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Effect of Support of Two-Dimensional Pt Nanoparticles/Titania on Catalytic Activity of CO Oxidation

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Smart catalyst design though novel catalyst preparation methods can improve catalytic activity of transition metals on reducible oxide supports such as titania by enhancement of metal oxide interface effects. In this work, we investigated Pt nanoparticles/titania catalysts under CO oxidation reaction by using novel preparation methods in order to enhance its catalytic activity by optimizing metal oxide interface. Arc plasma deposition (APD) and metal impregnation techniques are employed to achieve Pt metal deposition on titania supports which are prepared by multi-target sputtering and Sol-gel techniques. In order to tailor metal-support interface for catalytic CO oxidation reaction, Pt nanoparticles and thin films are deposited in varying surface coverages on sputtered titania films using APD. To assess the role of oxide support at the interface, APD-Pt is deposited on sputtered and Sol-gel prepared titania films. Lastly, characteristics of APD-Pt process are compared with Pt impregnation technique. Our results show that activity of Pt nanoparticles is improved when supported over Sol-Gel prepared titania than sputtered titania film. It is suggested that this enhanced activity can be partly ascribed to a very rough titania surface with the higher free metal surface area and higher number of sites at the interface between the metal and the support. Also, APD-Pt shows superior catalytic activity under CO oxidation as compared to Pt impregnation on sputtered titania support. XPS results show that bulk oxide is formed on Pt when deposited through impregnation and has higher proportion of oxidized Pt in the form of $Pt^{2+/4+}$ oxidation states than Pt metal. APD-Pt shows, however, mild oxidation with large proportion of active Pt metal. APD-Pt also shows trend of increasing CO oxidation activity with number of shots. The activity continues to increase with surface coverage beyond 100%, thus suggesting a very rough and porous Pt films with higher active surface metal sites due to an increased surface area available for the reactant CO and O_2 molecules. The results suggest a novel approach for systematic investigation into metal oxide interface by rational catalysts design which can be extended to other metal-support systems in the future.

Keywords: CO oxidation, Platinum nanoparticles, Arc plasma deposition, Sol-gel