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Electrochemical preparation of nanostructured CeO_2-Pt catalysts on Fe-Cr-Al alloy foams for the low-temperature combustion of methanol

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Methanol is a valuable energy feedstock for the future beyond oil and gas, due to its easy storage as a liquid at room temperature, and an excellent fuel for catalytic combustion, a process that is stable in a wide methanol/air operating range, and produces ultra-low NO_x, CO and VOC emissions. Lightweight catalytic burners are often realized using metal foams, due to their outstanding properties in terms of heat and mass transfer coupled with low pressure-drops and thermal resistance. Among the foam materials, Fe-Cr-Al alloy (Fecralloy) have outstanding resistance to high temperatures.
The procedures for depositing firmly anchored, homogeneous catalytic layers onto the foam substrates are often cumbersome and involve many steps. Therefore, there is interest for innovative preparation methods which take advantage of the metallic nature of the foam support, such as electrodeposition and spontaneous deposition through galvanic displacement. Both approaches are capable to form well-dispersed, homogeneously distributed noble metal nano-particles strongly adhering to the substrate (1, 2).
As a part of an ongoing research project, our groups have recently prepared Pt-based structured catalysts for the low-temperature combustion of methanol by electrochemical methods (3). These catalysts consisted of Pt nanoparticles, deposited onto Fecralloy foam supports by pulsed electrodeposition from H_2PtCl_6 aqueous solution, and CeO_2 thin films electrodeposited from a nitrate baths. Reduction of nitrates induced a local pH increase at the foam/electrolyte interface and caused the precipitation of mixtures of $Ce(OH)_3$ and CeO_2, which were converted to CeO_2 by heating in air. The Pt loading in the catalysts was measured by ICP-MS, while the noble metal surface area was determined by cyclic voltammetry, through the H desorption charge. Although the presence of a CeO_2 film decreased the Pt surface area accessible to electrolyte it enhanced the performance of the catalysts towards methanol combustion, without affecting the activation energy of the process. The enhanced catalytic performance of the CeO_2-Pt-Feclalloy catalysts as compared to Pt-Fecralloy was ascribed to the formation of additional active sites along the interface of CeO_2-coated Pt nanoparticles.

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