Interfacial Electrochemistry and Electrocatalysis at Monocrystalline Electrodes

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Contemporary research in interfacial electrochemistry focuses on the understanding of structural electrochemical phenomena in relation to the electrode’s composition and surface geometry, the electrolyte’s composition and concentration, and experimental conditions, e.g. potential and temperature. On the other hand, research in modern electrocatalysis focuses on identifying and quantifying the relationship between the electrode’s composition, two-dimensional and three-dimensional structure, catalytic activity, stability, and durability. This contribution overviews recent developments made by our group in the area of the growth, orientation and final preparation of monocrystalline electrodes of noble metals (e.g., platinum) for electrochemistry and electrocatalysis research. It presents results on the electro-oxidation and (electro-)dissolution of platinum materials and analyzes the stability of twenty-five facets upon repetitive potential cycling in aqueous acidic electrolytes. The results show that the Pt(531) facet is the most stable and suggest that Pt nanoparticles possessing this specific surface structure might be the most suitable for application in polymer electrolyte membrane fuel cells and water electrolyzers. The contribution also presents the controlled atmosphere flame fusion (CAFF) method recently developed in our laboratory and successfully applied to the growth of monocrystalline electrodes of non-noble transition metals (e.g., nickel, copper, cobalt, iron). The latter is of great importance to interfacial electrochemistry and electrocatalysis, because for about four decades research employing monocrystalline electrodes concentrated exclusively on the electrochemical behaviour of monocrystalline platinum and gold electrodes, because its was impossible to prepare atomically ordered and oxide-free monocrystalline electrodes on non-noble transition metals for this type of research. This invention has the potential to start a new research direction in interfacial electrochemistry, electrocatalysis, and corrosion science.