The main objectives and activities of the laboratory

- Research of the new technologies for the nanofibrous materials preparation and functionalization.
- Development of the potential applications of the nanomaterials in the filtration, catalysis and barrier systems.
- Study of the thermo-hydro-mechanical-chemical processes during the migration of liquid contaminants through barrier systems.
- Development of the software and measurement tools for the assessment of the barrier systems thermal, mechanical and chemical stability.
- Comprehensive solutions to the specific problems of the barrier systems utilization in the environmental protection.

Laboratory specialization

Laboratory research is focused on the construction and testing of the barrier materials and systems for environmental protection. Main objectives include the preparation of the new filtration materials in a different geometric arrangements and compositions. According to the final application prepared materials can be functionalized to work as carriers of biologically or chemically active substances. Functionalization of nanofibrous composite materials bring the added valued in high-demanding applications such as the reduction of the air pollution from heavy industrial plants. The laboratory develops and tests filter elements for cleaning and catalytic decomposition of the undesirable contaminants in the flue gases and waste liquids. The catalytic efficiency of the new materials is studied in close collaboration with the Laboratory of Chemical Remediation Processes. The laboratory also examines the stability and durability of the materials, evaluates the level of thermal degradation and potential degradation products as well as their harmfulness. The laboratory has the equipment to measure the efficiency of nanofiber filters and filter characteristics, and to perform pilot tests in real filtration systems. The laboratory can also provide measurement of the filtration properties according to EU and international standards for the enterprises engaged in liquid and gas filtration. The second research direction deals with the issue of migration of nanoparticles in the environment. This area of research involves the release of nanofiber elements and catalyst particles from filter elements, the flow of aerosol through the structure of filters, and local evaluation of damage to filter elements. The research focuses on modeling the migration of nanoparticle in the rock massive during the remediation of industrial groundwater contamination. The solution of this problem also involves computer simulation of the iron nanoparticles and colloidal particles migration through rock and soil environments and their chemical and geochemical interactions. Migration of the small suspended particles is controlled by different physical processes than the transport of dissolved substances and successful model them it is necessary to perform the various theoretical and experimental tests. To achieve this we collaborate closely with the Laboratory of chemical remediation processes which, inter alia, will develop column test methodology and experimental instruments for capturing the necessary data. Design of migration column experiments, their interpretation and construction of models based on the results will be one of the activities of the Laboratory of nanomaterial applications. Practical applications of this research include modeling for the design of remedial systems using nanomaterials and the prediction of chemical interactions and the migration of colloidal particles of bentonite, which is a planned part of engineering barriers in a geological barrier environment. This multidisciplinary research includes the associated thermo-hydro-mechanical-chemical processes and is designed in collaboration with SIIRO, GG, UIV Rež, FITI and CEG FSV CTU, UG and CR and numerous other partners both from the academics as well as industrial sector. The laboratory is also involved in international cooperation on projects of mutual comparison of numerical simulation codes and their validation against experiments (Task Force EBD and DECOVAD). To verify field data the laboratory has a workplace in Bělidov tunnel and in a gallery in Josef v Mokrsku which is administered by ČVUT. Research methodology is based on laboratory measurements, field data collection and evaluation of mathematical models and the search for optimal variants of barriers to reduce the risk of leakage of nanoparticles and ensure environmental quality.

New research directions

- The new generation filtration and barrier materials preparation technologies based on admixtures of the catalytic additives in the form of nanoparticles, enzymes, and antimicrobial additives to the nanofiber and microfiber layers of different chemical compositions.
- Research of the properties of engineering and geological barriers used in the industrial applications and the protection of the population in the contaminated areas.
- Research of the external thermal, mechanical and chemical conditions effect on the properties of the synthesized and natural barrier materials.
- Development of the technologies and functional samples for laboratory and pilot test applications and careful processing of the composite materials.
- Research of the migration processes through engineering and geological (natural) materials.
- Development of the software tools for the selection of the radioactive waste repositories locations and assessment of their long-term safety.
- Software tools and methodologies for the underground gas storage facilities projection and management.
- Study of the thermo-hydro-mechanical-chemical processes in the complex heterogeneous environments through the development of computer models.
- Research and development of the methodologies of applied science for the processing of the visual information and information on measured field data, methodology for the study of fluid mechanics based on modeling and experiments.

Outputs

- Prototypes and functional samples of the thermally stable filters improving the reduction of the chemical contamination in the flue gas emissions.
- Prototypes and functional samples of the filtration equipment for dusty and toxic operations.
- Prototypes and functional samples of special filters designed for the ultra-clean manufacture facilities and operating rooms.
- Functional samples of the facemask filters and other elements specialized for the integrated rescue systems and the civilian protection.
- Cooperation on the development of the prototype machinery for the manufacture of the composite sandwich filters materials, development of the technical components for the machinery (electronics, management and control methods).
- Functional samples and prototypes of the laboratory instruments for the thermal and mechanical stability, chemical efficiency of different types of filtration and barrier materials measurement.
- Methodologies for the migration processes through engineering and geological (natural) materials assessment.
- Methodology and development of the software tools for selecting locations for radioactive waste repositories and assessing their long-term safety.
- Development of methodologies and software tools for planning and management of underground gas storage facilities.
- Publications, including alternative scenarios for the development of associated THMC processes in complex heterogeneous environments through the development of computer models.
- Methods of applied science for the processing of visual information and information on measured field data.
- Methodology for the study of fluid mechanics based on modeling and experiments.
Laboratory instruments and equipment, and their use

- VDI
- Porosimeter
- Instrument for measuring HEPA filters.
- Instrument for measuring particle size.
- Portable X-ray fluorescence analyzer.
- ANSYS
- Speed camera.
- Lighting module.

Contractual research

Contractual research is performed for the following partners: Ecotex, VUTS, Termizo, Elmarco, Trevox, GEA-LVZ, Sigma, SORAD, SUIB, RWE Gasstorage, UVZ Řež, LEWIN, SIMGEO, G-Impuls and institutes of the ASCR. These companies and organizations are also partners in the following projects. The results of this cooperation are also in our references.

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International grants

DECOVALEX
EBS - Task Force