weaning on postnatal day 21, no differences in body weight were apparent among the groups. Systolic blood pressure was elevated by 10-15 mmHg as early as 7-10 weeks of age in male offspring in all treatment groups when compared to the negative controls. Female offspring in the PFNA group demonstrated elevations in systolic blood pressure as early as 10 weeks of age, while PFOS and Dex female offspring showed an increase at 37 weeks of age, the next testing period. These results suggest that programming of systolic blood pressure in juvenile and adult rats can be altered by prenatal exposure to PFOS or PFNA. We are currently completing evaluations of key pathways involved in blood pressure regulation and programming, including glucocorticoid and renin-angiotensin-aldosterone system components and kidney nephron endowment. This abstract does not reflect EPA policy.

P-23 **Adult Outcomes of Gestational or Adult Exposure to Perfluorooctanic Acid (PFOA) in Female CD-1 Mice**

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PFOA, an environmentally persistent chemical detected in humans and wildlife, is a surfactant with wide consumer and industrial applications. Developmental exposure to PFOA is associated with decreased body weight in neonates as well as other later life effects. This study addresses whether prenatal exposure to PFOA also leads to adult weight gain and changes in organ weights. Timed pregnant CD-1 mice (n>30 per dose group) were exposed to PFOA (0.01, 0.1, 0.3, and 1 or 5 mg/kg/day) via oral gavage over days 1 to 17 of pregnancy. At post-natal day 1 (PND1), litter weights were recorded and the 5 mg/kg litters weighed significantly less than control animals. At 18 months, the animals were sacrificed and body weight, organ weight, and fat weights recorded. There was a significant increase in both body weight (0.01, 0.1, and 1 mg/kg) at 20-29 weeks and intrasubscapular brown fat in the 1 and 3 mg/kg PFOA group at 18 months when compared to control animals. Liver, spleen, abdominal white fat and liver to body weight ratio were not significantly different in any of the treatment groups. A subset of the gestationally exposed females ovariectomized (ovx) at PND21 were followed concomitantly with the intact animals. The body weights of these ovx animals showed no significant difference versus intact animals when compared within dose groups. A final group of age-matched females were dosed as adults (0, 1, 5 mg/kg PFOA) for 17 days and followed out to 18 months. These adult exposed animals showed no significant increase in body weight and no significant changes in organ or fat weight at 18 months when compared to controls. These data show a critical window of exposure to PFOA leads to increased weight gain as an adult. Whether increased body weight associated with prenatal PFOA exposure is associated with other health effects later in life is under investigation. (This abstract does not necessarily reflect EPA policy.)

P-24 **Sodium Perfluorohexanoate: Oral Repeated Dose Subchronic, One-Generation Reproduction, Genotoxicity and Developmental Toxicology**

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Sodium perfluorohexanoate (PFHxNa) was evaluated in subchronic, one-generation reproduction, genotoxicity, and developmental toxicity studies. In the subchronic/one-generation reproduction study, four groups of young adult male and female Crl:CD(SD) rats were administered PFHxNa daily by gavage at dosages of 0, 20, 100, or 500 mg/kg/day. Rats were dosed for 90 days and evaluated after one- and three- month recovery periods. In the developmental study, time-mated female rats were dosed via gavage on GD 6-20 with the same doses of PFHxNa used in the subchronic study. On GD-21 rats were euthanized and fetuses were examined for soft tissue and skeletal alterations. The NOAEL for subchronic toxicity was 20 mg/kg/day, based on nasal lesions observed at 100 and 500 mg/kg/day. The relevance to humans is unknown. The NOAEL for reproductive toxicity was 500 mg/kg/day, the highest dose tested. No test substance-related effects were observed on reproductive parameters. The NOEL for P_1 adult rats was 20 mg/kg/day (reduced body weight/gains in males at 100 mg/kg/day). The NOEL for F_1 offspring was 100 mg/kg/day (reduced pup weights during lactation at 500 mg/kg/day). The NOEL for F_1 adults was 100 mg/kg/day, (reduced body weight/gains in F_1 males and females and reduced food consumption in F_1 adult males at 500 mg/kg/day). Genotoxicity studies of PFHxNa indicated no mutations in the bacterial reverse mutation assay or chromosome aberrations in human lymphocytes. In the developmental study, there were no test substance-related deaths or gross findings in the dams at any dose. The NOEL for the developmental study was 100 mg/kg/day (maternal toxicity observed as decreased body weight and food consumption and developmental toxicity based upon decreased fetal weights was observed in rats administered 500 mg/kg/day). PFHxNa is therefore concluded not to present a reproductive or developmental hazard. The lowest NOEL representing all of the studies described above was 20 mg/kg/day.

P-25 **Effects of Perfluorobutyrate on Thyroid Hormone Status in Rats**

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Perfluorobutyrate (PFBA) is a perfluorinated carboxylate that has been shown to be a peroxisome proliferator activated receptor alpha (PPARα) agonist. Subchronic (28 d and 90 d) oral studies at doses up to 150 mg/kg-d produced adaptive effects in male rats that included increased hepatocellular hypertrophy and increased minimal-mild hypertrophy/hyperplasia of the thyroid follicles. These effects were accompanied by hypothyroxinemia without elevation of thyrotropin (TSH). We investigated the hypothesis that PFBA, like some other PPARα agonists, for example, free fatty acids and aspirin, may compete for binding with thyroxine (T4), and increase peripheral tissue turnover of T4.

Experiments evaluated: 1) potential for in vitro binding displacement of T4 by PFBA; 2) potential in vivo binding displacement of T4 by PFBA (time-course and relation to serum PFBA concentration); 3) disposition of ^{125}I from ^{125}I-labelled T4 on dosing with PFBA in vivo; and 4) expression of marker genes for thyroid hormone (TH) response in liver by quantitative RT-PCR.

Results demonstrated that: 1) PFBA does compete with T4 for binding in serum in vitro; 2) total T4 was decreased, free T4 increased, and TSH decreased within 2 hours after a single dose of PFBA, and homeostasis was regained within 72 hours corresponding to PFBA serum concentration; 3) ^{125}I excretion in feces was increased by PFBA treatment; and 4) expression of marker genes for TH response did not suggest hypothyroid status.

Conclusion: PFBA increases thyroid hormone turnover and transiently increases free T4. Therefore, PFBA, like some other PPARα agonists, may act as a thyroid-displacement compound.

P-26 **Comparison of the Activities of Carboxylates and Sulfonates of Perfluoroalkyl Acids (PFAA) of Various Carbon Chain Lengths on Mouse and Human Peroxisome Proliferator-Activated Receptor-Alpha (PPARα) in COS-1 Cells**

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PFAAs are used in consumer products and persist in the environment. They elicit adverse effects on rodent development and neonatal survival, and may act via PPARα to produce some of their effects. The induction of mouse and human PPARα activity by perfluorinated carboxylic acids (PFCAs) and perfluorinated sulfonic acids (PFSAs) of various carbon chain lengths was tested using a transiently transfected COS-1 cell assay. COS-1 cells were transfected with either a mouse or human PPARα receptor luciferase reporter plasmid. After 24 hours, cells were exposed to either vehicle control (DMSO [0.1 %]), PPARα agonist (WY14643, [10 μM]), PFAA vehicle control (water or DMSO [0.1 %]); perfluorooctanoic acid (PFOA) or perfluorononanoic acid (PFNA) at 0.5-100 μM; perfluorobutanoic acid (PFBA), perfluorodecanoic acid (PFDA), or perfluorohexanoic acid (PFHxA) at 5-100 μM; perfluorohexane sulfonate (PFHxS) at 5-100 μM; or perfluorobutane sulfonate (PFBS) or perfluorooctane sulfonate (PFOS) at 1-250 μM. After 24 hrs of exposure, PPARα plasmid luciferase activity was measured. Lowest observed effects concentration (LOEC) was determined by ANOVA ($p < 0.05$). Each of the PFAAs activated the mouse and the human PPARα plasmid in a concentration dependent fashion, except PFDA, which did not activate human PPARα plasmid at any concentration. Activation of both mouse and human PPARα was positively correlated with carbon chain length, for PFBA (C4), PFHxA (C6), and PFOA (C8). PFDA (C10) induced high activity in the mouse PPARα plasmid (LOEC, 5 μM). PFOA produced a biphasic dose-response with a plateau at high doses. PFSAs generally induced lower activity of mouse and human PPARα compared to PFCAs. We have found that PFCAs of different chain lengths induce activity of the mouse and human PPARα differently, and that PFSAs are weaker activators of mouse and human PPARα than PFCAs. This abstract does not necessarily reflect EPA policy.

P-27 **Development of Health-based Drinking Water Guidance for PFOA**

Gloria Post

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Health-based drinking water guidance for perfluorooctanoic acid (PFOA) was developed in response to a request from a public water supply in New Jersey with PFOA detections. The starting point for the assessment was the USEPA Draft Risk Assessment of the Potential Human Health Effects Associated with Exposure to Perfluorooctanoic Acid and Its Salts (2005) and the USEPA Science Advisory Board (2006) review of this assessment. More recent studies which were not included in the USEPA (2005) draft risk assessment, including studies of developmental effects in mice, were not considered in developing the drinking water guidance. The USEPA draft risk assessment (2005) aimed to evaluate the significance of the exposure of the general population to PFOA and developed margins of exposure (MOEs) in humans compared to LOAELs and NOAELs from animal studies. USEPA (2005) classified PFOA as a suggestive carcinogen, while the SAB (2006) classified it as a likely carcinogen. Since the half-life of PFOA in humans is much longer than in animals, MOEs are based on comparison of animal blood levels and human blood levels rather than administered doses. However, USEPA did not address the relationship between intake of PFOA and blood levels in humans, and this information is needed to develop drinking water guidance. A study of an Ohio community ingesting water contaminated with PFOA indicates that there is a 100-fold concentration factor between PFOA in drinking water and blood (e.g., 1 ug/L in drinking water results in 100 ug/L in blood. Emmett et al., 2006), and

this factor was used to develop health-based drinking water concentrations for the non-cancer and cancer endpoints identified by USEPA (2005). Similar results were obtained by others using the ratio of half-lives of PFOA in humans and experimental animals. The most sensitive endpoints were decreased body weight and hematological effects in a chronic study in female rats, and the guidance value based on this endpoint is 0.04 ug/L. The drinking water concentration based on cancer at the one in one million risk level is 0.06 ug/L. This assessment is available at http://www.nj.gov/dep/watersupply/pfoa_dwguidance.pdf.

P-28 Derivation of Groundwater Standards for Perfluorobutyric Acid (PFBA) and Perfluorooctanoic Acid (PFOA)

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Perfluorochemicals (PFCs) have been found in the groundwater in Washington County, Minnesota. The chemical structures of PFCs make them resistant to environmental degradation. PFCs are very soluble in water but unlike most groundwater contaminants PFCs are slowly removed from the body, with half-life estimates for some PFCs of nearly 9 years. In contrast, the half-life in some laboratory animals is a few hours to a few weeks.

PFCs present unique challenges for risk characterization. The Minnesota Department of Health (MDH) has incorporated new risk characterization approaches to derive health based criteria for PFCs.

MDH evaluates the health risks of contaminated groundwater and establishes human health based values, expressed as micrograms of contaminant per liter of groundwater (µg/L), that represent a level that is without appreciable risk to human health. Historically, noncancer health based values were based on protecting against adverse health effects from long-term exposure and combined an adult intake rate with a chronic reference dose.

However, recent legislative mandates have placed an increasing emphasis on protecting children from environmental exposures due to greater exposure (on a per body weight basis) and mounting scientific evidence to support the vulnerability of the developing fetus and child.

MDH has responded by incorporating a variety of risk characterization approaches recommended by recent US EPA guidance into the process utilized to derive health based criteria. The derivation process includes: 1) assessing evidence of life stage sensitivity; 2) assessing the relationship between the effects observed and duration of exposure; 3) selecting endpoints based on characterization of the entire database rather than the "critical" study; 4) incorporating water intake rates based on age and duration considerations; and 5) comparing the calculated HRL values for different durations to ensure that the final values are protective of human health.

The revised derivation process was used to derive health based criteria for perfluorobutyric acid (PFBA) and perfluorooctanoic acid (PFOA). The derivation process demonstrated that the historic reliance on chronic assessments may not be protective of less-than-chronic exposures. A major challenge encountered in the derivation process involved interspecies extrapolation toxicokinetic issues such as differences in internal dose (serum levels) and estimation of internal dose levels from short duration exposure as well as toxicodynamic issues such as human sensitivity to adverse effects.

A limited number of toxicokinetic and toxicity studies have been conducted on PFBA. The half-life of PFBA in humans has been estimated to be only a few days. Based on this limited data set RfDs for acute, short-term, subchronic and chronic exposure were derived. A corresponding time-weighted water intake rate was estimated for each duration. The resulting calculated health based values were 8, 7, 8 and 10 ug/L for acute, short-term, subchronic and chronic. Longer duration values must be protective of the periods of higher exposure which occur within the longer duration period. Therefore, the final subchronic and chronic health based values were set at the short-term value of 7 ug/L.

Unlike PFBA, the half-life of PFOA in humans is nearly 4 years. The toxicokinetic information necessary to confidently estimate acute, short-term or subchronic RfDs for PFOA which slowly accumulates over time is currently not available. Additional uncertainties include: toxicokinetics in young infants (the most highly exposed population via water ingestion) and pre-existing body burden at birth (PFOA readily crosses the placenta). As a result health based criteria were not derived for acute, short-term or subchronic exposure durations. A human equivalent dose associated with a steady-state serum level was used to derive a chronic health based value of 0.3 ug/L.

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