Abstract

Development of energy conversion devices that use renewable resources and produce no green houses gases is a major goal for a sustainable society. In this regard, direct alcohol fuel cells (DAFCs) have been intensively studied as clean and high-efficiency energy conversion devices. However, the expensive Pt-based materials as anode catalyst in DAFC make it unsuitable for large scale commercialisation. To address this shortcoming, considerable efforts have been made toward Pt-based alloys synthesis and/or suitable support materials such as reduced graphene oxide, carbon nanotube, and metal oxide not only to reduce the cost of the catalyst but also reduce the use of such expensive catalyst material. In this work, several bimetallic and trimetallic alloy nanoparticles (NPs) involving Pt, Au, and Ni are synthesized using wet-chemistry techniques and their electrocatalytic performance are demonstrated for the oxidation of alcohols (methanol, ethanol, ethylene glycol, and glycerol). Trimetallic alloy NPs shows superior alcohol oxidation performance in terms of small onset oxidation potential and high mass activity than their bimetallic counterparts and standard Pt/C. In addition, reduced graphene oxide is used as a support for the alloy NPs to demonstrate the importance of support material for the development of anode catalysts in DAFC.

The photocatalytic water splitting to produce H_2 fuel is another prospect to solve the energy crisis and environmental problem. Despite enormous efforts devoted toward development of efficient photocatalysts for photocatalytic H_2 production, those suffer from low efficiency due to poor light absorption and fast charge-carrier recombination. The cocatalyst loading is considered as an effective way to suppress the charge carrier recombination rate and increase the effective proton reduction sites. Noble metals, especially Pt, Pd, and Au, are generally used as cocatalysts for H_2 evolution. To improve the cocatalyst performance, two different bimetallic alloy systems (PtAu and AuPd) are considered here using a graphitic carbon nitride support (g–C_3N_4). In both cases, the percentages of individual metal contents are varied to find an optimum alloy composition for the best cocatalyst performance with highest H_2 production activity.

In summary, this thesis focuses on the development of bi/trimetallic alloy electrocatalysts for alcohol oxidation and bimetallic alloys as cocatalysts for photocatalytic H_2 production with suitable support material.

Keywords: *DAFC, alcohol electrooxidation, photocatalytic H_2 evolution reaction, Pt-based alloy, bimetallic and trimetallic alloy nanoparticles*