Localized charge of single CdSe quantum rods and the role of lattice imperfections

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The local electronic structure of colloidal semiconductor nanoparticles is of significant fundamental and technical interest. Electrostatic force microscopy was used to determine that single CdSe quantum rods (QRs) have a permanent polarization surface-charge density, an unexpected observation for supposedly well-shaped, neutral dielectric particles. To investigate the source of the surface charge, we performed electron nanodiffraction studies with a scanning transmission electron microscope (STEM). Electron nanodiffraction patterns suggest that rotations exist between various “sections” of individual QRs, and that the rotation axes may form substantial angles with the c-axis. Thus, the surface charge results from the slight angle between the QR sides and the direction of internal electric polarization. Despite the large dipole moment expected for CdSe QRs, none was observed. The unavoidable presence of permanently charged surfaces on CdSe QRs has the potential to impede the development of novel devices incorporating these materials.