AC-HRTEM vs AC-STEM for imaging of electron sensitive zeolites

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Zeolites composed of alumino-silicate frameworks have great potentials in various fields. Their covalent frameworks built from TO4-tetrahedra (T: Si or Al) produce various kinds of nano-cavities inside the crystals. Non-framework species such as counter cations and adsorbed molecules are located within nanocavities. Structural information about framework and non-framework species is essential for various applications of zeolitic materials. While X-ray diffractometry have been a useful tool for structural analysis, they hardly bring any information on non-periodic structures such as some kind of non-framework species. A high-resolution electron microscopy has great advantage of structural analysis in an atomic scale. However, its applicability for zeolitic materials is severely restricted, due to the problem of electron irradiation damage. In order to improve the quality of high-resolution image, optical conditions must be optimized to zeolitic materials.
In this study, we considered validities of aberration corrected (AC)-HRTEM and AC-STEM for imaging of electron sensitive zeolites. Especially after the development of aberration corrector, comparison between AC-STEM and AC-HRTEM as low damage imagings have been an important subject. We observed some types of zeolites with low dose technique of AC-(S)TEM. All observations were performed with an accelerating voltage of 200 kV. Negative and positive Cs conditions were applied to an AC-HRTEM imaging. Annular bright field and high-angle annular dark field images were acquired simultaneously in the AC-STEM mode. Signal-to-noise ratios (SNRs) of raw AC-HRTEM images were improvement over AC-STEM images. In contrast to SNRs of raw images, spatial resolution of filtered AC-STEM images, namely images removed Poisson nose, were superior to AC-HRTEM images. In addition to experimental observations, image contrast of each imaging techniques were estimated by multi-slice simulation depending on optical conditions and specimen thickness. From the result of image simulations, tolerance thickness limit for atomics scale imaging were different from each imaging mode. We suppose the optimum imaging mode according to target zeolites and their purpose.
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