Education and Research Center on Nanotechnologies at the Lomonosov Moscow State University

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Established in 1755, named after Mikhail Lomonosov (1711-1765) in 1940

Major classical university in Russia, about 50,000 students, 5000 professors, more than 60% of lecture courses given in the world are delivered in MSU.

No 1 research organization in Russia (each year more than 300,000 citations).

The MSU campus in Moscow covers 205.7 hectares, over 600 buildings and facilities including the skyscraper on Lenin Hills (over $10^6$ sq.m)
On 10\textsuperscript{th} November 2009 president Medvedev signed the law establishing a special status of Moscow and Saint-Petersburg State Universities.

According to the law MSU has the right:
- To develop its own educational programs;
- To accept students as a result of admission examinations;
- To get funding directly from State budget (not through the Ministry of Education);
- To issue own diplomas
- Etc.

For the implementation of this law MSU prepared the development program. The main research directions of the program are: supercomputers, space research, medical studies, energy efficiency/nanobiotechnologies, nature preservation.
Education and Research Center on Nanotechnologies

Aim: to consolidate efforts of MSU units aimed at research and development and true cross-disciplinary education in nanotechnology, nanomaterials and nanosystems

Solution: leave borders of single departments and faculties

Advantages:

- Truly flexible and multidisciplinary education
  - Student access to resources (practicum, seminars) from different departments

- Do not disturb traditional mono-field educational programs.
  - Accumulate selected representatives of different science schools and ensure continuity and fundamental nature of the education.

http://nano.msu.ru/
Education and Research Center on Nanotechnologies

Select students from 3rd year from Physics, Chemistry and Biology departments, about 60 students per year

3 students specializations:

- Nanosystems and Nanodevices
- Functional Nanomaterials
- Nanobiotechnology

Magister program:

Composite nanomaterials in cooperation with Rusnano
Education and Research Center on Nanotechnologies

Russian publishing of best education and scientific literature in nanotechnologies

In 2010 we start to publish 3 lines (in cooperation with “Nauchnyi Mir”)

Line «Fundamental background of nanotechnologies: best foreign textbook»
  • *Intermolecular and Surface Forces* by Jacob N. Israelachvili
  • *Electrodynamics of Metamaterials* by Vladimir M. Shalaev and Audrey K. Sarychev
  • *Understanding Molecular Simulation* by Daan Frenkel and Berend Smit

Line «Handbooks»
  • *Handbook of Microscopy for Nanotechnology*
  • *Nanostructures and Nanomaterials: synthesis, properties and applications*
  • *Nanoparticle technology handbook*

Line «Research and development»
  • *Nanotherapeutics: Drug delivery at nanoscience*
  • *Biomedical polymers*
Education and Research Center on Nanotechnologies

Conferences, schools, seminars.

2010 events:

• 2nd Russian-Japan conference on nanomaterials and nanotechnologies for young scientists.

• Special scholarship for MSU students and PhDs (in cooperation with Intel)

• Scientific conference “Calculations and simulations with GPU in molecular biology and bioinformatics”

• Science school in nanotechnology for young teachers from universities

• 4th Internet-Olympiad on nanotechnologies for schoolchild and students

• Conference and School for young scientists “Macromolecular nanosystems and polymer nanocomposites”.

• Conference “Perspectives of Education and research centers in Russia”.

Nanoscience popularization

Open courses:
- «Fundamental basis of nanotechnology»
- «Topical questions in nanotechnology»
- «Molecular physiology»

Video lectures: http://video.nano.msu.ru/nano/
Including: lectors, terms, links, search.

Internet broadcast of scientific lectures and seminars
Education and Research Center on Nanotechnologies

Research

Range: from geology to biology through physics and chemistry

Synergy from connecting:

• Biology and material science
• Geology and microfluidics
• Quantum physics and lab chemistry
• Soft matter and hard matter
Innovative methods of increasing oil recovery

Novel methods of increasing oil recovery

- Allow to bring to commercial production disperse oil-and-gas fields (resource potential of billions of tons) and other unconventional sources of gas-extraction (coal beds, clay shale and chert);

“Intelligent” polymer systems for blocking water in a well

- Earlier proposed technologies for increasing oil recovery based on polymer liquids for hydrofracturing, generation and filling artificial fissures will be improved
- Polymer systems with improved properties for control of inflows in wells and magnetic field driven transport of substances in a well will be developed
Innovative technologies of processing of raw and alternative hydrocarbons

At present conversion rate at Russian factories approximately equals to 70% while in other countries this index exceeds 90%.

Catalyst passivation technology has been developed at MSU which allows to draw to processing heavy crude (high-boiling oil fractions, bituminous oil et al.)

Annual loss of accompanying gas is 28 billions m³, but cost of its utilization and desulphurization is unacceptable because of complexity of conventional technologies.

Accompanying gas desulphurization technology based on catalytic oxidation of H₂S has been developed at MSU. This technology considerably simplifies purification process and reduces the cost 2-3 times.

The main Goals:

- Development of innovative methods of increasing conversion rates of oil refining;
- Considerable enhancement of oil processing and petrochemical selectivity; reduction of the production energy costs;
Renewable energy and raw materials sources, chemistry and biology-based methods of producing energy.

Scientific principles of the processes transforming sunlight energy directly into bio-energy carriers have been worked out in MSU. Main advances in this field are based on the synthesis and utilization of natural and artificial functional nano- and micro-biocatalysts for fuels production and transformation processes.

The Goals:

- Creation of a new generation Energy Carriers in the form of organic fuels obtained by means of CO₂ photosynthetic fixation and chemical or biotechnological transformation of various biologically renewable energy sources.
- Development of an effective setup transforming organic wastes into electric energy with intermediate production of biohydrogen.
Nanotechnological approaches for creation of biosensors and biocatalysts

- Biomimetic approaches
- Artificial enzymes
- Fermentative metallography
- Autometallography

Development of nanocatalysts – biomimetic proteins for chemical processes of different types. Creation of the technological base for preparation of bioanalytical platform for complex analysis of biochemical parameters of organisms and surrounding media

Enhancement of signal in immunochromatographic analysis
New materials for electrochemical and photovoltaic production of energy and for its effective consumption.

- Lithium batteries
- Supercapacitors
- Fuel cells (PEMFC, SOFC)

**Main task:** Synthesis of new functional nanomaterials for production and storage of energy and for its effective utilization in solar and electrochemical energetics.

**MSU-RUSAL:** Development of a green aluminium production technology based on an energy-efficient electrochemical process.
Main principles of the HTSC-coatings on metallic bands have been worked out
- new architectures of buffer layers
- increase of the critical current

Nanostructured thermoelectric materials with record low thermal conductivity have been obtained

Main goals:
Development of novel superconducting, thermoelectric and magnetic nanostructured materials and devices based on them.
Development of novel improved methods and technologies of energy generation, transportation and transformation.
Modern carbon materials for energy-saving technologies.

Synthesis of carbon materials by condensation from methane/hydrogen mixture activated by plasma

methane \( \text{CH}_4 \)
hydrogen \( \text{H}_2 \)

Application of carbon materials

- Light sources
- Supercapacitors
- High-frequency electronics
- Optoelectronics
- Lithium batteries

Diamond nanotool

Integrated solution of scientific problems related to synthesis of new types of carbon nanomaterials, investigation of their properties and development of scientific principles of various functional applications for energy-saving technologies
New polymer composite materials for energy-saving technologies.

Polymer composite materials

NANOFILLERS
(CARBON NANOTUBES AND NANOFIBERS, INORGANIC FIBERS, METAL NANOPARTICLES)

BINDERS
EPOXY, POLYESTER, POLYIMIDE RESINS, PHENOLICS, POLYCARBONATES, POLYAMIDES, POLYSTYRENES etc..

Development of a new generation improved competitive composite polymer materials for building, transportation and high-technology processes.
Biocompatible nanostructured materials, composites and coatings

- Selectivity of surface interactions
- “Smart” recognition and controllable response

Synthesis and practical applications of wide spectrum of new polymer, ceramic and carbon nanostructured materials for medical applications
Nanobiotechnologies for development of therapeutic antibodies and nanovaccines

• Development of universal nanobiotechnology of block assembly outside of the cell: nanovaccines on surfaces of highly immunogenic plant virus particles

• Preparation of highly immunogenic, safe and cheap nanovaccines against influenza, rubelia and other infections which pose a threat for humans and animals

Development of nanobiotechnologies for construction of the recombinant antibodies for development of a new generation of drugs in Russia, Development of universal nanobiotechnology of block assembly outside of the cell: biologically safe nanovaccines as a result of structurally modified plant virus particles

New type of nanoplatform – spherical nanoparticles – product of thermal reconstruction of tobacco mosaic virus (SEM image)

Nanovaccine for influenza prevention (fluorescent microscopy).
Nanobiotechnologies for drug delivery and new types of medicines

• Active and passive drug delivery
• Preparation of nano-sized drugs, including antioxidants
• *In vitro* and *in vivo* clinical trials of new types of medicines

Research in Moscow State University will allow to expand the area of application of mitochondria-based medicines try new more effective ones in clinical trials
RNA and DNA nanotechnologies for medical applications

• development of DNA- and RNA-based nanotechnologies for the preparation of new medicines for treatment of different cancer diseases through the inactivation of telomerase

• development of new gene therapy approach based on DNA-nanotechnologies with preparation of DNA-enzymed particles

• Synthesis of inhibitors of proteasome as a way for treatment of autoimmune diseases

Obtaining of the new generation of medicines in Russia for therapy of previously untreatable diseases such as cancers, autoimmune illnesses and HIV through the use of DNA- and RNA based nanotechnologies
Education and Research Center on Nanotechnologies is open for cooperation with you!

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