Multilengthscale characterisation of industrially relevant Fischer-Tropsch catalysts

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The Fischer-Tropsch (FT) process is a key technology in the production of synthetic fuels from natural gas, coal, biomass and increasingly from waste. One of the main factors influencing the product distribution of the FT process is the composition and structure of the catalyst which is typically based on iron or cobalt with promoters such as Platinum or ruthenium. One approach which has been used to increase the selectivity of cobalt catalysts is to pre-treat the catalyst with a reduction-oxidation (RO) cycle prior to activation.
A multilengthscale study of Co_3O_4 on alpha-Al_2O_3 as well as Pt promoted Co_3O_4 on Al_2O_3 is the subject of this paper. By combining state-of-the-art aberration corrected microscopy and spectroscopy measurements carried out on an ARM200F in the recently opened electron Physical Sciences Imaging Centre (ePSIC) within the Diamond Light Source facility (DLS)) with measurements carried out at the I18 and I14 synchrotron beamlines @DLS it was possible to cover the lengthscale range from Å to several 100 um which enables us to get a more complete picture of the catalyst under investigation.
This contribution highlights the effect of a redox treatment on the catalyst structure and performance. Catalyst testing results as well as ex-situ characterization data such as ICP, XRD, TPR, BET and hydrogen chemisorption giving a clear representation of the variations in the catalyst.
Using state-of-the-art in-situ synchrotron (I18@DLS) XRD imaging, XANES mapping and tomography a complete picture of the catalyst material at a 5um resolution could be obtained (Figure 1).
These results are further enhanced with the newly commissioned I14 hard X-ray nanoprobe beamline @DLS, enabling to bridge the lengthscale from several um down to 100 nm.
I18 and I14 beamline results are complemented by a state-of-the-art aberration corrected microscopy study which will shine light on the Pt and Co location as well as their chemical state (Figure 2). We will discuss the presence of Pt in different oxidation states affected by the RO treatment and their distribution within the sample from the Å to um scale.
This contribution shows the strength of combining highly spatially resolved TEM techniques with synchrotron based spectroscopic techniques in order to get a complete picture of industrially relevant catalyst materials.

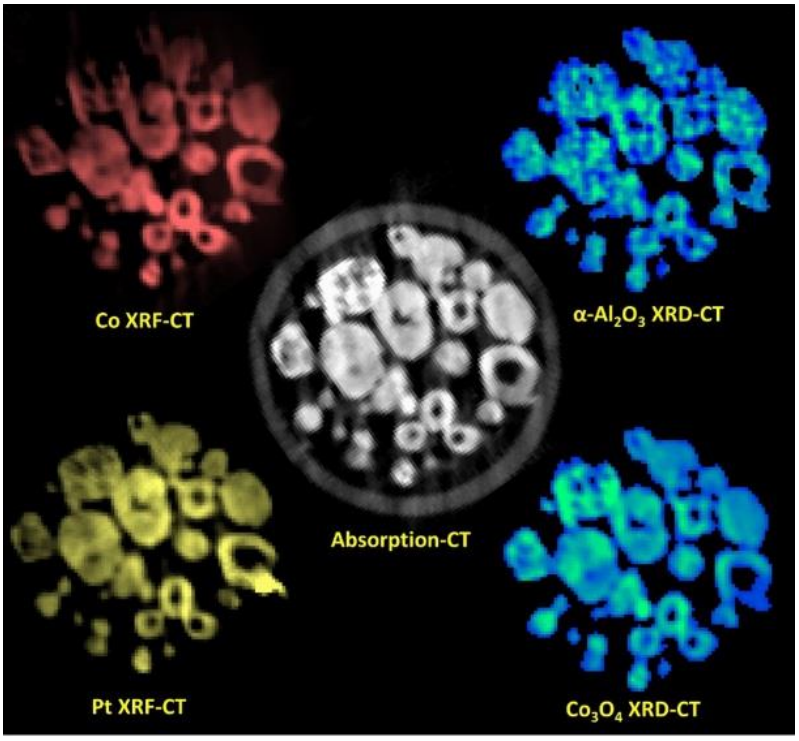

Figure 1: Absorption-CT, Co and Pt XRF-CT and XRD-CT reconstructions of Al_2O_3 and Co_3O_4 area (parent material) acquired at I18

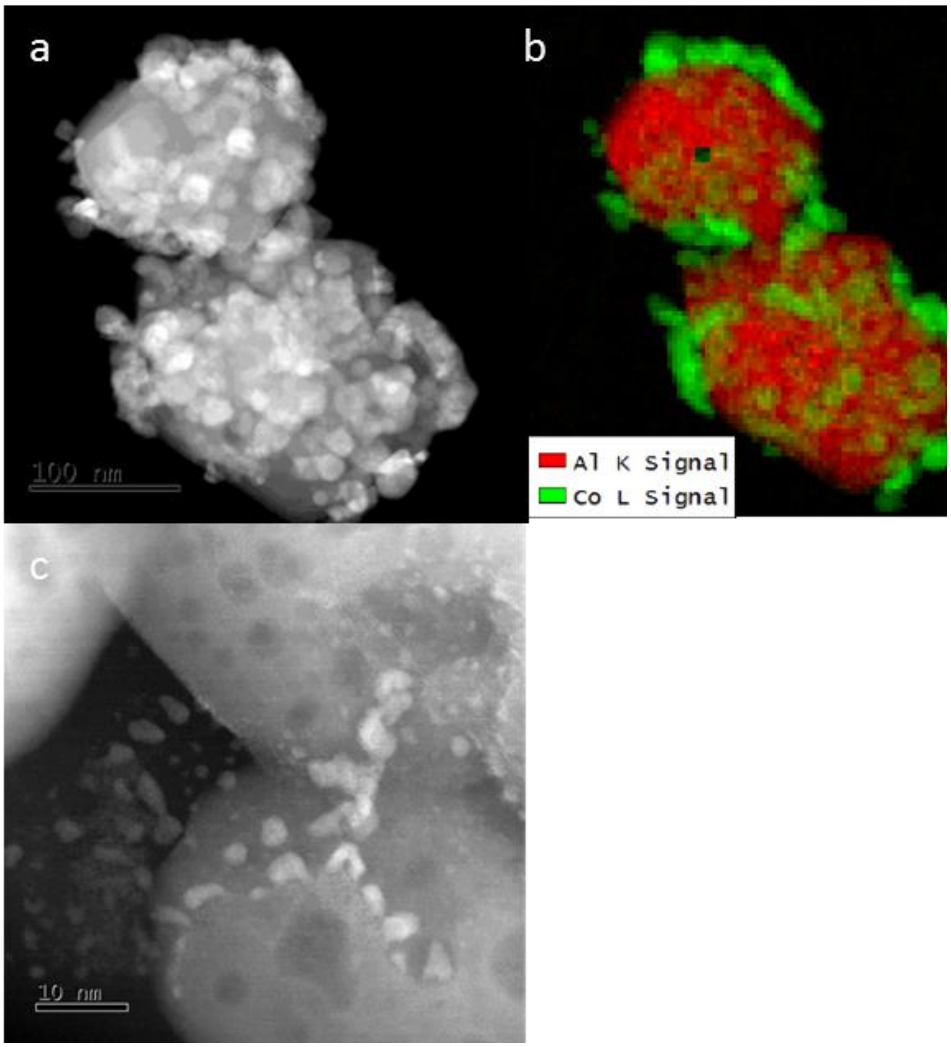

Figure 2: HAADF STEM image (a), STEM Al and Co EDX map (b) of Co/α-Al_2O_3 RO treated sample; HAADF STEM image (c) of Pt doped Co/α-Al_2O_3.