Characterization of Microenvironmental Acidity in Solid Acid Catalysts by Single Molecule Spectroscopy

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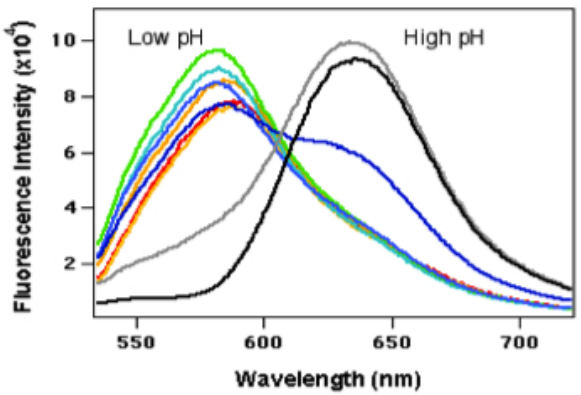
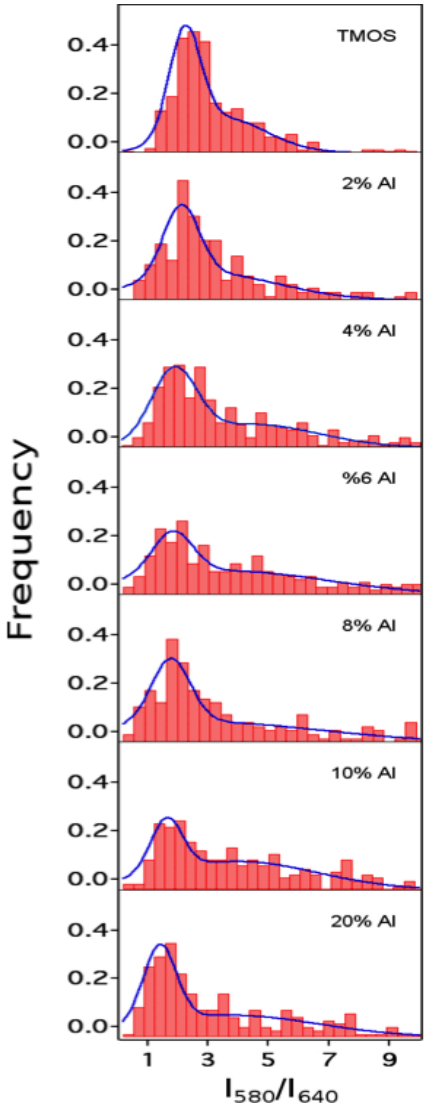
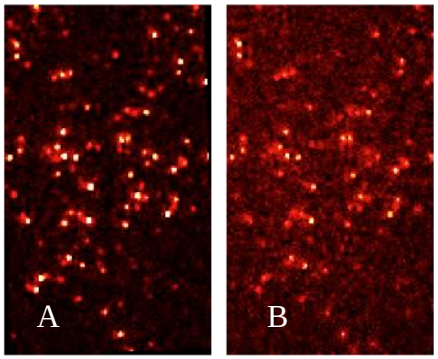
We have demonstrated that single molecule spectroscopic methods provide a powerful new means to study the acidity of individual microenvironments in heterogeneous catalysts. Our studies reveal the approximate local pH within the catalysts and provide valuable information on the pKas of incorporated acid sites. Studies of aluminosilicate films demonstrate that the local pH decreases with increased aluminum doping. The pH distributions depict nanoscale variations in materials acidity, resulting from an inhomogeneous population of acid sites.





Dual-color single molecule video microscopy was employed to determine the approximate pH within individual microenvironments. C-SNARF-1 was used as the pH-sensitive probe. The local acidity was determined from the ratio of C-SNARF-1 emission in the two detection channels for each single molecule.



By careful interpretation of intensity ratio histograms, we found two classes of microenvironments in pure silica films, with pH near 4 and 7.5. These were converted to be more acidic sites upon aluminum doping. This research demonstrates the value of single molecule methods for characterizing acidity distributions in solid acid catalysts.