



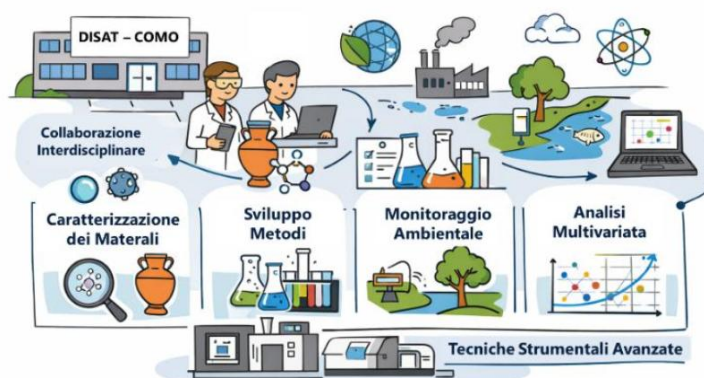
UNIVERSITÀ DEGLI STUDI
DELL'INSUBRIA

“STARTT: Analytical Strategies for Research and Technology Transfer”

Coordinator: Prof. Sandro Recchia

Mail: sandro.recchia@uninsubria.it

Keywords: analytical methods, materials characterization, environmental monitoring, multivariate analysis



Purpose: The STARTT facility aims to promote analytical innovation through the development of advanced methodologies, dedicated protocols, and multivariate analysis approaches, as well as artificial intelligence tools, for scientific, environmental, and technological applications. The facility focuses on the design, optimization, and validation of analytical protocols aimed at solving complex characterization challenges across multiple sectors, ranging from industry to environmental sciences. The facility serves as an infrastructure supporting research and technology transfer, fostering interdisciplinary collaborations.

Location: Department of Science and High Technology, Via Valleggio 9, 22100 Como, Italy.

Organization: The facility integrates a network of researchers with complementary expertise in the field of analytical chemistry. This organization represents a reference point for research and the development of broad-spectrum analytical solutions, structured into the following sub-units:

- Advanced methodologies for materials characterization, from nanomaterials to cultural heritage
- Development of analytical protocols
- Chemical and environmental monitoring
- Smart analytical methods and multivariate data analysis

Connection with the CRIETT Technological Platforms and the University Scientific Facilities:

This facility operates in collaboration with the Sustainability Platform within the framework of the Green Chemistry and Environmental Contaminants objectives, and with the Technologies for Energy, Health and Environment Platform within the framework of the Materials and Nanomaterials objective.

The facility makes use of the large-scale instrumentation available through the CRIETT *Technological Platforms for Matter Analysis and Characterization, and Microscopy and Imaging*.

Sub-unit: “Advanced Methodologies for Materials Characterization, from Nanomaterials to Cultural Heritage”

Coordinators: Dott. Davide Spanu, Prof. Sandro Recchia, Prof.ssa Laura Rampazzi, Prof.ssa Barbara Giussani

Mail: davide.spanu@uninsubria.it, sandro.recchia@uninsubria.it, laura.rampazzi@uninsubria.it, barbara.giussani@uninsubria.it

Keywords: materials characterization; photocatalysis; electrocatalysis; spectroscopy; cultural heritage



The sub-unit is dedicated to the development and application of advanced analytical methodologies for the chemical, structural, and functional characterization of materials, ranging from the nanoscale to materials of historical and artistic interest.

Its activities include the study of photo- and electrocatalytic materials for environmental and energy applications, with particular attention to reactivity mechanisms and to the evaluation of catalyst performance, stability, and morphology. The facility integrates spectroscopic, electrochemical, and advanced microscopy techniques in support of these activities.

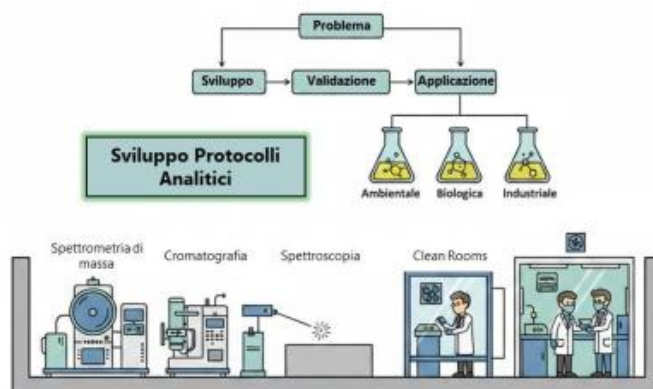
At the same time, non-invasive spectroscopic methodologies are developed and applied for the characterization of cultural heritage materials, with the aim of identifying constituent materials, describing manufacturing technologies, and assessing conservation status. The methodologies are portable and allow analyses to be carried out without contact with the surface of the artifacts.

Sub-unit: “Development of Analytical Protocols”

Coordinators: Prof. Sandro Recchia, Prof. Davide Spanu, Prof. Damiano Monticelli

Mail: sandro.recchia@uninsubria.it, davide.spanu@uninsubria.it, damiano.monticelli@uninsubria.it

Keywords: analytical protocols; chemical speciation; ICP-MS and ICP-OES; ESI-Orbitrap HRMS



The sub-unit is dedicated to the development, validation, and application of innovative analytical protocols for the qualitative and quantitative characterization of elements and chemical species in complex environmental, biological, and industrial matrices. The activities mainly focus on the study of ultra-trace elements and their speciation through advanced techniques such as ICP-MS (also coupled with chromatographic methodologies developed in-house and Laser Ablation for solid materials), ICP-OES, and ESI-Orbitrap HRMS. These protocols are applied in chemical speciation studies, isotopic analysis, and environmental monitoring, ensuring high precision and reliability. The facility integrates mass spectrometry, chromatography, and spectroscopy instrumentation, operating in controlled environments such as laminar flow hoods and clean rooms to ensure extremely clean conditions and to support analytical protocols tailored to specific research needs.

Sub-unit: “Chemical and Environmental Monitoring”

Coordinators: Prof. Gilberto Binda, Prof. Andrea Pozzi, Prof. Carlo Dossi, Prof. Davide Spanu, Prof. Damiano Monticelli

Mail: gilberto.binda@uninsubria.it, andrea.pozzi@uninsubria.it, carlo.dossi@uninsubria.it, davide.spanu@uninsubria.it, damiano.monticelli@uninsubria.it

Keywords: sampling; environmental quality; pollutants; risk assessment.



The Chemical and Environmental Monitoring sub-unit supports the analysis of various environmental matrices, including water, soils, sediments, and biological materials. It is equipped with advanced instrumentation for the determination of macronutrients and trace elements.

Its activities include the application of analytical methods for environmental monitoring and support for interdisciplinary research projects, including data interpretation and the planning of monitoring activities.

The facility is also implementing methodologies for the analysis of plastics and microplastics in environmental matrices, contributing to the development of new approaches for assessing their impact on ecosystems.

Sub-unit: “Smart Analytical Methods and Multivariate Data Analysis”

Coordinators: Prof. ssa Barbara Giussani

Mail: barbara.giussani@uninsubria.it

Keywords: analytical protocols; portable instrumentation; process control; multivariate analysis; artificial intelligence.



The Smart Analytical Methods and Multivariate Data Analysis sub-unit focuses on the development of analytical methods for the direct analysis of samples of different nature (food, pharmaceutical, polymeric, archaeological, etc.), based on the use of portable analytical instrumentation, particularly spectroscopic devices, integrated with multivariate data analysis techniques.

The activities also include the study and monitoring of products and processes through artificial intelligence approaches aimed at defining normal operating conditions and identifying possible deviations from normality. Multivariate analysis techniques are also applied to the study and optimization of products and processes through Experimental Design strategies.

Publications:

Advanced Methodologies for Materials Characterization, from Nanomaterials to Cultural Heritage:

1. Pinna, M., Zava, M., Grande, T., Prina, V., Monticelli, D., Roncoroni, G., Rampazzi, L., Hildebrand, H., Altomare, M., Schmuki, P., Spanu, D., & Recchia, S. (2024). Enhanced Photocatalytic Paracetamol Degradation by NiCu-Modified TiO₂ Nanotubes: Mechanistic Insights and Performance Evaluation. *Nanomaterials*, 14(19), 1577. <https://doi.org/10.3390/nano141915772>
2. Abudukade, M., Pinna, M., Spanu, D., De Amicis, G., Minguzzi, A., Vertova, A., Recchia, S., Ghigna, P., Mul, G., & Altomare, M. (2024). In Situ X-ray Absorption Spectroscopy Study of the Deactivation Mechanism of a Ni-SrTiO₃ Photocatalyst Slurry Active in Water Splitting. *The Journal of Physical Chemistry C*, 128(38), 16020–16031. <https://doi.org/10.1021/acs.jpcc.4c046883>
3. Geminiani, L., Paolo Campione, F., Corti, C., Giussani, B., Gorla, G., Luraschi, M., Recchia, S., & Rampazzi, L. (2025). Non-invasive identification of historical textiles and leather by means of external reflection FTIR spectroscopy. *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy*, 326, 125184. <https://doi.org/10.1016/j.saa.2024.125184>
4. Corti C., Bettinetti R., Brunello V., Motella De Carlo S., Rampazzi L., Recchia S., & Castelletti L. (2024). Ancient bread recipes: archaeometric data on charred findings. *Journal of Cultural Heritage*, 66 572-583. <https://doi.org/10.1016/j.culher.2024.01.009>

Development of Analytical Protocols:

1. Roncoroni, G., Spanu, D., Binda, G., & Monticelli, D. (2025). Metal Ion Isotope Ratio Using ESI-Orbitrap HRMS: Proof of Concept and Initial Performance Evaluation for Lead Isotopic Ratios. *Analytical Chemistry*, 97(25), 13176–13183. <https://doi.org/10.1021/acs.analchem.5c010332>
2. Spanu, D., Butti, L., Recchia, S., Dossi, C., & Monticelli, D. (2024). A high-throughput, straightforward procedure for biomonitoring organomercury species in human hair. *Talanta*, 270, 125612. <https://doi.org/10.1016/j.talanta.2023.1256124>
3. Spanu, D., Roncoroni, G., Cinosi, A., Furian, R., Siviero, G., & Monticelli, D. (2022). Quantitative extraction and determination of trace elements by surfactant-free liquid-liquid microextraction from aviation and motor fuels. *Fuel*, 310, 122458. <https://doi.org/10.1016/j.fuel.2021.122458>
4. Spanu, D., Monticelli, D., Binda, G., Dossi, C., Rampazzi, L., & Recchia, S. (2021). One-minute highly selective Cr (VI) determination at ultra-trace levels: An ICP-MS method based on the on-line trapping of Cr (III). *Journal of Hazardous Materials*, 412, 125280. <https://doi.org/10.1016/j.jhazmat.2021.125280>

Chemical and Environmental Monitoring:

1. Binda, G., Carnati, S., Passignani, N., Hurley, R., Nizzetto, L., Spanu, D., Kalčíková, G., & Pozzi, A. (2025). A screening of metal (loid) content in conventional and compostable plastic polymers:

understanding the sources and the connected environmental implications. *Environmental Pollution*, 126364. <https://doi.org/10.1016/j.envpol.2025.126364>

2. Binda, G., Carnati, S., Spanu, D., Bellasi, A., Hurley, R., Bettinetti, R., Monticelli, D., Pozzi, A., & Nizzetto, L. (2023). Selection of the optimal extraction protocol to investigate the interaction between trace elements and environmental plastic. *Journal of Hazardous Materials*, 452, 131330. <https://doi.org/10.1016/j.jhazmat.2023.131330>
3. Binda, G., Frascoli, F., Spanu, D., Ferrario, M. F., Terrana, S., Gambillara, R., Trotta, S., Noble, P. J., Livio, F. A., Pozzi, A., & Michetti, A. M. (2022). Geochemical Markers as a Tool for the Characterization of a Multi-Layer Urban Aquifer: The Case Study of Como (Northern Italy). *Water*, 14(1), 124. <https://doi.org/10.3390/w14010124>

Smart Analytical Methods and Multivariate Data Analysis:

1. Monti, M., Pellacani, S., Strani, L., D'Alessandro, A., Cocchi, M., Giussani, B., & Durante, C. (2026). Smart screening of durum wheat: a comparative study of NIR portable sensors for protein and moisture content. *Microchemical Journal*, 220, 116378. <https://doi.org/10.1016/j.microc.2025.116378>
2. Giussani, B., Monti, M., & Riu, J. (2024). From spectroscopic data variability to optimal preprocessing: leveraging multivariate error in almond powder adulteration of different grain size. *Analytical and Bioanalytical Chemistry*, 417(7), 1393–1405. <https://doi.org/10.1007/s00216-024-05710-1>.
3. Gorla, G., Fumagalli, S., Jansen, J. J., & Giussani, B. (2022). Acquisition strategies for fermentation processes with a low-cost miniaturized NIR-spectrometer from scratch: Issues and challenges. *Microchemical Journal*, 183, 108035. <https://doi.org/10.1016/j.microc.2022.108035>



Thermo Scientific ICP-MS ICAP Q coupled with the CETAC ASX-260 autosampler: This is an inductively coupled plasma mass spectrometry instrument designed for ultra-trace elemental analysis. The ICP generates a high-temperature plasma that atomizes and ionizes the sample; the mass spectrometer then detects and quantifies isotopes with high sensitivity. The CETAC ASX-260 autosampler enables automated handling of multiple vials, increasing analytical efficiency and reproducibility. It is ideal for environmental monitoring, food analysis, and complex materials.



Laser Ablation New Wave UP266: This is a compact, high-precision laser ablation system designed to remove material from solid samples in a controlled manner. The vaporized material is transported to a spectrometer (typically ICP-MS) for elemental or isotopic analysis. The system offers high spatial resolution, minimal thermal damage, and versatility across a wide range of materials, making it suitable for geochemistry, advanced materials, archaeometry, and microanalytical studies.



Thermo Scientific ICP-MS ICAP MSX coupled with the Thermo ISC-65 autosampler: This is an inductively coupled plasma mass spectrometer capable of ultra-trace elemental analysis with high precision. The high-temperature plasma atomizes and ionizes the sample, while the spectrometer detects specific isotopes. The ISC-65 autosampler automates sample uptake and introduction, improving efficiency, reproducibility, and throughput. It is well suited for environmental, food, industrial chemical, and complex materials applications.



ICP-OES Agilent 5800: This is an inductively coupled plasma optical emission spectrometer designed for high-sensitivity multi-element analysis. The plasma generates characteristic light emitted by the elements present in the sample, which is then detected and quantified. The integrated autosampler enables automated and reproducible introduction of liquid samples, increasing efficiency and productivity. The instrument is ideal for environmental, food, industrial, and complex materials applications, offering precision, accuracy, and ease of use.



Atomic Absorption - GBC 908-SYS3000: This is an atomic absorption spectrometer designed for the quantitative determination of metallic and metalloid elements in liquid samples at trace and ultra-trace levels. Atomization is performed using a graphite furnace, which provides high sensitivity and low detection limits through programmed sample heating. The instrument ensures good selectivity and precision and is particularly suitable for environmental, food, biological, and quality control applications.



LC-MS Orbitrap Exploris 120 Basic System: This is a liquid chromatography–mass spectrometry system based on a high-resolution Orbitrap analyzer, designed for the identification and accurate quantification of compounds in complex matrices. The instrument provides high resolution and mass accuracy, enabling both targeted and untargeted analyses. The ionization interface (IC) ensures efficient ionization of compounds eluting from the LC. It is ideal for environmental, chemical, food, pharmaceutical applications, and emerging contaminant studies.



HPLC – SHIMADZU SCL-10 AVP CE (LV) with DAD detector: This is a high-performance liquid chromatography system used for the separation and quantification of compounds in complex matrices. The diode array detector (DAD) enables UV–Vis spectral acquisition, while the thermostated column oven and gradient elution ensure high reproducibility and separation efficiency. The instrument is suitable for environmental, chemical, pharmaceutical, and food applications.



Eco IC – Metrohm: This is an ion chromatography system designed for the separation and quantitative determination of anions and cations, with a focus on major ions in aqueous matrices. The system uses dedicated columns and a controlled elution setup to ensure high resolution and sensitivity, while the conductivity detector enables precise and reproducible measurement of ion concentrations. It is ideal for environmental, industrial, and food applications, as well as for the analysis of drinking and wastewater.



GC-MS – Thermo Scientific™ ISQ 7610 Single Quadrupole: This is a gas chromatography–mass spectrometry system designed for the qualitative and quantitative analysis of volatile and semi-volatile compounds. The GC column separates mixture components, while the single quadrupole mass spectrometer enables accurate identification and quantification based on mass and fragmentation patterns. The instrument offers high sensitivity, selectivity, and reproducibility, making it suitable for environmental, food, chemical, and industrial applications.



Gas Chromatographs – Hewlett Packard 5890 with ECD, FID, and TCD detectors: This is a gas chromatography system designed for the separation, identification, and quantification of volatile and semi-volatile compounds in various matrices. It can be equipped with an electron capture detector (ECD), flame ionization detector (FID), and thermal conductivity detector (TCD), providing flexibility for the analysis of pesticides, solvents, industrial gases, and organic/inorganic components. It is widely used in environmental, chemical, food, and industrial applications, ensuring high sensitivity and reproducibility.



FT-IR spectrometer – Thermo Scientific Nicolet iS10 with ATR interface: This is a Fourier-transform infrared spectrometer designed for qualitative and quantitative analysis of organic and inorganic materials. The ATR (Attenuated Total Reflectance) interface enables rapid analysis of solid, liquid, and thin-film samples without complex preparation, ensuring reproducible and highly sensitive measurements. The instrument is ideal for applications in materials chemistry, environmental science, pharmaceuticals, and polymer science.



FTIR Bruker Alpha equipped with external total reflection module: This is a spectrometer designed for the identification of molecular compounds. The external reflection mode enables non-invasive and Mail-free surface analysis. The instrument, portable and equipped with a photographic stand, is particularly suitable for cultural heritage studies, including large objects whose conservation state does not allow destructive or invasive methods or physical movement.



HORIBA Xplora Plus confocal Raman microscope: This instrument enables chemical characterization of materials by coupling an optical microscope with a Raman detector, without requiring complex sample preparation. It allows simultaneous imaging and precise chemical identification with high spatial resolution. The system is particularly suited for solid materials, particles, and heterogeneous surfaces, enabling point analysis and two- and three-dimensional chemical mapping. Main applications include identification and characterization of plastics and microplastics, study of biofilms and biological materials, analysis of minerals and sediments, material quality control, and support for environmental, geological, and advanced materials research.



UV-Vis spectrophotometer – Shimadzu UV-2600i: This is a double-beam UV-Vis spectrophotometer designed for absorbance and transmittance measurements over a wide spectral range. It is also equipped with an integrating sphere, allowing analysis of solid or powder samples by collecting diffusely reflected light for more representative measurements. The instrument offers high stability, photometric accuracy, and low noise, making it ideal for environmental, chemical, biological, and materials science applications.



Portable NIR sensor – NeoSpectra Scanner: The NeoSpectra Scanner is a portable near-infrared (NIR) sensor designed for rapid, non-destructive, in-situ analysis of samples in the field. It is based on an integrated MEMS interferometer and typically covers the 1350–2500 nm spectral range, acquiring diffuse reflectance spectra. Thanks to its compact size and ease of use, it is suitable for screening, quality control, and process monitoring applications. The acquired data can be easily integrated with chemometric and artificial intelligence models for multivariate analysis.



ESEM-FEG Scanning Electron Microscope – FEI (PHILIPS) ESEM-FEG XL30: This is an environmental scanning electron microscope equipped with a field emission gun (FEG), designed for high-resolution observation of surfaces and microstructures. The ESEM mode allows analysis of non-conductive or partially hydrated samples without complex preparation. The integrated EDX system enables qualitative and semi-quantitative elemental analysis. It is suitable for advanced materials, environmental sciences, polymers, and microanalytical studies.



Scanning Electron Microscope – Zeiss GeminiSEM 360: This is a state-of-the-art scanning electron microscope designed for ultra-high-resolution imaging of surfaces and microstructures. Equipped with a field emission gun (FEG) and advanced secondary and backscattered electron detectors, it provides high-contrast imaging and detailed topographic analysis. The system is ideal for advanced materials, nanoscience, polymer science, electronics, and microanalysis. It is integrated with elemental microanalysis systems such as EDX for elemental identification.



Potentiostats – Metrohm 663 VA Stand with MicroAutolab Type III and Potentiostat 757 VA Computrace: These are electrochemical systems designed for the study of redox processes and advanced voltammetric analyses. They enable highly sensitive and reproducible measurements with precise control of potential and current, supporting trace metal determination in solution as well as laboratory and applied research experiments. The instruments are suitable for environmental, analytical chemistry, biochemical applications, and surface studies.



Potentiostats – AMEL 4330 and 2559: These are electrochemical systems designed for the study of redox processes and voltammetric and amperometric analyses. They provide high sensitivity and accuracy with precise control of potential and current, and are suitable for trace metal determination, electrocatalysis studies, and surface analysis. Available techniques include chronoamperometry, cyclic voltammetry, linear sweep voltammetry, stripping voltammetry, and coulometry, making them ideal for environmental, analytical chemistry, biochemical, and applied research applications.



Shimadzu TOC-L Analyzer: This is an automated system for measuring Total Organic Carbon (TOC) in liquid environmental samples, with extended capability for total nitrogen and carbon analysis in solid or suspended samples. Based on high-temperature catalytic combustion and NDIR detection, it enables reliable determination of various carbon species over a wide concentration range. The system is widely used in environmental studies, water quality monitoring, biogeochemical cycling of carbon and nitrogen, assessment of natural matrices, and analysis of complex samples in academic and applied research contexts.

	<p>Simultaneous Thermal Analyzer TG-DSC – NETZSCH STA 409 PC: This is a simultaneous thermal analysis instrument combining thermogravimetry (TG) and differential scanning calorimetry (DSC). It enables the study of mass changes and thermal effects of a sample as a function of temperature or time. It is particularly suitable for the thermal characterization of materials, polymers, and organic and inorganic compounds, providing information on thermal stability, phase transitions, and decomposition processes.</p>
	<p>X-ray Diffractometer – SIEMENS D5000: This is an X-ray diffraction instrument designed for the identification and structural characterization of crystalline materials. Based on the measurement of diffraction patterns generated by the interaction of X-rays with the crystal lattice, it enables qualitative and quantitative phase analysis. It is widely used for studies of inorganic materials, powders, minerals, catalysts, and advanced materials, offering reliable performance and good analytical resolution.</p>
	<p>TPD-MS (Temperature-Programmed Desorption – Mass Spectrometry): This is a combined analytical system designed to study the controlled desorption of chemical species from solid surfaces. The sample is heated according to a programmed temperature profile, while released gases or vapors are analyzed in real time using quadrupole mass spectrometry (Extorr XT200M). The instrument allows identification of adsorbed species, desorption kinetics, and surface-gas interactions, making it ideal for catalysis studies, materials chemistry, polymer science, and surface contaminant analysis.</p>
	<p>Nuclear Magnetic Resonance – BRUKER AVANCE I 400 MHz: This is a high-resolution NMR spectrometer operating at 400 MHz, used for the structural characterization of organic and inorganic compounds. The instrument enables both one-dimensional and multidimensional analyses, providing detailed information on molecular structure, dynamics, and sample purity. It is widely used in chemistry, materials science, and pharmaceutical research.</p>
	<p>Ultrapure Water System – Merck Milli-Q EQ 7008: This is a system designed for the continuous production of high-quality ultrapure water, free of ions, particles, organic compounds, and microorganisms. The system integrates filtration units, ion-exchange resins, and reverse osmosis membranes, ensuring water that meets stringent standards for analytical, chemical, biological, and general laboratory applications. It is ideal for reagent preparation, sensitive experiments, chromatography, spectroscopy, and microbiology.</p>



Milestone DuoPUR SubBoiling: This is a sub-boiling distillation and acid purification system designed for the preparation of ultra-high-purity reagents for trace elemental analysis. It uses sub-boiling technology to vaporize and recondense acids (typically HNO_3 and HCl), removing metallic impurities and ensuring high acidity with extremely low contaminant levels. The instrument is ideal for applications in mass spectrometry, analytical chemistry, environmental monitoring, and trace metal laboratories.



Fritsch Pulverisette 0 micro mill: This is a laboratory grinder designed for the crushing and fine pulverization of small amounts of solid samples. It produces very fine powders quickly while maintaining chemical integrity and minimizing cross-contamination. The instrument is suitable for chemistry, materials science, geochemistry, environmental analysis, and sample preparation for techniques such as ICP-MS, XRD, and spectroscopy.



Milestone Ethos One microwave digestion system: This is a microwave-assisted digestion system designed for rapid and safe sample preparation prior to chemical analysis. It uses controlled microwave heating to uniformly process samples in closed high-pressure vessels, ensuring complete digestion of complex organic and inorganic matrices. It is widely used in analytical chemistry, environmental monitoring, food analysis, and trace metal determination, offering high efficiency, reproducibility, and operational safety.



Cressington Sputter Coater 108 Auto: This is an automatic sputter coating system designed to deposit uniform thin conductive films (typically gold, platinum, or alloys) onto samples prior to scanning electron microscopy (SEM) analysis. The coating improves electrical conductivity of non-conductive samples, reducing charging artifacts and enhancing image contrast and resolution. It is widely used in advanced materials, polymers, nanoscience, and microanalysis studies.



Memmert IPP110eco Peltier-cooled incubator: This is a laboratory incubator designed for precise and uniform temperature control using Peltier technology, enabling both heating and cooling without refrigerants. It features integrated LED lighting for the growth of photosynthetic organisms. The system provides high thermal stability and low energy consumption and is suitable for controlled incubations, microbiological studies, environmental testing, and research applications requiring reproducible thermal conditions.



Clean room and laminar flow hoods – MiTec and BioAir Aura HZ72: The MiTec clean room provides a controlled environment with low levels of particulate and chemical contaminants, making it suitable for sensitive operations in chemistry, biotechnology, and advanced materials research. The BioAir Aura HZ72T laminar flow hoods ensure protection of both the sample and the operator by maintaining a HEPA-filtered airflow that minimizes cross-contamination during handling of sterile samples or sensitive materials. This integrated system enables safe and reproducible workflows in environmental, chemical, biological, and pharmaceutical applications.