Intrinsic peroxidase-like activity of Pt nanoparticles immobilized in spherical polyelectrolyte brushes

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Peroxidase-like nanoparticles have been established as low cost and highly stable alternatives of natural peroxidase in wide range of applications [1]. Recently, a significant amount of research has been focused on imitating peroxidase activity with various nanomaterials. The mechanism of the peroxidase-like activity is still under debate. Usually, the kinetic data of nanoparticles are interpreted by Michaelis-Menten equation (MM). However, the mechanism can hardly be revealed by this enzyme model.

In our study, Pt nanoparticles about 5 nm immobilized in spherical polyelectrolyte brushes (SPB-Pt) were found own high peroxidase-like activity. Owing to the excellent colloidal stability in solution [2-3], the kinetics and mechanism of peroxidase-like activity can be precisely analyzed. The oxidation of 3,3',5,5'-tetramethylbenzidine (TMB) with hydrogen peroxide (H2O2) was used as a model reaction. The kinetic data was modelled by Langmuir-Hinshelwood (LH) model for the first time. In this model, both TMB and H2O2 are assumed to adsorb on the surface of the nanoparticles to react. Based on this, the time evolution of product can be well modelled up to the conversion of 50%. Excellent merging of the theory with the experimental data is found for both SPB-Pt and Fe3O4 nanoparticles. Compared with MM kinetics with initial reaction rate at the beginning several or tens of seconds, the LH kinetics responsible for the whole period is more reliable. All these provide hints to design effective peroxidase-like nanomaterials.

Figure 1 (a) TEM graph of the peroxidase–like Pt nanoparticles immobilized in spherical polyelectrolyte brushes (SPB-Pt), (b) kinetic analysis of peroxidase–like activity of SPB-Pt nanoparticles: conversion evolution at different substrate concentrations, the solid lines are fitting lines based on Langmuir-Hinshelwood model.