Oklahoma NSF EPSCoR Research Connection

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Inside this issue:

Stalking the Wild Viruses at Tallgrass Prairie 2

NSF Grant Continues Momentum 3

Upcoming Events 3

Nanoscale Materials Research 4

SouthWest Nanotechnologies 5

Science Exploration is Child's Play at Museums 6

OSU's OSL Technique Takes Flight 7

New Equipment for Nanomaterials 7

National Science Foundation Grant Continues Momentum of Oklahoma Researcher Gains

Oklahoma received a renewal of its 2002 National Science Foundation EPSCoR Research Infrastructure Improvement (RII) grant at the funding level of $6 million, with additional matching funds of $3 million from the Oklahoma State Regents for Higher Education. The three-year grant provides the resources necessary for the state to become nationally competitive in nanotechnology and plant virus bio-diversity and ecology research. Annual conferences for these two areas of research are held in mid-May on the Oklahoma State University campus.

"The RII award will continue the momentum that Oklahoma scientists have gained in genomics and nanosciences from past NSF and State Regents funding and will aid in the development of a critical mass of researchers in the state while stepping up to the next level of competitiveness," said Dr. Frank Waxman, EPSCoR director.

Chancellor Paul G. Risser commented, "This grant comes at a time when research in areas such as biotechnology, nanotechnology and genomics is helping Oklahoma move one step closer to becoming the 'Research Capital of the Plains.' The State Regents are pleased to be able to provide financial support for this very worthwhile research, and we wish Oklahoma EPSCoR continued success."

> ***"The RII award will continue the momentum that Oklahoma scientists have gained. . . "***

Plant Virus Biodiversity and Ecology

Viruses are associated with almost every known organism, yet we have discovered only a small fraction of this diversity. Concentrating on The Nature Conservancy's 39,000-acre Tallgrass Prairie Preserve, we are exploring

virus-host interactions, their geographic distributions, and the principles that govern them.

According to Dr. Ulrich Melcher, Oklahoma EPSCoR Plant Virus Biodiversity and Ecology Project Coordinator, "EPSCoR support is bringing together scientists from diverse fields into a team that will lay the foundation for a major leap in our understanding of the diversity of viruses and how that diversity interacts with other components of biological communities. The physical and intellectual infrastructure we develop will put Oklahoma at the vanguard of this new field."

Continued on Page 3

Stalking the Wild Viruses at the Tallgrass Prairie

Submitted by: Dr. Ulrich Melcher, Plant Virus Biodiversity & Ecology Project Coordinator

Viruses, nature's nanoparticles, carry their genes from one host to another. They normally catch our attention when their presence causes disease. However, viruses don't always cause disease. How often do symptomless infections occur? Perhaps most organisms harbor benign viruses. What about organisms whose health we usually ignore? Do these organisms have viruses different from the ones we know about? We know of many viruses that infect corn, wheat and soybeans, but none that naturally infect the Indian grass (*Sorghastrum nutans*) inhabiting our native prairies. Do viruses affect the diversity and number of organisms in natural settings? These are among the questions that are the focus of a new NSF-EPSCoR supported effort in Oklahoma.

Oklahoma EPSCoR's Plant Virus Biodiversity and Ecology effort is divided into two phases: a biodiversity inventory of viruses inhabiting plants in Oklahoma and studies of the ecological roles of these viruses. The program concentrates on viruses of plants found in The Nature Conservancy's Tallgrass Prairie Preserve in northeastern Oklahoma. The Preserve is particularly well suited for the plant virus biodiversity effort because of its diverse plant population, over 700 species of plants. Also, it is well studied ecologically offering unique opportunities to assess the effects of bison grazing and controlled burning on interactions among organisms and viruses.

The inventory began this summer when team members gathered samples from more than 400 species of Preserve plants under the direction of Dr. Michael Palmer of Oklahoma State University (OSU). When the scientists found a stand of plants to harvest, they took pictures of the plant (see example of a *Baptisia australis* above right), recorded its GPS position, and removed some leaves for later analysis in the laboratories. They also dug up a second sample of the species for drying and filing in the OSU herbarium collection.

***Baptisia australis* specimen collected at the Tallgrass Prairie Preserve.**

Finding viruses is not as simple as picking flowers or leaves. The leaves need to be probed in the laboratory for the presence of viral molecules. Few models for such inventories exist. One strategy was developed by team co-coordinator Dr. Marilyn Roossinck of the Samuel Roberts Noble Foundation (SRNF) in a similar study of plant viruses in Costa Rica. In this approach, the researchers isolate double-stranded RNA, a telltale sign of infection by RNA-containing viruses. By genetic engineering techniques, they make DNA copies of that RNA and analyze them.

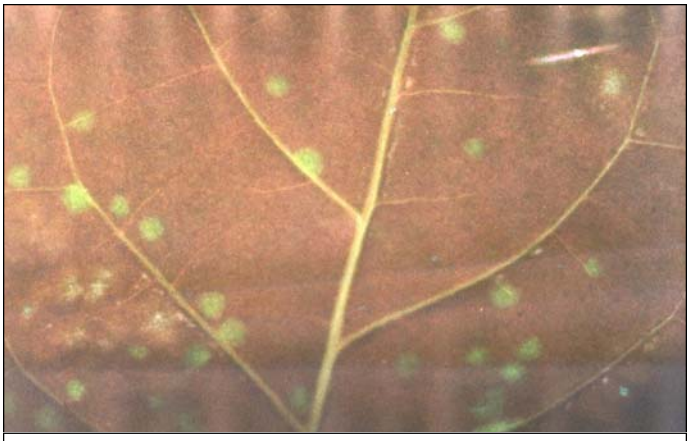
Another strategy is being explored in the laboratory of project co-coordinator Dr. Ulrich Melcher (OSU). In his laboratory, nucleic acid from the sample is allowed to find and bind to complementary sequences among thousands of small snippets of DNA arrayed as tiny spots on a microscope slide. Successful methods can also be used for routine testing for pathogens in plants.

Viruses found in the Preserve will be characterized by obtaining the full nucleotide sequences of their genetic material (often RNA instead of DNA) at the Advanced Center for Genome Technology directed by team member Dr. Bruce Roe of the University of Oklahoma (OU). Dr. Roe's laboratory will also perform "bar coding" on a sample of the plant's DNA. In bar coding, two short DNA sequences of genetic regions found in all higher plants are determined. The regions are known to have the right amount of species to species variation to be useful for taxonomic classification. Bar coding thus serves as a back-up to depositing dried specimens in the herbarium.

Characterized viruses will be passed on to other team members (Dr. Jeanmarie Verchot-Lubicz and Dr. Kay Scheets of OSU; Dr. Adam Zlotnick of the OU Health Sciences Center; Dr. Rick Nelson of SRNF) for use in their studies to understand how

viruses replicate, move within and between cells in the host and form protected structures (capsids), all while avoiding host defense pathways. For example, Drs. Verchot-Lubicz and Nelson want to understand how viruses move within and between cells in the host (see photo below). Newly discovered viruses may use different means to move between cells from those used by viruses whose movement has been studied. Common themes may emerge. These and other molecular biological studies will also contribute to a variety of biotechnological applications.

The inventory of Tallgrass Prairie viruses will open the door to the mostly unexplored area of plant virus ecology. Under the leadership of team ecologist and botanist, Dr. Michael Palmer, team scientists will be able to examine how different viruses interact with one another, with their hosts, and with other symbionts of their hosts in nature. Are they antagonistic or cooperative with one another? The team will explore the relationship between the structure of plant communities and the distribution of infecting viruses. Critical to the exploration will be mining information gathered in the project's database. To this end database and data mining experts, such as Dr. Jonathan Wren (OU), are participating in this process.



Fluorescent image of a leaf in which a virus is spreading (green fluorescent spots).

Dr. Melcher said "This project excites me in so many ways. For one, it brings together a range of scientific talents, some for the first time. Members of the team include plant pathologists, molecular biologists, biophysicists, computer scientists, ecologists, genomic scientists who come from four institutions (OSU, SRNF, OU, OUHSC) and will place a new team member at the University of Tulsa. For another, the project builds strongly on Oklahoma strengths, including its natural areas and the research infrastructure developed under previous rounds of NSF-EPSCoR funding. And finally, there is the great unknown. How big is the universe of viruses? What rules govern the interactions among viruses and plant species?"

NSF Grant Continues Momentum

Continued from Page 1

Nanoscale Materials Science and Engineering

Oklahoma EPSCoR has made substantial investments in nanotechnology via the Oklahoma Network for Nanostructured Materials (NanoNet). The NanoNet is a statewide group of 60 science and engineering faculty, their students, and industrial researchers. The major emphases in nanoscale materials are in the following areas: carbon nanotubes, fuel cell materials, novel nanoscale devices and interfaces of nano- and bio-materials.

According to Nanoscale Materials Science and Engineering Project Coordinator, Dr. Warren Ford, "NanoNet participants have a goal of establishing a major federally funded research and education center in nanoscale science and engineering."

The EPSCoR program continues its support of nanomaterials through faculty development opportunities and additional equipment essential to nanomaterials science and engineering research.

Education and Human Resources Outreach

Education and human resources outreach programs are an integral part of the RII grant. Its initiatives aim to strengthen the human resources available for the emerging high-tech workforce in Oklahoma through a comprehensive plan which targets the essential areas of the science and technology pipeline and include student development (K-12 & postsecondary), faculty development, entrepreneurship, and public outreach.

By addressing these strategic areas and through collaboration with existing programs and agencies, EPSCoR hopes to support current efforts by colleges and universities to better prepare Oklahoma students and faculty for careers in science technology fields.

Upcoming 2005 Events
www.okepscor.org

SEPTEMBER

Sep. 13 — BioLife Science Symposium, Cox Convention Center, OKC

Sep. 14 — 2005 NSF Plant Science Grants Conference, Ardmore

Sep. 25-28 — National NSF EPSCoR Conference, Puerto Rico

OCTOBER

Oct. 5 — OU Supercomputing Symposium, Norman

Oct. 28 — OK BIOS, Cox Convention Center, OKC

NOVEMBER

Nov. 4 — EPSCoR & i2E sponsored Workshop: "Who Wants to Be an Entrepreneur?", PHF Conference Center, OKC

Nov. 11 — UCO Research Day for Regional Universities, Edmond

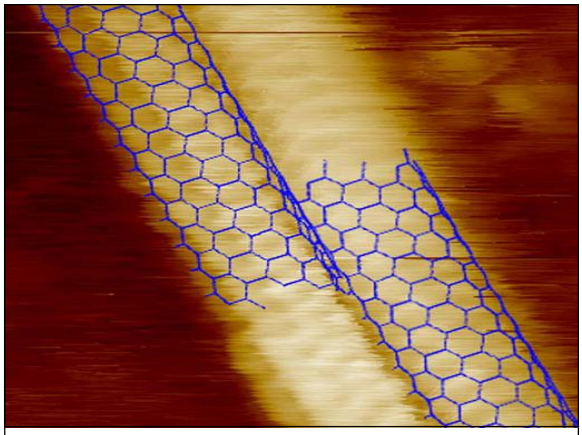
Nov. 18 — Women in Science Conference, Langston University-OKC

Nanoscale Materials Research in the Oklahoma EPSCoR Research Infrastructure Grant 2005-2008

Submitted by: Dr. Warren T. Ford, Nanoscale Materials Science and Engineering Project Coordinator

Nanotechnology is forecast to have a worldwide economic impact in the next 20 years rivaling that of information technology and biotechnology, and extending into these fields and others including energy and medicine. Major corporations, startup companies, and governments worldwide are investing heavily in nanotechnology. The 2004 *Small Times* business directory lists 2,300 business firms in 44 countries, anticipating a projected $1 trillion impact on the global economy.

With the research assets of its universities, growing companies and EPSCoR RII funding, Oklahoma is on the verge of having the critical mass of researchers required to be a national center of excellence in selected areas of nanotechnology. The objective of the 2005 RII grant is to build strength for a NSF-supported major research and education center. New efforts are organized into four interdisciplinary research groups (IRGs): 1) Carbon Nanotubes, 2) Novel Nanoscale Devices, 3) Fuel Cell Materials, and 4) Interfaces of Nanomaterials and Bio-materials.

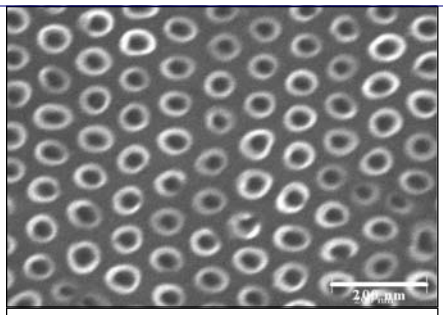


STM image of single-walled carbon nanotubes

Here are some research highlights .

Carbon Nanotubes. Carbon nanotubes have great importance in nanotechnology because of their exceptional mechanical strength and electrical and thermal conductivity. A unique catalytic process has been developed in Oklahoma for the large-scale production of high-quality single-walled carbon nanotubes (SWNT). Based on this technology, a start-up company (Southwest Nanotechnologies) was formed to commercialize the SWNT. OU researchers working in conjunction with DuPont first used single-stranded DNA molecules to separate a nanotube sample of just one type. Such SWNT samples open a vast number of opportunities in both fundamental research and applications in fields such as electronics and biomedical devices. With these recent accomplishments, we are poised for further major advances in SWNT materials. This IRG will investigate electronic theory, sensors, and nanobatteries of specific types of tubes. SWNT also are employed in the research of the other three IRGs.

Novel Nanoscale Devices. Oklahoma makes quantum wells with the highest room temperature mobility in the world. They are prime candidates for the read heads in magnetic disk storage, perhaps exceeding five times the density of today's hard drives. Oklahoma research is also yielding continued improvements in light emitters and detectors, as well as chemical sensors. New support will aid the development of mesoscopic magneto-resistance read heads and ordered ferromagnetic ring arrays for magnetic storage systems, PbSe-based IR lasers, ultra-efficient cavity lasers, optical detectors and photonic devices, nanobatteries, and chemical and biological sensors using



SEM image of ordered array of nickel rings

carbon nanotubes and bioconjugate materials.

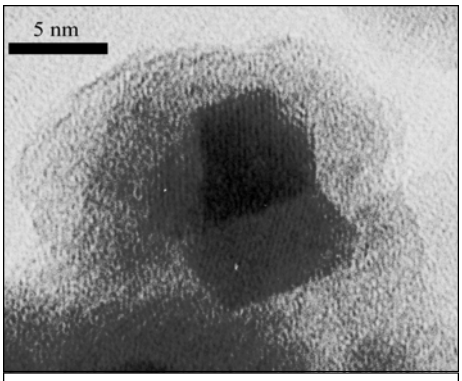
Fuel Cell Materials. Oklahoma has considerable expertise in polymer electrolytes as well as petroleum science. These two technologies meet in fuel cell research. Development of new polymer electrolyte membranes that permit operation of fuel cells at higher temperatures will improve efficiency and utilization of precious metal catalysts. This will ultimately allow fuel cell vehicle technology to compete economically with hybrid gasoline/battery-powered vehicles and will enable the development of new materials to address the global challenge of abundant and clean energy. Hydrogen and methanol fuel cells show great promise to improve energy efficiency and reduce emissions but neither system is widely commercialized. Both types of fuel cells rely on platinum or platinum alloy electrocatalysts, which are expensive due to the high precious metal loadings required for acceptable electrode performance. Both types of fuel cells require a more mechanically stable, highly proton-conducting polymer electrolyte membrane. This IRG is working to overcome these barriers through research on the fuel cell components. Complete fuel cells will be engineered and tested.

Interfaces of Nanomaterials and Biomaterials. This IRG unites a diverse group of investigators.

Continued from page 4

Nanoscale Materials

The unique opportunity is that Oklahoma has strengths in the fabrication of bioconjugate nanomaterials for sensors as well as the targeted delivery of nanomaterials. Bright luminescence and high stability make semiconductor quantum dots (QDs) well suited as biosensors and for new methods of clinical analysis. Strategies of targeted intracellular delivery of nanoparticles (NP) will be tested on model cell lines. Nano-bio conjugates can be guided to a precise location within tissues using magnetic fields. Magnetite nanoparticles (NPs) are functionalized for rapid and slow release delivery into cells, and for extended release of antibodies, proteins and DNA.



Fe2O3 nanocrystal

No single university department in Oklahoma can carry out all of these projects. Close collaborations of different departments and universities have been strengthened through technical staff, new faculty, and new microscopy and particle sizing equipment. This infrastructure also benefits nano-related businesses, in particular Nomadics and Ekips, two Oklahoma grown companies.

The Nanoscale Materials Research effort is led by the Project Coordinator, Dr. Warren Ford (OSU), the Co-Project Coordinator, Dr. Matthew Johnson (OU), and an Executive Committee including Dr. Ken Dormer (OUHSC), Dr. Roger Frech (OU), Dr. Brian Grady (OU), Dr. John Mintmire (OSU), Dr. Daniel Resasco (OU), and Dr. Dale Teeters (TU).

SouthWest NanoTechnologies: Company formed from Nanoscale Research at OU

July 13, 2005 – In 2001, a privately held specialty chemical company was formed in Norman, Okla., to adopt technology evolving from research at the University of Oklahoma.

From that marriage of private and public resources, SouthWest NanoTechnologies has developed into a company that sells single-wall carbon nanotubes for $500 per gram to customers in the United States, Korea, Japan and Germany, said Daniel Resasco, founder and chief scientist for SouthWest NanoTechnologies, as well as the S.A. Wilson Professor of Chemical Engineering and George Lynn Cross Professor, School of Chemical, Biological and Materials Engineering at OU.

"There are many other groups in the world producing nanotubes," he said. "But we are the only group growing nanotubes in a controlled environment."

The technology was developed at the OU Energy Center by a research team led by Resasco, who has pioneered a process that could dramatically lower the price of mass-producing single-wall carbon nanotubes.

Controlled production allows the nanotubes to be grown in circles on a silicon wafer or in lines.

"This is what got people in electronics very excited," he said.

Single wall nanotubes are in demand because of their electrical, thermal and mechanical properties. In addition, they may be mixed with polymers to make nanocomposites, which prevent the build-up of electric charges - an important consideration in the semiconductor industry.

Exploratory research is conducted in laboratories at OU. SouthWest NanoTechnologies handles the manufacturing at its facility.

The company was spun off from OU with support from private investors and ConocoPhillips. Other supporters include the Oklahoma Center for the Advancement of Science Technology (OCAST), the National Aeronautics and Space Administration and the U.S. Department of Energy.

"OCAST has been very generous with us," Resasco said.

In March, Resasco and Leandro Balzano, development engineer for SouthWest NanoTechnologies, received an OCAST grant to supervise interns researching optimization of single-wall carbon nanotube production.

Resasco also received an OCAST grant in June to investigate a process to improve the quality of transportation fuels, and Donna Nelson of OU received an OCAST grant to develop nanotubes for specific electronic applications.

Grants also were used to purchase nanotechnology research equipment at OU. Groups providing the grants for equipment included NASA, the U.S. Department of Energy and the National Science Foundation.

SouthWest NanoTechnologies has seven full-time employees. The company recently hired David Arthur as CEO. Arthur has more than 25 years experience commercializing products utilizing advanced materials, working at Rogers Corp., A.T. Cross Co., Composite Solutions, Helix Technologiesm and Eikos. He has a degree in chemical engineering from Tufts University, a master's degree in chemical engineering from the University of Connecticut and a master's of business administration from Northeastern University.

Resasco received his bachelor's degree in chemical engineering at the Universidad Nacional del Sur, Argentina, in 1975, and a doctorate from Yale University. He was chairman of the Chemical Engineering Department at the Universidad Nacional de Mar del Plata in Argentina in 1987-88 and was senior scientist at Sun Co. from 1991 to 1993.

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Science Exploration is Child's Play at Museums

Submitted by: Ms. Shelley D. Wear, Oklahoma EPSCoR Special Programs Coordinator

Science exploration is the focus of Oklahoma EPSCoR-funded field trips provided to K-12 students in Oklahoma. Whether climbing on a giant-sized tooth at Omniplex, digging for dinosaur bones at the Museum of the Great Plains, building stomp-rockets at the Tulsa Air and Space Museum, touching and handling the chinchillas, lizards and snakes at Leonardo's Discovery Warehouse or exploring the function of channels and levees in the waterway exhibit at the Jasmine Moran Children's Museum, **more than 10,461 school children from 130 public schools in Oklahoma** had a great time experiencing science on field trips to Oklahoma museums funded by the NSF Research Infrastructure Improvement grant.

The development of a successful partnership with Oklahoma's largest science museum, Omniplex, two years ago, resulted in the K-12 Science Field Trip Initiative. The field trip grant program for public schools was developed in response to mass cancellations of field trips by school districts.

Ms. Sherry Marshall, Education Director at Omniplex, indicated that "Schools reported rising transportation costs and increased budget cuts made the cancellations necessary."

To ensure that students from needy districts would continue to engage in much needed science enrichment activities, Oklahoma EPSCoR made grants available to provide financial assistance for entrance fees and/or transportation costs. Oklahoma EPSCoR served 30 schools and 3,200 school children in the first year of the program. Recognizing the benefit of these science enrichment experiences to students, Oklahoma EPSCoR sought to expand its K-12 science field trip initiative to include partnerships with four additional Oklahoma museums within the Reynolds Foundation Oklahoma Children's Discovery Center Network that include: Omniplex, Tulsa Air and Space Museum, Leonardo's Discovery Warehouse, Jasmine Moran Children's Museum and the Museum of the Great Plains.

Students exploring a giant-sized tooth at Omniplex.

Successfully establishing partnerships with these networked museums enabled Oklahoma EPSCoR to serve many rural school districts who simply did not have the funds available for extracurricular activities such as field trips.

Students learn about anatomy at the Jasmine Moran Children's Museum.

Many teachers from recipient schools have expressed their appreciation for the program that provides interactive science enrichment activities for students.

"Anytime we can teach using hands-on activities, the student degree of understanding is increased," reported one teacher from a rural school district.

Another elementary school teacher reported, "Our students were very excited about this trip. Through the use of hands-on exhibits they learned some key concepts in an interesting manner. They hadn't realized that so much of our world is science, so they came away with a new appreciation."

Grant applications for field trip assistance are currently being accepted by the Oklahoma EPSCoR program. For more information on K-12 science-related field trip grants, please contact Ms. Shelley Wear, Oklahoma EPSCoR Special Programs Coordinator at (405) 225-9287 or swear@osrhe.edu or visit the EPSCoR website at: *www.okepscor.org/programs/k12.html.*

Students discover the fun of science while digging for dinosaur bones on a field trip.

Students engaged in science at the archeology exhibit at the Jasmine Moran Children's Museum.

Oklahoma State University's OSL Technique Takes Flight

Submitted by: Ms. Jana Smith, Coordinator, Research Communications, Office of the Vice President for Research & Technology, OSU

Researchers at Oklahoma State University (OSU) have been working for the past few years to develop a technique called Optically Stimulated Luminescence (OSL) as a method to measure radiation exposure to astronauts during space flight. NASA funded the research led by Dr. Stephen W. S. McKeever, vice president for research and technology transfer, along with Dr. Eduardo Yukihara, assistant professor of physics, and Dr. Ramona Gaza, former graduate student now working for NASA's Johnson Space Center.

Photo courtesy of NASA

Astronauts aboard the Discovery--NASA's most recent shuttle mission.

The result of these efforts is that the OSL technique developed by OSU was used by NASA in badges (known as a "dosimeter") worn by astronauts aboard the latest Discovery mission, STS-114. Research results presented by the OSU team at international meetings and in discussions with NASA convinced the NASA Space Radiation Analysis Group (SRAG) to use OSU's OSL technique as part of the radiation measurement "badges" worn by astronauts on the Discovery mission. Gaza is currently setting up OSL facilities for SRAG at NASA's Johnson Space Center.

The OSL technique uses luminescence emitted from a radiation-sensitive material to measure the radiation exposure. The material used by the OSU group was aluminum oxide and NASA needed to make modifications to current astronaut dosimeter badges to accommodate the aluminum oxide materials. The radiation-sensitive aluminum oxide is made in Stillwater, Oklahoma at the Crystal Growth Division of Landauer, a Chicago-based company, who mass produces aluminum oxide crystals for about 1.5 million customers.

NASA accepted the first prototype modifications made to the badges by OSU's Physics Department using OSU's design. Mike Lucas, OSU Physics Department, made additional component parts for NASA to include in the radiation dosimeter badges as part of the OSL system. Parts shipped to NASA for the new badges were assembled by NASA for use by astronauts on Shuttle mission STS-114. NASA will use OSL and aluminum oxide as part of their astronaut dosimeter badge in future flights.

In addition, as part of a large multi-national consortium to estimate radiation doses inside the human body while in space, the OSU team is taking part in an experiment called MATROSHKA, which is currently flying on the International Space Station. Later this year, samples from MATROSHKA will return to earth on the Soyuz spacecraft for analysis.

For more information about OSU's research programs, contact the Office of the Vice President for Research and Technology Transfer at (405) 744-6501 or visit our website at *www.vpr.okstate.edu* .

Editor's note: OK EPSCoR provided seed funding for Dr. McKeever's early research that led to the technology used on the space shuttle.

New Equipment for Nanomaterials

Submitted by: Dr. Brian P. Grady, Chemical Engineering, University of Oklahoma

Two x-ray instruments, a powder diffractometer and a small-angle x-ray scattering (SAXS) diffractometer, were recently installed in the School of Chemical, Biological and Materials Engineering at the University of Oklahoma. Funds were obtained through a Major Research Instrumentation (MRI) grant from the National Science Foundation as well as matching funds provided by the University of Oklahoma Vice President for Research. The success of obtaining these funds was through the efforts of a number of NanoNet scientists to include Dr. Brian Grady, the grant's PI. Sections in the proposal were included from Oklahoma's three major research Universities. Both instruments represent capabilities not previously found in the state. The powder diffractometer is unique because of a high-throughput area detector that allows for the identification of minor components in a particular sample. Alternatively, the area detector allows for following rapid changes in the atomic ordering of samples on the time-scale of seconds. Samples can be run in either reflection or transmission depending on the characteristics of the sample, and a high-temperature sample stage with controllable atmosphere is available. The SAXS system uses pinhole optics and an area detector that allows the resolution of inhomogeneities on a length scale as large as 500 Angstroms. Special liquid sample holders and a high temperature stage are available as well. Finally, a special image plate system allows for the simultaneous collection of both SAXS and WAXS samples, ideal for polymers with nanoscale ordering. This instrument was purchased with the purpose of being available to any researcher within Oklahoma. Please contact Dr. Brian Grady at bpgrady@ou.edu to discuss the possibility of having samples run on either instrument.

SAXS/WAXS

WAXS

Return Address:

225C Noble Research Center
Stillwater, OK 74078

Oklahoma Experimental Program to Stimulate Competitive Research

Oklahoma City Office:

Dr. Frank Waxman
State EPSCoR Director
Oklahoma State Regents
for Higher Education
655 Research Parkway, Suite 200
Oklahoma City, OK 73104
405.225.9459
405.225.9230 (fax)
fwaxman@osrhe.edu

Stillwater Office:

Dr. James Wicksted
Associate EPSCoR Director
Oklahoma State University
225C Noble Research Center
Stillwater, OK 74078
405.744.9964
405.744.7688 (fax)
james.wicksted@okstate.edu

www.okepscor.org

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