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Graphene Supported Nano Cerium Oxides Hybrid as an Electrocatalyst for Oxygen Reduction Reactions

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Abstract : Today, the world is facing a severe challenge due to depletion of traditional fossil fuels. Scientists across the globe are working for a solution that involves a dramatic shift to practical and environmentally sustainable energy sources. High-capacity energy systems, such as metal-air batteries, fuel cells, are highly desirable to meet the urgent requirement of sustainable energies. Among the fuel cells, Direct methanol fuel cells (DMFCs) are recognized as an ideal power source for mobile applications and have received considerable attention in recent past. In this advanced electrochemical energy conversion technologies, Oxygen Reduction Reaction (ORR) is of utmost importance. However, the poor kinetics of cathodic ORR in DMFCs significantly hampers their possibilities of commercialization. The oxygen is reduced in alkaline medium either through a 4-electron (equation i) or a 2-electron (equation ii) reduction pathway at the cathode ((i) $O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$, (ii) $O_2 + H_2O + 2e^- \rightarrow OH^- + HO_2^-$). Due to sluggish ORR kinetics the ability to control the reduction of molecular oxygen electrocatalytically is still limited. The electrocatalytic ORR starts with adsorption of O_2 on the electrode surface followed by O–O bond activation/cleavage and oxide removal. The reaction further involves transfer of 4 electrons and 4 protons. The sluggish kinetics of ORR, on the one hand, demands high loading of precious metal-containing catalysts (e.g., Pt), which unfavorably increases the cost of these electrochemical energy conversion devices. Therefore, synthesis of active electrocatalyst with an increase in ORR performance is need of the hour. In the recent literature, there are many reports on transition metal oxide (TMO) based ORR catalysts for their high activity TMOs are also having drawbacks like low electrical conductivity, which seriously affects the electron transfer process during ORR. It was found that 2D graphene layer is having high electrical conductivity, large surface area, and excellent chemical stability, appeared to be an ultimate choice as support material to enhance the catalytic performance of bare metal oxide. g-C_3N_4 is also another candidate that has been used by the researcher for improving the ORR performance of metal oxides. This material provides more active reaction sites than other N containing carbon materials. Rare earth oxide like CeO_2 is also a good candidate for studying the ORR activity as the metal oxide not only possess unique electronic properties but also possess catalytically active sites. Here we will discuss the ORR performance (in alkaline medium) of N-rGO/C_3N_4 supported nano Cerium Oxides hybrid synthesized by microwave assisted Solvothermal method. These materials exhibit superior electrochemical stability and methanol tolerance capability to that of commercial Pt/C.

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