In-situ Resonant Inelastic X-ray Scattering of cobalt Fischer-Tropsch catalysts

Purpose of the experiment:

Carbon nanotube (CNT) supported Cobalt Fischer–Tropsch Synthesis (FTS) catalyst is one of the most widely used FTS catalysts, however, the change of cobalt species during the activation/reduction procedure is still not fully unveiled. The cobalt species, for lab and industry catalysis, is one of the key information. Although some other works by using in-situ X-ray Diffraction (XRD) or in-situ X-ray absorption (XAS), etc., were trying to find the cobalt species information, the limitation of them prevented the satisfactory explanation. We aim to use the in-situ Resonant Inelastic X-ray Scattering (RIXS) for the vacuum reduction of the CNT supported Co_3O_4 FTS catalyst, in order to trace the change of the cobalt species, especially the temperature dependent valence information.

Summary of the result:

We performed the in-situ measurement on our Co_3O_4/CNT sample at four temperatures, 30K, 300K, 473K and 823K. From the cobalt L edge XAS spectra, we could easily see the change of the cobalt L_3 and L_2 edges. The RIXS spectra at each temperature allows us to more accurately define the cobalt valence information, especially the determination of Co^{2+} and metallic cobalt at highest temperature.

Experimental Methods:

XAS were measured by both partial florescence yield and total electron yield mode. Excitation energy for RIXS spectra were based both on the XAS data and theoretical prediction. Under each temperature measurement, three excitation energy were chosen on the pre-edge of Co^{2+}, peak of Co^{2+} and the peak Co^{3+}. RIXS spectra at each excitation energy were collected by two times at the same measurement condition in order to get more reliable data.

Conclusion:

The temperature dependent RIXS spectra acquired from beamline BL07LSU offered us the complimentary information from in-situ STXM data we get from Swiss Light Source. From the data we could more accurately determine the reduction of our catalyst under vacuum, especially the cobalt valence information at highest temperature.