Development of Electroanalytical Tools for Nanoparticle Catalyst Evaluation and Screening

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The increasing interest in nanoparticles (NPs) due to their unique properties and multifarious applications has necessitated the development of new analytical tools for characterizing NPs in a fast and reproducible manner. Especially, to better understand the fundamental properties, correlate structure-function relationships of NPs and optimize NPs activity for various applications analytical tools that enable precise characterization of individual NPs in terms of their size, shape and composition are of immense importance.

The development of "electrocatalytic amplification" is one such method where single NPs are detected by measuring electrocatalytic current due to the electrochemical processes (oxidation/reduction of the species present in solution) occurring on the surface of the NP whenever a NP collides with an inert UME (gold, platinum, platinum oxide and carbon) which otherwise cannot catalyze the NP collision concentrated over a range of (180-400) and (40-100) pC respectively. Whereas, for naked hexagonal and cubic Pt NPs the integrated charge passed per spike during single NP collision for polyacrylate capped hexagonal and cubic Pt NPs was found to be 11.2 ± 2.8 nm and 11.8 ± 1.7 nm respectively.

Here we report the application of electrocatalytic amplification method employing Hg/Pt UMEs as electrodes for evaluating the catalytic activity of Pt NPs of different shapes (hexagones and cubes) for hydrazine oxidation. To precisely correlate structure-function relationship of Pt NPs, Pt NPs without ligands referred as "naked Pt NPs" were used in this study. "Naked Pt NPs" were obtained by following the procedure reported before where polyacrylate capped Pt NPs were synthesized first followed by a strong base treatment (potassium hydroxide) to remove the ligand (polyacrylate) off the NPs surface. From TEM the average size of polyacrylate capped hexagonal and cubic Pt NPs was found to be 11.2 ± 2.8 nm and 11.8 ± 1.7 nm respectively. Hexagonal Pt NPs possess (100) and (111) facets whereas cubic Pt NPs possess (111) planes as preferential surface facets. Complete removal of polyacrylate ligand from the Pt NPs surface was confirmed by obtaining CVs, TGA and IR spectra of polyacrylate capped Pt NPs before and after KOH treatment. Also, Pt NPs retained their size and structure after KOH treatment. The integrated charge passed per spike during single NP collision for polyacrylate capped hexagonal and cubic Pt NPs was found to be 11.2 ± 2.8 nm and 11.8 ± 1.7 nm respectively.

References: