A Surface Study of Ultrathin Ceria Nanoparticles Decorated with Transition-Metal Ions

Nanomaterials are a fascinating class of materials due to the ability to control their chemical and physical properties by changing their size, shape, and composition. One of the unique features of nanoparticles (NPs) is their large surface area compared to their volume. As a consequence, a wide range of NPs’ properties can be tuned by changing their surface characteristics, especially in ultrathin nanostructures. Surface modification with transition-metal ions may affect a variety of NPs’ properties including the surface charge, the electronic structure and the electrical and optical characteristics. In this work, a surface study of ultrathin ceria (CeO$_2$) NPs modified by adsorption of various transition-metal ions to their surface is conducted. Characterization of the decorated particles as well as of the modifying transition-metal ion confirmed the attachment of the cation to the surface of ceria, both in solid state and in colloidal suspension. We show that the metallization process had a significant effect on the surface charge of the NPs by consistently shifting the zeta potential to more positive values and on the optical properties of the modifying transition-metal ions by red-shifting their absorption peak. The modification of ultrathin NPs with transition-metal ions can be used to improve their catalytic and electronic properties for a variety of applications.