Incorporating Principles of Industrial Ecology
Room 304 - Session IE-TuM

Methods of Industrial Ecology Analysis / Global Concerns

Moderator: R.L. Bersin, Ulvac Technologies, Inc.

9:00am **IE-TuM3 The 21st Century Co-Evolution of Technology and Environmental Science**, ***T.E. Graedel,*** Yale University **INVITED**

Technology, traditionally seen as the enemy of the environment, is likely to be a positive environmental force in the 21st century, and not only through its application to feed the 8-12 billion people that will occupy the planet. Technology is also likely to be central to improving overall quality of life. Nevertheless, 21st century technology will have to consider the potential environmental impacts of its every action. The process of so doing, termed industrial ecology, is rapidly entering planning, product design, and customer response activities throughout the world. Industrial ecolgoy works in cooperation with environmental science, and incorporates new environmental knowledge in its decision-making processes. The tools of industrial ecology, including life-cycle assessment, design for environment, and materials flow analysis reveal that the potential benefits to both corporations and the environment of optimizing technology-environment interactions are substantial. Some examples of such optimization will be presented and discussed.

9:40am **IE-TuM5 Single Particle Analysis of Particulate Pollutants in Yellowstone National Park and Hawaii Volcanoes National Park**, ***R.E. Peterson,*** *B.J. Tyler,* Montana State University

Particulate pollution is a complex mixture of organic and inorganic compounds which includes a wide range of sizes and whose composition can vary widely depending on the time of year, geographical location, and both local and long range sources. Particles greater than 2 micrometers in diameter are generally formed by mechanical processes while smaller particles are formed by gas to particle conversion and accumulation/coagulation. Because particles smaller than 2.5 micrometers can become trapped deep in the lungs, it is of particular interest to identify toxic substances, such as heavy metals and polyaromatic hydrocarbons, that may be present in particles of this size range. We are evaluating the potential for using TOF-SIMS to study the composition of single particles from atmospheric aerosol. For this study, samples of naturally occurring and anthropogenic atmospheric aerosol were collected at the west entrance to Yellowstone National Park (YNP) during the winter snowmobile season of 1998/99. During the winter snowmobile season, incomplete combustion products from snowmobile exhaust may be a predominant source of airborne particulate matter in YNP. In Hawaii Volcanoes National Park (HVNP), lava flows from the ongoing Kilauea volcano eruption are a particulate source which has been little investigated. Aerosol near fresh pahoehoe flows was sampled in January and May of 2000. Graseby/Anderson cascade impactors were used to collect size segregated fractions of the aerosol onto aluminum substrates in YNP and onto gold coated substrates in HVNP. Sections of the substrates have been imaged using a PHI TRIFT I instrument with a Ga primary ion source. Both positive and negative ion images have been studied. A large number of particles could be distinguished on the impactor surfaces. Multivariate methods, including mixture models and principal components analysis have been employed to enhance image resolution and aid in interpretation of the SIMS images.

10:00am **IE-TuM6 Environmental Concerns in Brazil**, ***T.M. Tavares,*** Federal University of Bahia (UFBA), Brazil **INVITED**

Brazil has not reached the phase of concern for industrial ecology. Society has not even been able to practice selection of solid wastes in a broad sense. Industries are now concerned on obtaining ISO14000 certificate and adopting clean technologies. In a capitalist society the main driving force is economic interest. The means available to society to protect the environment are government regulation/ law enforcement and consumers demand. In Brazil the frame of the legislation for environmental management is closer to that of Europe than of USA. It includes a good and often efficient system of licensing installation of new enterprises and operation of existing ones. A great number of large ecological reserves have been established. However two things are lacking: proper criteria for a great number of chemical pollutants and law enforcement. National consumer's demands have concentrated on protection of natural reserves and on industrial emission reduction. Demands of international consumers have resulted in cleaner production, as in pulp industries with change to elemental chlorine free (ECF) or total chlorine free (TCF). Brazil as a whole has no tradition in development of technologies. First, it lacks both financial and trained human resources since society never demanded it. This has also not been a concern of the government until 1999, when a new program for development of technologies has been launched ; Secondly, not before recently, part of the restricted development of technology in the country aimed green production. However, when government takes the initiative and demands new technology to meet economic interest, society responds. In 1970, 80% of the oil consumed in Brazil came from abroad, and the international prices were rising. With incentives from the Government, ethanol was introduced as fuel and new motors were development. Although the economic interest was the driving force, the environment profited from this less polluting fuel, and now other countries are adopting it. International demands can play an important role, and may be able to introduce carbon fixation through incentives, to more recycling, to assessment of life-cycle of products and to a greater environment conscious attitude.

10:40am **IE-TuM8 Multi-phase Atmospheric Chemical Processes: A Major Gap in Understanding Regional to Global Air Pollution Issues**, ***L. Barrie,*** Pacific Northwest National Laboratory **INVITED**

Chemicals from natural or anthropogenic activities that are released to the atmosphere as gases or particles are dispersed and transported on the winds. Their residence time and hence, range of influence, is determined by the processes of chemical and physical transformation, air-surface exchange and precipitation scavenging. Multi-phase chemistry involving interactions of gases with solids or liquids in the atmosphere or at the Earth's surface is often a major obstacle in understanding environmental chemical cycles and hence establishing effective pollution abatement strategies. There are a variety of pollution issues operating on a range of scales from local to global that threaten the quality of life on this planet. They include: urban smog (e.g. ozone and particulate matter), regional acidification/toxification and visibility reduction, global stratospheric ozone depletion and climate change. An understanding of multi-phase reactions is complicated by the largely unknown, highly variable nature of liquid/solid particles in the atmosphere. These include atmospheric aerosols (0.001 to 10 micrometers), cloud droplets and ice (1 to 20 micrometers) and rain/snow particles (20 to 20000 micrometers). They range greatly in composition and ionic strength (6x10@super -6@ to 10 molal). The interaction of gases with particles involves unreactive phase-partitioning processes as well as reactive kinetic processes. In the case of persistent semi-volatile substances such as herbicides, pesticides and polycyclic aromatic compounds, the environmental pathways are often dominated by the former process, In contrast, many substances are chemically produced or transformed during gas-particle interactions. There is a need to understand the nature of organic compounds in atmospheric particles and the basic physical chemistry of the interaction of these mixtures with water vapour and other gases.

11:20am **IE-TuM10 Structure and Composition of Size- and Time-Resolved Outdoor Aerosols Determined Using TOF-SIMS**, ***D.J. Gaspar,*** *M.A. Carpenter, J.P. Cowin, D.R. Baer,* Pacific Northwest National Laboratory

The study of aerosol particles has been identified as a top priority in atmospheric research due to their importance as heterogeneous reaction sites and the potential health consequences of particulate inhalation. Aerosols are known to have highly variable composition, with non-volatile, semi-volatile, and volatile organic and inorganic constituents. Although much work has been done recently, further understanding of structure and composition remains important. Thus, the composition of outdoor aerosols have been investigated using time-of-flight secondary ion mass spectrometry (TOF-SIMS). Particles were collected using a multiple stage impactor, which time tagged and sorted incident particles from 0.1 to 10 microns into discrete size ranges. A PHI TRIFT TOF-SIMS instrument was used with a Ga@super +@ liquid metal ion gun (LMIG) for both depth-profiling and analysis, and a Cs@super +@ ion source for more extensive depth-profiling. Mass spectra for both negative and positive secondary ions were obtained for the time- and size-sorted particles. Data was obtained for both collections of particles and a number of individual particles. The mass spectra have been analyzed to determine the inorganic and organic fractions of the aerosol particles. Three-dimensional molecular and atomic maps have been constructed for key environmentally important components of several characteristic particles. We relate the composition to environmental factors such as daylight and road traffic, and inferences are drawn concerning sample chemical history.

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