**X-Ray Photoelectron Spectroscopy**

*(completed by the responsible coordinator of equipment)*

**Equipment:** X-Ray Photoelectron Spectroscopy newly equipped with UPS and Raman Spectroscopy modul

**No. of Equipment:** *UPOL 3 (upgrade – Pro-NanoEnviCzIII)*

**Responsible coordinator:** Mgr. Martin Petr, Ph.D.

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**Equipment Description**

X-Ray Photoelectron Spectroscopy (XPS) is a highly precise, non-destructive analytical technique used to determine the elemental composition and chemical state of surfaces. By measuring the kinetic energy of photoelectrons emitted from a material upon X-ray irradiation, XPS provides valuable insight into the first few nanometers of a sample, making it ideal for surface chemistry studies. This technique enables the identification of elements, their oxidation states, and chemical environments, offering essential data for material science, thin-film characterization, corrosion studies, and nanotechnology applications.

**Ultraviolet Photoelectron Spectroscopy (UPS)** is an advanced non-destructive technique for investigating the electronic structure of surfaces, often referred to as valence band spectroscopy. It utilizes ultraviolet photons to eject electrons from the material, enabling the precise determination of electron binding energies and work functions critical for surface and interface analysis.

**Raman Spectroscopy** is an advanced non-destructive optical method for examining the vibrational modes of materials. By analyzing the inelastic scattering of monochromatic light, it provides a unique molecular fingerprint that reveals detailed information about chemical bonds, crystallinity, and structural properties.

**Specification of expertise relevant to NanoEnviCz workpackages:**

|  |  |
| --- | --- |
| **WP3 SYNTHESIS AND DESIGN OF NEW MULTIFUNCTIONAL NANOMATERIALS FOR ENVIRONMENT PROTECTION** | |
| Conceptually new nanostructured materials with the potential for application in innovative technologies | Yes |
| Computer aided nanomaterials design | No |
| Low dimensional materials and their composites (carbon dots, nanotubes, graphene derivatives) | Yes |
| Nanofibers | Yes |
| Magnetic hybrids | Yes |
| Metal and metal oxide NPs | Yes |
| Redox active nanomaterials | Yes |
| Nanomaterials for biomedical applications | Yes |
|  | |
| **WP4 HETEROGENEOUS CATALYSIS FOR ENVIRONMENTAL PROTECTION** | |
| Nanomaterials for catalytic degradation of pollutants in water, soil and air | Yes |
| Nanostructured heterogeneous catalysts for abatement of pollutants from industrial processes and automotive transport | Yes |
| New “clean” catalytic processes for chemical production | No |
|  | |
| **WP5 NOVEL NANOMATERIALS AND TECHNOLOGIES FOR SUSTAINABLE PRODUCTION** | |
| Processes and technology for sustainable energy and chemical production | Yes |
| Catalytic processes for transformation of natural gas to liquids | No |
| Nanomaterials for utilization of renewables; Magnetically separable green catalysts | Yes |
|  | |
| **WP6 EFFECTIVE PHOTOCATALYTIC TECHNOLOGIES** | |
| Mastering nanomaterials for photocatalysis | Yes |
| Effective photocatalytic processes | No |
| Photovoltaic paints | Yes |
| Functional surfaces for environmental protection | Yes |
| Hybrid materials combining photocatalysts and heterogeneous catalysts | Yes |
| Thin photocatalytic films for direct solar splitting of water | Yes |
|  | |
| **WP7 NANOTECHNOLOGY FOR TRAPPING AND CHEMICAL DEGRADATION OF POLLUTANTS** | |
| Nanomaterials for sorption | Yes |
| Natural based nanomaterials produced by “green” technology | Yes |
| Reactive sorbents for degradation of pesticides and highly toxic agents | Yes |
| Degradation of chemical warfare agents | Yes |
| Analysis of filtering capabilities of nanomaterials | Yes |
| Elimination of radionuclides contamination | No |
| Modified nanofiber filters; Advanced antimicrobial filters/membranes | Yes |
| Nanoiron for groundwater and waste water treatment | Yes |
| Nano-trapping of heavy metals | Yes |
|  | |
| **WP8 SENSING AND MONITORING OF POLLUTANTS** | |
| Efficient sensing of pollutants | Yes |
| Biosensing by new devises | Yes |
| Application of new sensors in monitoring of pollutants | Yes |
| Magnetic sensors; Magnetically assisted SERS sensors | Yes |
| Advanced electrochemical sensors | Yes |
| Graphene based nanosensors | Yes |
|  | |
| **WP9 TOXICITY AND RISKS OF NANOMATERIALS** | |
| Health risks | No |
| Environmental risks | No |
| „In vitro“ and „in vivo“ toxicity tests – cytotoxicity, genotoxicity, interactions with membrane | No |
| RNA gene expression changes and protein expression changes | No |
| Complete eco/aquatoxicity ecotoxicity evaluation | No |
| Toxicity against bacteria and fungi | No |

**Detailed description of expertise**

**Please, specify the main research topics connected with equipment**:

XPS: Surface Chemistry and Catalysis, Thin Films and Coatings, Semiconductors and Electronics, Energy Storage and Conversion, Nanomaterials and Low-Dimensional Systems, Corrosion and Surface Modification, Polymer Science and Organic Coatings,

**UPS:** Electronic Structure & Valence Band Analysis, Work Function & Energy Level Alignment, Thin-Film & Semiconductor Surface Studies,

**RS:** Vibrational Fingerprinting & Molecular Identification, Crystallinity & Phase Identification, Nanomaterial & 2D Material Characterization, Polymer & Organic Compound Analysis

**Please, specify the secondary research topics connected with equipment**:

XPS: Environmental and Biointerfaces, Adhesion and Surface Treatment, Tribology and Wear Studies

**UPS:** Organic & Inorganic Material Characterization

**RS:** Stress/Strain & Defect Analysis

**Keywords describing research area:**

Surface Chemistry, Material Characterization, Surface Modification and Functionalization

**Competence**

**Relevance for applied and industrial research:**

Understanding surface composition and chemical states for instance enables the development of better catalysts, coatings, and adhesives for industrial applications. It also aids in quality control and process optimization for manufacturing and material treatment.

UPS provides precise insights into surface electronic properties—such as work function and valence band structure—that are essential for optimizing semiconductor devices, thin-film solar cells, and organic electronic components, ensuring enhanced performance and reliability in high-tech industries. In parallel, Raman Spectroscopy offers a unique molecular fingerprint through vibrational analysis, facilitating rapid material identification, quality control, and process monitoring across sectors such as pharmaceuticals, automotive coatings, and environmental monitoring.

**Relevance for fundamental studies:**

Investigating surface interactions and chemical bonding provides insight into fundamental reaction mechanisms, adsorption processes, and molecular behavior at interfaces.

**Comments**



