MISSOURI UNIVERSITY OF SCIENCE AND TECHNOLOGY

Missouri University of Science and Technology (Missouri S&T) is a public land grant and space grant university in Rolla, Missouri. It is a member institution and technology flagship university of the University of Missouri System, Missouri’s only public research and doctoral-level institution. As a technological research university, Missouri S&T is a member of a small but elite group of American institutions that distinguish themselves by having a mission-based commitment to improving the world through the study and application of advanced sciences and technology. The University has an Imaging Facility, a Bioanalytical Laboratory, and a Histology Laboratory. These three laboratories are located in Schrenk Hall. The University’s Center for Biomedical Research (CBR), Center for Research in Energy and Environment (CREE), and Material Research Center (MRC) provide additional instrumentation and technical support. Together, Missouri S&T research facilities create a unique environment for interdisciplinary research in arts, sciences, business, computing, and engineering. By applying the science and technology of today, we are digging deeper to uncover the technologies of tomorrow.

LABORATORIES

The proposed research will be conducted in two laboratories with complementary skill sets: Dr. Yang Wang’s Particle Measurement and Technology Laboratory in the Department of Civil, Architectural and Environmental engineering. Dr. Yue-Wern Huang’s Molecular Toxicology and Nanobiotechnology Laboratory in the Department of Biological Sciences. Both laboratories are located on the campus of the Missouri S&T. The Civil, Architectural and Environmental engineering and biological sciences departments are located in Butler-Carlton Hall and Schrenk Hall, respectively. Schrenk Hall recently has been renovated with state-of-the-art open laboratory space. Butler Carlton Hall is nearby Schrenk Hall. Each laboratory has workbench space, chemical hoods, and all of the equipment required to carry out the proposed study (see this and “Equipment” files).

OFFICES

The offices of both PIs are located in close proximity to their laboratories and to each other. Each faculty has an office area of approximately 250 sq. ft. The academic department of each PI is supported by full time staff members, undergraduate assistants, copy machines, fax machines, and other logistic items. Conference rooms contain multimedia and teleconference equipment that support meetings for faculty, students, and visitors. Students have study areas with access to the campus network, via 802.11 b/g/n WiFi access ports located across campus, or by a VPN connection from off campus.

COMPUTING CAPACITY

Students at Missouri S&T can access computing resources through a network of thirty-two Computer Learning Centers (CLCs) located in 18 different buildings on campus, including the residence halls, library, and cultural center. Each CLC contains 30-60 Dell workstations with >3.0 GHz, core i5 processors, at least 8 Gb memory, and 20-inch monitors running Windows 10 as the operating system. A campus level data store provides at least 16 Gb of storage for each student. Many students also maintain files on personal USB drives. Most CLC rooms are available 24/7. The campus IT Department maintains a web-based index of machine-type, software product, location, and operating hours for all CLC rooms on campus. The CLC workstations host discipline-specific software in addition to a common core set of software packages. The common core set of software products include SigmaPlot, SYSTAT, SPSS, Microsoft Office suite, Maple, Mathematica, MathCAD, Matlab (all toolboxes), and AutoCAD. All workstations in the CLCs are connected to the campus-wide network that provides access to the internet and academic resources, including the holdings of the Curtis Laws Wilson Library on the Missouri S&T campus. In addition, Dr. Wang’s laboratory is equipped with four workstation desktops (owned by the laboratory) with core i7 processors, 16 GB memory, and 1 TB hard drive. Two laptops (core i5 processors, 8 GB memory, 500 GB hard drive) are available for direct data collection from the in-situ aerosol instruments.
MISSOURI S&T CORE FACILITIES

There are numerous shared resources and core facilities available to Missouri S&T researchers generally. There are several institutional core facilities operated on a non-profit, fee for service basis, and which offer a variety of support applications.

Center for Biomedical Research (CBR) is a multidisciplinary research center with the following objectives: (1) facilitate discovery in basic biological sciences; (2) promote interdisciplinary collaboration that facilitates scientific discovery and technological advances to develop the next generation of biomaterials and biomedical devices; (3) provide facilities and equipment for research in biomedical science, biomaterials, and biomedical devices; and (4) develop research and education programs to train the next generation of biomedical/biomaterial scientists and engineers. Key research and development areas include general biomedical science, bioactive glass science and engineering for bone repair and regeneration, nanofibrous bioactive glass for wound healing, and nanostructured biocompatible phosphate devices for drug and growth factor delivery.

- **Nikon A1R-HD Confocal Microscope (Eclipse Ti2):** The Nikon A1R-HD is a fully automated confocal imaging system able to image in the X, Y, and Z planes with both a high-speed resonant scanner to capture the dynamics of a system and a Galvano scanner to maximize resolution in fixed samples. Features include: A large field of view, capable of a resolution below 200 nm; A sophisticated postprocessing software to deconvolve and attractively display results; A 2D and 3D tracking system for particle tracking can be set up to automatically track several regions of interest in a time series scan. The confocal is equipped with both a sensitive A1-DUG Hybrid GaAs/PMT 4 channel Detector System and an A1 DUS spectral detector capable of obtaining 32 channels of fluorescence in a single scan. The system also has a Stage-Top Incubator for Temperature and Carbon Dioxide Control when imaging live cell cultures.

- **Olympus IX51 Inverted Microscope:** Both cell related image and video clips can be taken with high resolution up to 1500 folds magnification. White field as well as epi-fluorescent channels could provide wide spectrum of images for targeted molecules or cellular compartments. Being equipped with a second digital camera and a separate imaging screen, provide it an extra capability of accurate manipulation and imaging with one single cell.

- **NEXION 300 ICP-MS:** A new ICP-MS with single nanoparticle (SP)-ICP-MS function is highly sensitive to metal elements and other elements analysis with a specific software system that can be used for single nanoparticle analysis. Not only can it detect the trace concentrations of nanoparticle, but it also detects particle size, aggregation, hybridization and more.

- **4000 QTRAP® system:** This AB SCIEX 4000 QTRAP® mass spectrometer uses tandem QqLIT mass analyzers which enables a range of possible scan modes including normal triple quadrupole scans including highly sensitive multiple reaction monitoring (MRM) mode, as well as enhanced linear ion trap (LIT) modes for high resolution structural elucidation among others. Total scan types include: Q1 MS, Q3 MS, Product Ion, Precursor Ion, Neutral Loss or Gain, MRM, EMS, EPI, ER, MS3, TripleTrap™ Scanning. Ionization occurs within an AB SCIEX Turbolon chamber with either TurbolonSpray™ or APCI probes. A Shimadzu ultrafast liquid chromatograph (UFLC) with accompany degasser, binary pumps, autosampler, and column oven provides superior analyte separation with a maximum pressure of 9500 psi. This instrument is used for small molecules (<2000 Da) with detection limits near parts-per-trillion (ppt) or parts-per-billion (ppb) for most substances with common applications including metabolites, pharmaceuticals and personal care products (PPCPs), water disinfection by-products (DBPs), pesticides and herbicides, explosives, and many more.

- **GC-FID:** Gas chromatography (GC) is a Perkin Elmer product. The GC model is Clarus 500. FID is one of the most used detectors for Gas chromatography. The GC-FID is well suited for analysis of hydrocarbons such as methane, ethane, acetylene, etc., but also for organic substances containing hydrocarbons and for volatile organic compounds (VOCs).

- **Gas chromatography (GC) with a Network Chromatography interface (NCI).** It is a Perkin Elmer product. The GC model is Clarus 500 and NCI model is 900. This system responds to nitrogen phosphorus compounds about 100,000 times more strongly than normal hydrocarbons. Due to
this high degree of selectivity, the NPD is commonly used to detect pesticides, herbicides, and drugs of abuse.

- An Agilent 1100 Series high-performance liquid chromatography system provides rapid separation of a wide range of analytes of interest, including metabolites, environmental contaminants, pesticides, and many more. The system includes a degasser, quaternary pump, thermostatted autosampler, thermostatted column compartment and UV-Vis DAD detector. The HPLC system has a maximum pressure of 5600 psi and can function under a range of inorganic and organic buffers. The detector includes a deuterium discharge lamp and tungsten lamp for simultaneous absorbance measurements between 190 nm and 950 nm.

- Field Flow Fractionation System: It is an AF2000 system from PostNova. The AF2000 Series platform is based on the Flow FFF principle, using a cross-flow field as driving force for the particle size separation. The samples which are affected by this field are separated by their dynamic diffusion on the basis of the molar mass or particle size. The AF2000 can be easily used for separation of a broad range of different samples from the area of biopharmaceuticals, food-agro-cosmetics, environmental, chemicals and nanotechnology.

- Multiple High-Performance Capillary Electrophoresis (HPCE) analytical systems were purchased from Beckman Coulter. The system includes a P/ACE™ MDQ configured with both a photo diode array and selectable-wavelength UV/Vis (200, 214, 254 and 280 nm filters included) detector, UV source optics, temperature-controlled sample storage module and 32 Karat™ Software configured on an IBM personal computer. This instrument is used to separate and quantify many kinds of molecules, such as proteins, DNAs and other small molecules.

Center for Research In Energy and Environment (CREE) serves as a focal point for research, development, and deployment activities related to energy and environment technologies and in particular the Energy/Environment nexus. CREE researchers focus on educating students to analyze and solve issues related to energy and environmental and economic sustainability that improve communities and expand resource diversity. The center fosters close collaboration between Missouri S&T and other research centers in industry, national laboratories, and other universities. Work conducted through the CREE is aimed at benefitting the university, the state of Missouri and the nation.

- Elan DRC Inductively Coupled Plasma-Mass Spectrometer (ICP-MS): A model Elan DRC Inductively Coupled Plasma-Mass Spectrometer (ICP-MS) was purchased from PerkinElmer. There are three different sample introduction systems for this instrument, a model ASX-510 liquid autosampler (CETAC Technologies product) for general aqueous sample introduction, a model UP213AS laser ablation system (NewWave product) for solid sample introduction, and a model Series 200 high performance liquid chromatography (HPLC) sample separation/introduction system (PerkinElmer product) for speciation analysis (such as different species of arsenic, selenium, chromium, iodine compounds, bromine compounds and more). This instrument is mainly used for trace to ultra-trace level (part per billion to part per trillion concentrations) metal and semi-metal elements analysis.

- 4000Q Trap LC/MSn: An ultra-fast liquid chromatography (UFLC) coupled with a tandem mass spectrometer (MSn). The mass spectrometer is an AB Sciex product, and the model is 4000Q Trap. A Shimadzu Prominence UFLC-XR system is used for compound separation with an autosampler. This instrument is used to analyze many trace level compounds including large and small molecules such as proteins, pharmaceuticals and personal care products (PPCPs), water disinfection by-products (DBPs), pesticides and herbicides, explosives, and many more. The detection limits can reach part per billion (ppb) to part per trillion (ppt) for many compounds. It not only can do the quantification of the compounds, also can be used to elucidate some compound structures for qualitative identification by doing MS2 and MS3.

- Waters HPLC: A Waters High performance liquid chromatography (HPLC) system composed with a model 600E controller, a model 60F pump, a model 717 Plus autosampler, a model 996 PDA (photodiode array) detector, and a model 2475 fluorescence detector (FLD). This HPLC is used to analyze those compounds absorbing UV and visible wavelengths light by PDA detector and those compounds fluorescence by FLD.
Materials Research Center (MRC) sets a mission to enable the success of interdisciplinary research and graduate education in the area of materials science and engineering. MRC activities support the activities of faculty with center resources that include:

- Research instrumentation available through the Advanced Materials Characterization Laboratory
- The MRC administrative and technical staff; laboratory and office space in Straumanis-James Hall
- Seed grants for early-career faculty
- The collective expertise of the staff, students, and faculty affiliated with MRC

Major items for electron spectroscopy, X-Ray diffraction and scanned probe microscopy include:

- FEI Helios NanoLab 600 FIB/FESEM is intended for a simultaneous site-specific FIB cross-sectioning and high-resolution nondestructive SEM imaging. It is equipped with a STEM detector for STEM imaging and an Omniprobe (AutoProbe 200.2) nanomanipulator for high-accuracy nanomanipulation. The instrument is capable of nanoscale Platinum deposition, patterning, lithography, and TEM cross section specimen preparation.
- FEI Tecnai F20 is a 200kV field emission gun (FEG) high resolution TEM/STEM, which was installed in 2010. The microscope has a SuperTwin objective lens with a Cs of 1.2 mm. With its 200 kV acceleration voltage and its Schottky field emission source, this instrument provides outstanding stability, ease-of-use and high-resolution performance in TEM/STEM imaging and micro-analysis.
- Hitachi S4700 is intended for high resolution nondestructive SEM imaging. It is equipped with a GW Centaurus Backscatter detector for backscatter imaging, a Gatan CL detector for catholunesencous samples and the DEBEN 200 Micro Tensile tester can be fitted on the stage for in-situ tensile testing up to 200 N. An AMTEK Energy Dispersive Spectrometer (EDS) composition analyses is available with elemental and elemental mapping capabilities.
- The Philips X-Pert Diffractometer is a specialized diffractometer best suited for thin film studies. A variety of switchable PREFIX optics modules are available that allow for grazing incidence diffraction of thin films, stress and texture analysis, as well as high resolution studies of epitaxial films, including rocking curves and reciprocal space mapping.
- The Philips X-Pert Multi-purpose Diffractometer is equipped with a PiXcel detector and 15 sample changer, allowing for rapid data collection with excellent signal to noise ratio. It features both a Pt and W heating strip with maximum temperature capabilities of 1500C and 2300C respectively. The instrument is also equipped with a small angle X-ray scattering (SAXS) attachment.
- The Digital Instruments Nanoscope IIIa is a multimode scanning probe microscope capable of performing scanning tunneling microscopy, atomic force microscopy (tapping and contact mode), and magnetic force microscopy.
- KRATOS AXIS 165 Photoelectron Spectrometer is equipped for X-ray photon spectroscopy.

Department of Environmental Health and Safety (EHS) is available as a resource to assist all members of the university community with environmental and regulatory compliance and preparing for emergencies. With regards to biohazard safety, the e-cigarette aerosol generation systems will be housed in a hood under negative pressure. Filtered dilution air (HEPA filtered; humidity conditioned) will be introduced into the exposure chambers which will use different dilution air flow rates to achieve the target concentration. All exhaust particles and gases leaving the chambers will be removed by a HEPA filter. The hood is monitored on a regular basis and certified annually by the EHS. The disposal of wastes follows S&T’s EHS policy.

MISSOURI S&T LIBRARY
The Curtis Laws Wilson Library acquires, organizes, and curates scholarly collections, and provides library service and instruction in a community space that is conducive to study and collaboration. In addition to a large volume of print collection and periodical subscriptions, Missouri S&T library has an
extensive collection of digital indexes, full-text digital periodicals, and other digital materials, to support the academic work of the community. The library provides leading edge, web-based services as well as exceptional instruction and individual reference consultation to help support Missouri S&T research, teaching, and learning.