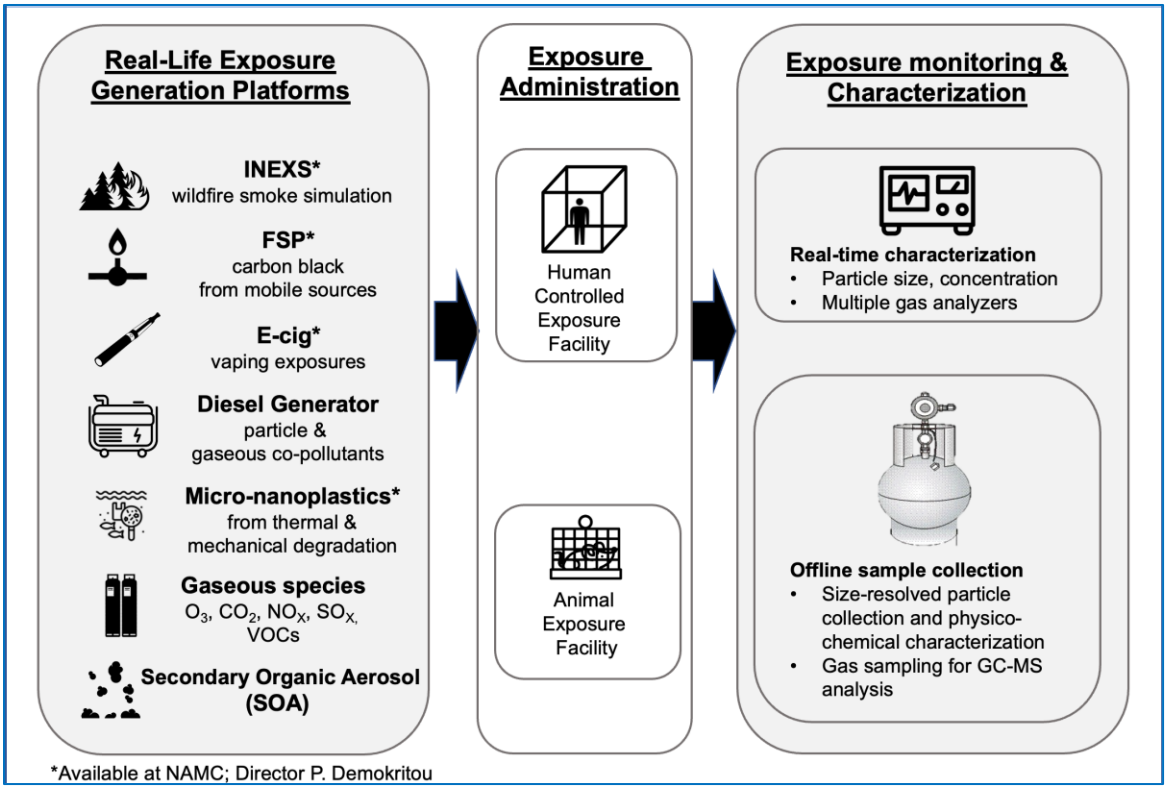
Facility Core Technology Services and Equipment

Specific Services

- Human inhalation exposure study design and implementation in the CEF
- Animal inhalation exposure study design and implementation in the AEF or individual CEED investigator laboratories
- Generation and characterization of aerosol and gaseous exposures for inhalation studies and exposure assessment in the CEF and in animal exposure chambers
- Generation and physicochemical characterization of simulated exposures including wildfire smoke, source specific black and brown carbon, e-cigarette emissions, and engineered nanoparticle atmospheres.

Core Facilities and Instrumentation



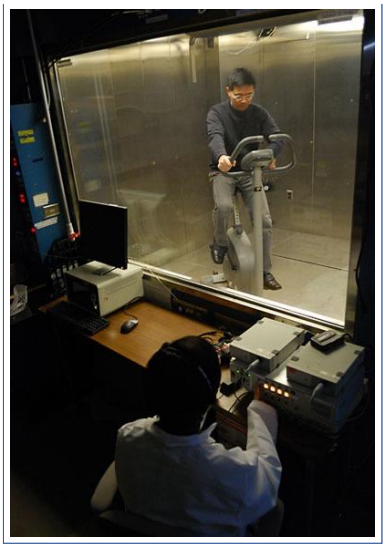
A. Novel Exposure Generation and Delivery Systems for Human and Animal Exposure Studies

Inhalation exposure generation systems are available to meet study requirements for specific pollutants, concentrations, and exposure durations. The systems used depend on whether the pollutant is a primary or secondary particle, a gas, or a semi-volatile compound. New exposure generation platforms are available via the Rutgers/EOHSI Nanoscience and Advanced Materials Center (NAMC), directed by Advisory Group member P. Demokritou. NAMC has established methodologies to generate and characterize environmental nanoparticles from multiple sources including wildfires,[61,62] incinerated micro-nanoplastics,[34,63-65] mobile sources,[35,37] e-cigarettes,[66-69] and engineered nanomaterials (ENMs). These exposure generation platforms and equipment for nanoparticle generation and characterization are available to CEED scientists for human and animal exposure studies from the NAMC. Standardized reference nanomaterials are also available from the NAMC or from other groups that are part of the NIEHS Nanomaterials Health Implications Research Consortium.

The exposure generation systems can be paired with either the CEF for human studies or whole body/nose-only animal exposure chambers. Current environmental exposure generation systems include:

- **Integrated Exposure Generation System (INEXS):** INEXS is used to investigate the thermal decomposition (TD) behavior of materials. The platform enables controlled parametric studies under different operational conditions such as temperature, heating rate, oxygen concentration and residence time. The INEXS platform has been used to investigate the TD of several thermoplastic nanocomposites[63-65,70] and generation of micro-nanoparticles, and systematic characterization of wood smoke particles emitted from wildfires and stoves.[61,62]
- **Flame Spray Pyrolysis (FSP) platform:** The FSP platform is used to generate black carbon (BC) nanoparticles that emulate real emissions from mobile sources (e.g., planes, cars, trucks).[35] This platform allows for the synthesis and detailed characterization of the physicochemical and toxicological properties of BC emissions at various combustion conditions[37] and can be used for *in vitro* and *in vivo* toxicological studies.
- **Electronic cigarette (e-cig) exposure generation platform**: A single port, fully programmable-cig generator enables precise control of puffing pattern and e-cig operational voltage. It has been used extensively in the physicochemical characterization and toxicological studies of e-cigs.[66-69]
- **Diesel Exhaust Delivery System:** A diesel exhaust generation and delivery system can be coupled with the CEF for human studies and chambers for animal studies on health effects of diesel engine emissions (Model YDG 5500E, Yanmar Inc. diesel electric generator).[1,44] The diesel exhaust is diluted and mixed with pre-conditioned ambient air to provide and maintain designated exposure levels in the exposure chambers.
- **Gas Delivery Systems:** Gas delivery systems are used in protocols requiring pure environmental gaseous compounds and mixtures, including ozone (O_3, AZ Ozone Generator), chlorine (Cl_2), hydrogen sulfide (H_2S), NO_x, carbon dioxide (CO_2) and a range of volatile organic compounds (VOCs). VOCs are delivered to the CEF using a micro-syringe pump (Cole Palmer), which continuously injects the VOC mixture into a heated gas bulb whose contents are flushed with purified air though a heated transfer line to the CEF mixing area.
- **Secondary Gases and Particle Generation Systems:** Generation of secondary organic aerosols (SOA) is accomplished via reactions between unsaturated VOCs and ozone. Steady-state SOA PM mass concentrations can be maintained using VOC concentration of 6.6 ppm (±10%) for extended periods of time. A nanoparticle generator for ultrafine PM (3480 NRC Electrospray Aerosol Generator, TSI, Inc.) is also available as is a base acoustical system for particle aerosolization. This system uses custom software to monitor and control filtered air flow and exposure concentrations in real time via coordination of a DataRAM (PDR-1500), three staged mass flow controllers, Venturi impactor, and amplifier voltage within an acoustical housing to aerosolize dry particles (e.g., engineered nanomaterials or samples collected from environmental sites) from a rubberized bed (IEStechno, Morgantown, WV) into an animal-size chamber. Concentration measurements are verified through gravimetric sampling (GilAir 5 Personal Air Sampler).

B. Exposure Facilities



Controlled Exposure Facility (CEF): The room-sized exposure chamber is located in the EOHSI building. The CEF consists of a ~25 m^3 stainless steel room, which is controlled for temperature, humidity, and air exchange rate. The renovation planned during the next grant period will allow air exchange rates to vary between 1 and 15 air changes/hour, reflecting real-life residential and occupational ventilation conditions. The temperature control ranges roughly from 55º to 95º ± 1ºF, and the relative humidity from approximately 15% to 85% ± 2%. This wide range of parameters will also be feasible after the renovation and will allow CEED researchers to use the CEF as a "Climate Simulator" recreating extreme weather conditions. The dehumidifying system allows the CEF to recreate micro-environments such as aircraft passenger cabins with very low relative humidity (<15%).[71] In addition to the pre-conditioning process, the supply air is filtered through carbon and HEPA filters. The CEF includes a lavatory attached to the chamber for participant use during experiments. Safety features include smoke and CO detectors, a sprinkler system, emergency lighting and a 4-foot-wide emergency exit from the chamber. Human exposure experiments range from ~30 min to 3 hr. Strict safety protocols are developed, implemented, and reviewed with study participants by TRSC clinical staff prior to the start of experiments. TRSC staff also provide clinical oversight during exposures.

Animal Exposure Facility (AEF): The AEF is located in the EOHSI building. Both Plexiglas and stainless-

steel chambers including BUXCO systems are available to CEED investigators for whole body and nose only rodent inhalation exposures. Temperature and humidity are monitored and recorded continuously throughout the exposures. Real time and time integrated systems for the physicochemical characterization of particles and other gaseous co-pollutants are used for a comprehensive exposure characterization. All animal exposures are monitored by CEED investigator laboratory personnel. Also available in the AEF is equipment for lung lavage and cytospin and tissue preparation, as well as a Scireq Flexivent for pulmonary function testing. Animal chambers/systems for gas and aerosol exposures available for use by CEED investigators include: one 84 L stainless steel exposure chamber with specially designed caging to hold 12 mice or 6 rats, one acrylic nose-only exposure chamber with ports for 12 animals, 4 stainless steel exposure chambers for exposures of up to 24 rodents and nose cones for rats and mice, three acrylic whole-body chambers for use with 2 rats or 6 mice/chamber, and 2 BUXCO systems, one for mice and one for rats complete with a plethysmograph platform. These systems can be used for primary exposures to gases, particles, other aerosols or filtered air, including radioisotope, and live bacterial aerosol challenges.

C. Monitoring and Characterization Equipment

Environmental gaseous species monitoring equipment for use during human and animal exposures

- Real-time ozone monitor (Thermo Electronics Model 49i, Two B Technology 205)
- CO monitor (Langan Instrument)
- *NO-NO_2-NOxmonitor (Thermo Electronics Model* 42C)
- Total hydrocarbon analyzer (Thermo Electronics Model 51iLT)
- Multiple CO, CO_2, O_3, SO_2 and NOx analyzers.
- Multiple high-sensitivity monitors/sensors of temperature, relative humidity, and CO_2
- Hobo Data Logger

Analytical Instrumentation for Comprehensive Particle/Advanced Materials Characterization

Real-Time Particle (2 nm to 20 μm) Sampling and Characterization

- TSI, SMPS nanosizer (Scanning Mobility particle sizer)
- TSI Model 3320 Aerosol Particle Sizer (APS)
- TSI NRC Scanning Mobility Particle Sizer (SMPS)
- TSI Model 8520 DustTrak (10)
- TSI Model AM510 SidePak monitors (10)
- TSI Model 100 Micro-orifice Cascade Impactor
- (HSPH-Custom built) High Volume Low Cutpoint Impactor (HVLI)
- (HSPH-Custom built) Compact Cascade Impactor
- Portable Condensation Nuclei Counters
- TEI 146C gas dilution calibrator
- TSI Model 3400A Fluidized Bed Aerosol Generator

Physical and Morphological Properties including size, shape, crystal structure/phase, crystallinity, density, surface area, and porosity (pore volume and pore size)

- Quantachrome NOV/Atouch LX
- Quantachrome Ultrapyc 1000 Gas Pycnometer
- Mercury Porosimeter Quantachrome Porometer

Chemical Properties of Particles/Advanced Materials (chemical composition, surface functionalization, purity, stoichiometry, and concentration for suspended particles)

- SpectraMax M5 UV/Vis Light absorption Spectrometer
- Malvern, ZetaSizer Nano ZS Dynamic Light Scattering (DLS)
- Malvern, NanoSight NS300 Single Particle Tracking (SPT)
- Malvern, Easier Nano ZS Zeta Potential

Portable real-time instruments are available for loan to CEED researchers for field projects. Additional instruments are available through the TRSC to measure cardiovascular responses of participants before, during and after exposure including an ambulatory ECG recorder (Trillium 5000, Forest Medical, East Syracuse, NY) to measure heart rate variability, an ambulatory blood pressure monitor (Oscar 2, SunTech Medical, Morrisville, NC) to record changes in pulse wave and central blood pressure during the same time periods, and a wireless heart rate monitor (Polar H10, Polar Electro, Kempele, Finland) to evaluate subject exertion level and safety.