Electrocatalytic Reduction of CO₂ on Mono-Metal/Graphene/Polyurethane Sponge Electrodes

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Metal nanoparticle (Pd, Cu, Fe, Ru and In)/graphene nanostructure catalysts for the electrocatalytic reduction of CO₂ have been prepared by sodium borohydride (NaBH₄) reduction. The nanostructure catalysts were characterized by X-ray diffraction (XRD), scanning electron microscopy (SEM), transmission electron microscopy (TEM), X-ray photoelectron spectroscopy (XPS), and cyclic voltammetry (CV). Moreover, a strategy to fabricate metal/graphene/polyurethane sponge (MGS) for the reduction of CO₂ through a facile and inexpensive ‘dipping and drying’ method was studied. The MGS electrode was characterized by SEM and linear sweep voltammetry (LSV) scans. Metal nanoparticles (Pd, Cu, Fe, Ru and In) with average sizes of 5.9, 5.4, 4.3, 6.2 and 4.2 nm were uniformly dispersed on the surface of graphene sheets with a noncrystalline structure. Metal/graphene nanostructure catalysts were well covered on the polyurethane sponge. When the voltage was less than the peak potential, sharper increases of the reduction current under CO₂ were observed, and the peak potentials (Pd, Cu, Fe, Ru and In) were −1.21, −1.25, −1.36, −1.38 and −1.10 V, which provided evidence for the catalytic reduction of CO₂ by the metal/graphene catalysts and the peak potential of 1% In/graphene was the smallest. However, the peak potential order of MGS was consistent with the metal/graphene catalysts, basically 1% In/graphene (−0.58 V) < 1% Cu/graphene (−0.71 V) < 1% Pd/graphene (−0.78 V) < 1% Ru/graphene (−0.80 V) < 1% Fe/graphene (−1.1 V). Therefore, the MGS electrode, as a supporting skeleton for metal/graphene catalysts, not only exhibits similar electrochemical properties of the metal/graphene catalysts, but also inherits the nature of the polyurethane sponge as a support material. Hence, the good performance of MGS makes it a promising candidate electrode for the electrocatalytic reduction of CO₂.

Keywords: electrocatalytic reduction; CO₂; polyurethane sponge; metal/graphene catalyst; gas diffusion electrode

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