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Electrochemical Oxidation of Ascorbic Acid by Hierarchical Catalysts

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The research mainly focuses on the preparation of metal catalysts with hierarchical structures for ascorbic acid (AA) oxidation. I have synthesized non-Pt-based electrocatalysts. The improvement in the AA electrooxidation leads to the construct of a direct alkaline AA-based liquid fuel cell (DAAFC) system. The DAAFC does not release any toxic chemicals or gases. The DAAFC can solve two problems at a time. I could reuse waste materials (Vitamin C containing fruits and vegetables) to extract AA and generate clean electricity from it. So DAAFC system could help us in achieving sustainable development goals. In this study, I have explored potential anode catalysts for the improvement of AA electrooxidation.

I have developed unique hierarchical metal catalysts to improve AA electrooxidation. The well-growth Ag dendrite structures are prepared by a simple electroless deposition technique and applied for AA electrooxidation for the first time. The Ag catalyst is applied for the kinetic study of the AA electrooxidation because the Ag could prevent the electrode fouling during AA electrooxidation. The kinetic study helped us to understand the two electrons transfer process during AA electrooxidation. To improve the performance of the AA electrooxidation I have applied Pd-based catalysts.

A controlled electrodeposition technique is further developed for the preparation of unique Christmas-tree-shaped Pd nanostructures. The many sharp edges of these nanostructures provide more active sites for electrocatalysis. The unique Christmas-tree-shaped Pd nanostructures are applied for the AA electrooxidation in the alkaline condition. The AA electrooxidation is enhanced by these unique structures of Pd metal. The greater improvement in the AA oxidation leads us to choose Pd-based anode catalysts for DAAFC.

For the practical use of Pd-based catalyst for the DAAFC system, I have further developed Pd nanoparticles incorporating reduced graphene oxide (rGO) and multiwall carbon nanotube (MWCNT) composite by the chemical reduction process. The Pd/rGO/MWCNT catalyst showed excellent AA electrooxidation in the alkaline condition. Next, I have constructed the DAAFC system by using Pd/rGO/MWCNT catalyst. The maximum power output is 9.5 mW/cm^2 at 60 °C. The DAAFC result enlightens us about the use of AA as a fuel to generate clean energy in near future.

Keywords: Hierarchical structures, Ascorbic acid, Ag dendrite, Christmas-tree-shaped Pd nanostructure, Alkaline fuel cell.