Development of Functionalized Graphene Supported Highly Durable Pt-Free Bi-metallic Electrocatalysts for PEMFC

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Abstract

Functionalized graphene supported Pt-free single metallic (Pd/FGP or Au/FGP) and bimetallic (PdAu/FGP) electrocatalyst were synthesized using NaBH4 reduction techniques. The electro-catalytic activity of developed Pd/FGP, Au/FGP, and PdAu/FGP were investigated x-ray powder diffraction (XRD), transmission electron microscopy (TEM), oxygen reduction reaction (ORR), and cyclic voltammetry (CV). The performance of the developed bimetallic electrocatalyst was compared with the commercial Pt/C. The oxygen reduction of PdAu/FGP was started gradually at a potential around 1.0 V and reached a limiting plateau at a potential around 0.75 V. Though the 50% Pd was replaced by Au but the ORR performance of the PdAu/FGP is almost maintained. The similar electro-catalytic activity of the Pd and/or PdAu can also be explained based on the synergetic effect of the Au and Pd in ORR. The active electrochemical surface area (ESA) is measured using CV analysis. The ESA for the Pd/FGP, PdAu/FGP, and Pt/C were found to be around 63.32, 51.27, and 43.4 m2•g-1Pt, respectively. The single cell polymer electrolyte membrane fuel cell (PEMFC) power density of the Pd/FGP, PdAu/FGP, and Pt/C were found to be 439, 414, 373 mW.cm-2, respectively. The developed bimetallic (PdAu/FGP) electrocatalys shows significantly higher stability under ORR test as compared to commercial Pt/C.

Introduction

Fossil fuels, together with oil, coal and fossil fuel, also as nuclear materials ar major sources of energy that presently cowl the bulk of world energy demands. However, fuel reserves ar restricted and ar expected to be depleted among a few of centuries. additionally, the combustion of fossil fuels is that the main supply of greenhouse gases (GHG), particularly greenhouse gas, that is believed to be the perpetrator for warming and as a significant supply of demand for energy, transportation presently accounts for half-hour of world energy consumption and twenty third of GHG emission supported this, it's of nice importance to search out inexperienced alternatives to combustion engines and cut back GHG emissions. Here, nucleon exchange membrane (PEM) fuel cells and metal–air batteries stand out among numerous different techniques and ar each GHG emission free For PEM fuel cells, element is employed because the fuel and gas from air because the chemical agent to provide power with solely water because the end result whereas for metal–air batteries, metals like Li, Zn, Mg, Al, etc., will be used the fuel conductor and gas (air) because the cathode chemical agent to provide power. And though totally different "fuels" ar needed at the anodes of PEM fuel cells and metal–air batteries, the cathode reaction is usually the gas reduction reaction (ORR), that in most cases is believed to be the rate-determining step of the chemical science method thanks to its sluggish dynamics, so resulting in lean performances in corresponding devices. The a lot of positive onset potential, also because the half-wave potential of FeCo-NCZ, compared to Pt/C and alternative control-carbon catalysts is principally thanks to the enriched doable active reaction centres like graphitic, pyridinic and Fe/Co–Nx sort coordination on the surface of FeCo-NCZ. The uniform distribution of those active reaction centres is achieved solely through adopting one precursor for the preparation of the electrocatalyst employing a high-temperature tempering method. The moderately high micropore extent of FeCo-NCZ improves the distribution of active reaction centres on the carbon surfaces and assists within the reduction of dioxygen a lot of with efficiency. This high density of active reaction centres on the surface of FeCo-NCZ along with the reduced defective sites (additional helps to enhance the chemical science stability of FeCo-NCZ. this is often clearly proven by the thirty seven mV negative shift in half-wave potential when 10k potential cycles as compared with Pt/C. The peculiar morphology of the FeCo-NCZ plays a big role in rising the chemical change activity. The fullerene interpenetrated porous carbon assists the economical mass transport also because the lepton transport throughout the catalyst. The high crystallization size of the FeCo-NCZ indicates low ohmic resistance in FeCo-NCZ. These results emphasise that the FeCo-NCZ could be a higher electrocatalyst for gas reduction in solid alkalic fuel cells. to beat this, numerous cathode electrocatalysts with high activity towards hockey player ar ordinarily utilized in that valuable catalysts, particularly Pt-based catalysts, ar thought-about to be the foremost active. However, these valuable catalysts ordinarily suffer from drawbacks like high costs and fewer tolerance to contaminants thus, researchers ar devoting nice attention to the event of non-precious metal catalysts (NPMC) to exchange precious metals within which metal, Co, Ni, Mg and alternative metals ar being explored to fabricate catalysts with exceptional hockey player

activity. additionally, researchers also are exploring metal-free catalysts that have shown promising hockey player activities and supported all of this, this review can gift the progresses, challenges and views within the development of hockey player electro catalysts. what is more, doable analysis directions ar planned to facilitate future analysis and development. In general, valuable catalysts, particularly Pt-based catalysts, possess high stability and superior electrocatalytic activity within which in several studies, Pt is commonly chosen because the reference or baseline catalyst within the exploration of alternative catalysts like NPMCs And though Pt nanoparticles supported by high-surface-area carbon stay the foremost with success commercial hockey player electrocatalysts, Pt is rare and pricy, that limits large-scale application. Overall, the goal of catalyst development, together with for Pt and alternative precious metal-based catalysts, as summarized by dynasty et al. is to extend the whole range and/or the intrinsic activity of active sites o come through this, researchers have developed several Pt-based catalysts with tunable sizes and morphologies together with core–shell structured and alloy catalysts Here, core–shell structured and alloy catalysts ar promising as a result of they will not solely cut back Pt loading by incorporating alternative metal(s) to permit for higher mass activity (A mg −1Pt), however may also surpass the intrinsic activity of Pt catalysts through interactions between Pt and metal counterparts or core metals that may have an effect on electronic structures Here, not solely will the dissolution of transition metal cores be alleviated, the interactions between Pt and core metal(s) also are robust, so inheritable the benefits of Pt alloy catalysts .In addition, as a result of solely little amounts of surface Pt is used throughout chemical change reactions in these core–shell structures, Pt utilization is maximized, that fulfills the principles of atom economy reportable that dealloyed Pt–Cu core–shell structures will possess extraordinary hockey player activity. Here, these researchers reportable that strain will kind in Pt-enriched shells supported on copper cores with a smaller lattice parameter which the compressive strain within the shell will tune the electronic band structure of Pt and weaken the surface assimilation of reactive intermediates, so leading to inflated hockey player activity. Researchers have conjointly determined that Pt alloy catalysts with a lot of higher chemical compound coverage and quicker chemical compound growth than pure Pt will show wonderful hockey player activity , that conflicts with the standard information that pure metal surfaces ought to be a lot of chemical change active than corresponding metal chemical compound surfaces, indicating that a lot of complicated mechanisms ar concerned for Pt alloy electrocatalysts. Therefore, additional investigation into the consequences of composition, structure, size and form of Pt alloys on hockey player activity is crucial to the planning and fabrication of a lot of economical and economically sensible catalysts NPMCs are intensively investigated thanks to the chance of eliminating the usage of Pt or alternative precious metals within which the distinctive structure of NPMCs will offer huge potentialities for the standardisation of catalyst activity, property, and sturdiness Transition Metal Oxides Transition metal oxides, together with single metal oxides and mixed metal oxides, ar representative hockey player electrocatalysts that ar earth plentiful, cheap, simple to organize, environmentally benign and a lot of significantly, possess comparable chemical change activities to Pt-based catalysts.