of several molecules, and thus the information obtained by classic SEVS methods is insufficient.

Techniques that offer the best lateral resolution are those integrating SEVS spectroscopic techniques in the form of near-field techniques with scanning probe microscopy (SPM), especially atomic force microscopy (AFM). The most important ones are tip-enhanced Raman spectroscopy (TERS) and scanning near-field infrared microscopy (SNIM). TERS combines SPM with Raman spectroscopy and enables both outstanding detection sensitivity down to single-molecule level and high spatial resolution down to sub-nanometers. Thus, TERS provides chemical information and morphological description about the nano-scaled surface simultaneously. The tips used in TERS are silver/gold or silver/gold-coated materials. The apex is usually only a few atoms wide, which makes it the dominant enhancing source of Raman signals. The electromagnetic field, arising in the close proximity of the tip apex on which the laser beam is focused, gives rise to the signal of molecules or even one molecule in this (near) field. The reliability of TERS results relies essentially on the stability and reproducibility of the TERS tips. In the case of SNIM, the source of irradiation is a tunable IR laser, adjusted to a specific wavenumber for an imaging/mapping experiment. The laser beam is focused to a space under the tip and coupled with tip oscillations. SNIM measurement reveals the chemical nano-scaled imaging information on the sample based on "distribution" of absorption and radiation phase shifts at the selected wavenumber for the molecules which absorb the radiation at this wavenumber and are located in the gap between the tip and supporting surface/substrate.

The experiences related to the TERS and SNIM studies performed on various model samples focused on either nanomaterial development (including electrochemical sensors) or chemico-structural analysis of biologically relevant samples will be overviewed and discussed in this contribution.

DESIGN OF ROBUST NI-BASED CATALYSTS AND THE APPLICATION OF AN INTENSIFIED PROCESS FOR CO$_2$ DRY REFORMING OF METHANE TO SYNGAS

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CO$_2$ dry reforming of methane (DRM) to syngas (global demand achieved ~290 GW thermal/Annum in 2016) has recently gained ever-increasing attention for its great potential in converting two greenhouse gases into valuable syngas-a building block for the production of synthetic fuels, ferti lisers and chemicals. DRM can also be valorizing natural gas fields and aerobic digestion of bio-wastes with high concentration of CO$_2$, whose application is currently economically unprofitable.

However, the DRM suffers from grand challenges in catalysts deactivation due to sintering and coking. which stimulate the exploration of stable yet robust catalytic materials and intensified reforming processes.

Addressing the above challenges facing DRM, we dedicate improving the performance of cost-effective Ni-based catalysts via tailoring redox property and metal-support interaction, in which the combination of inelastic neutron scattering and
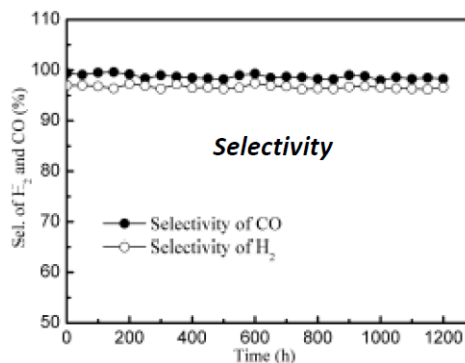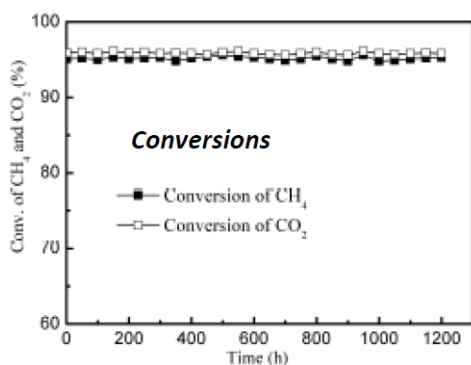
classical characterisations allows us to gain insights of the anti-coking mechanism. The application of certain tailored catalyst in an external-field-intensified reforming process, ~1200 hour continuous dry reforming with negligible carbon deposition has been achieved. Catalytic combustion was also adopted in order to provide energy for DRM at desired efficiency and low emission, inspiring investigation of CO_2 mitigation potential via multi-reforming processes (thermodynamic modelling) and upgrading low heat-value coke oven gas, blast furnace gas, etc.