

Catalysis “Toolbox”

Reaction experiments (micro or lab-scale reactors)

- Activity/selectivity/stability
- Kinetic parameters
- Deactivation characteristics
- Mechanistic studies

Bulk, structural and molecular characterization (*ex-situ*, *in-situ*, *operando*)

- X-ray Diffraction (XRD)
- Laser Raman Spectroscopy (LRS)
- Diffuse Reflectance Infrared Fourier Transform Spectroscopy (DRIFTS)
- Transmission IR Spectroscopy
- Photoacoustic IR Spectroscopy
- Nuclear Magnetic Resonance (NMR)
- Electron-spin Resonance (ESR)
- Mössbauer Spectroscopy
- Superconducting Quantum Interference Device (SQUID) Magnetometry
- X-ray Absorption Spectroscopy (XAS):
 - Extended X-ray Absorption Fine Structure (EXAFS)
 - X-ray Absorption Near Edge Structure (XANES)

Compositional analysis

- Inductively Coupled Plasma – Optical emission Spectrometry (ICP-OES)
- X-ray Fluorescence (XRF)

Physical characterization

- Surface area
- Pore volume / pore size distribution
- Dispersion
- Particle size

Microscopic techniques (Particle size/shape, morphology, dispersion, composition)

- Scanning electron microscopy (SEM)
- Transmission electron microscopy (TEM)
- Scanning transmission electron microscopy (STEM)
- High angle annular dark field (HAADF) STEM
- Energy Dispersive X-ray Analysis (EDXA)

Surface characterization

- X-ray Photoelectron Spectroscopy (XPS)
- Secondary Ion Mass Spectroscopy (SIMS)
- Auger-Electron Spectroscopy (AES)

Thermal analysis

- Thermo-gravimetric Analysis (TGA)
- Differential Thermal Analysis (DTA)
- Differential Scanning Calorimetry (DSC)
- Temperature Programmed Reduction (TPR)
- Temperature Programmed Oxidation (TPO)
- Temperature Programmed Desorption (TPD)
- Temperature Programmed Reaction (TPRxn)

Electrochemical Techniques

- Electrochemical Impedance Spectroscopy
- Electrical conductivity measurements
- Voltammetry
- Fuel Cell testing

