In-situ XAS, RIXS and TXM experiments

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New developments in in-situ x-ray absorption (XAS), transmission x-ray microscopy (TXM) and resonant inelastic x-ray scattering (RIXS) will be discussed. First a brief introduction is given of x-ray absorption spectroscopy, including the multiplet interpretation of XAS spectral shapes [1,2].

Nanoscale chemical imaging of catalysts under working conditions is possible with Transmission X-ray Microscopy. We have shown that TXM can image a catalytic system under relevant reaction conditions and provides detailed information on the morphology and composition of the catalyst material in situ [3]. The 20 nanometer resolution combined with powerful chemical speciation by XAS and the ability to image materials under reaction conditions opens up new opportunities to study many chemical processes. I will discuss the present status of in-situ TXM, with an emphasis on the abilities of the 10+ nm resolution TXM technique in comparison with 0.1 nm STEM-EELS [4,5]. Hard X-ray TXM allows the measurement of chemical images and tomographs under more realistic conditions, using a capillary reactor at 10 bar Fischer-Tropsch conditions [6].

The last part of the talk deals with resonant inelastic x-ray scattering (RIXS), In 2p3d RIXS one scans through the 2p XAS edge and measures the optical excitation range. As an example, the RIXS spectra of CoO will be discussed. The experimental resolution of 100 meV at ADRESS allows the detailed observation of the electronic structure. First-principle theoretical modelling was performed for the ground state and multiplet analysis for the RIXS experiments. The implications for measurements on coordination compounds (cobalt carboxylates) and cobalt nanoparticles is discussed, in particular the comparison with optical spectroscopy [7]. Related to the RIXS measurements is the analysis of Fluorescence yield (FY) detected x-ray absorption spectra (XAS), including the intrinsic deviations of FY-XAS spectral shape from the XAS spectrum [8,9].

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[1] Core Level Spectroscopy of Solids
Frank de Groot and Akio Kotani (Taylor & Francis CRC press, 2008)
[2] Download the x-ray spectroscopy simulation software at
http://www.anorg.chem.uu.nl/CTM4XAS/
[3] E. de Smit et al. Nature 456, 222 (2008).
[4] F.M.F. de Groot et al. ChemPhysChem 11, 951 (2010);
[5] M. van Schooneveld et al. Nature Nanotechnology 5, 538 (2010)
[6] I. Gonzalez-Jimenez et al. Angew. Chem. 124 12152 (2012)
[7] M. van Schooneveld et al. Angew. Chem. 52, 1170 (2012)
[8] R. Kurian, et al. J. Phys. Cond. Matt. 24, 452201 (2012)
[9] F.M.F. de Groot, Nature Chemistry 4, 766 (2012)
