Electrochemical stability of subnanometer Pt clusters

In the present work, the degradation of size-selected Pt nanoclusters is studied under electrochemical conditions. This model catalyst mimics carbon supported Pt nanoclusters and nanoparticles typically employed in proton exchange membrane fuel cells (PEMFCs). Insight into the early stage of degradation is given by high-angle annular dark-field scanning transmission electron microscopy (HAADF-STEM) and confirmed by transmission electron microscopy (TEM). In contrast to common assumptions, it is demonstrated that even extremely small Pt clusters exhibit a remarkable stability under electrochemical conditions. Such nanoclusters are then relevant to develop electrodes for energy applications. Furthermore, applying mixed cluster samples of Pt$_{22}$ and Pt$_{68}$, no preferential dissolution of Pt$_{22}$ by Ostwald ripening - usually held responsible to be the main mechanism for activity loss in Pt fuel cell catalysts - is observed. In light of the findings reported, developing highly-dispersed subnanometer Pt clusters as catalyst for PEMFCs is a realistic approach provided the operation conditions are suitably adjusted. Furthermore, mitigation strategies to improve the stability of few-atoms catalyst under electrochemical operation will benefit from addressing cluster-support interactions.

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