

Sensitivity enhancement and dynamic behavior analysis by Modulation Excitation Spectroscopy: The principle and applications in heterogeneous catalysis

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Modulation Excitation Spectroscopy (MES) is a powerful technique to investigate the dynamic behavior of chemical and physical systems.^{1,2} When a system is perturbed by a periodic change of a parameter (so-called *stimulation*), e.g. concentration, pH, light flux, and temperature, affecting a chemical or physical state of a system, the response of the state will also be periodic. The periodically alternating response can be selectively detected and the signal to noise ratio can be significantly enhanced by the detection method of the MES, Phase Sensitive Detection (PSD). The MES shows its great unique strength upon combination with broadband spectroscopy, e.g. IR and Raman spectroscopy or the combination of those, allowing kinetic differentiation of species and hence giving insights into transformation mechanisms and pathways.

In this talk, the principle of MES, how we achieve drastic sensitivity enhancement leading to high time-resolution and how we can study kinetics of a system using the phase-domain analysis, is presented, followed by some examples of MES in heterogeneous catalysis at gas-solid and solid-liquid interfaces. Finally, possibilities and expected advantages of MES combined with *in situ* XRD/Raman/XAS are discussed.

[1] D. Baurecht, and U.P. Fringeli, *Rev. Sci. Instrum.* (2001) 72, 3282

[2] A. Urakawa, T. Bürgi, and A. Baiker, *Chem. Eng. Sci.* in press