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Short Communication

A Brief Note on Oxygen Reduction Reaction

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DESCRIPTION

The Oxygen Reduction Reaction (ORR) is the core reaction of various sustainable energy-conversion technologies like fuel cells and metal-air batteries. It's crucial to develop cheap, extremely active, and durable electrocatalysts for ORR to beat the kinetics of the 4 electrons pathway. In recent years, the carbon-based electrocatalysts derived from Metal-Organic Frameworks (MOFs) have attracted tremendous attention and are shown to exhibit superior chemical catalytic activity and intrinsic properties like large surface area, large pore volume, uniform pore distribution, and chemical structure [1]. The event of MOF-derived heteroatom-doped carbon-based electrocatalysts, together with non-metal (such as N, S, B, and P) and metal (such as Fe and Co) doped carbon materials are summarized. It's incontestable that the enhancement of ORR performance is related to favorably well-designed porous structure, large surface area, and high-tensity active sites. Finally, the longer-term views of carbon-based electrocatalysts for ORR are supplied with a stress on the development of a clear mechanism of MOF-derived non-metal-doped electrocatalysts and bound metal-doped electrocatalysts.

The Oxygen Reduction Reaction (ORR) plays a key role in the progress of advanced electrochemical energy conversion systems, together with Proton Exchange Membrane Fuel Cells (PEMFCs), metal-air batteries, and Direct Alcohol Fuel Cells (DAFCs), etc. These energy systems have their own limitations, together with the kinetics of ORR, high price and poor stability owing to the aggregation/dissolution of platinum Nanoparticles (NPs) within the Pt-based electrocatalysts of those energy conversion systems [2]. Developing extremely economical electrocatalysts for ORR could be a crucial step to accelerating the development of that advanced energy storage and conversion devices. during this connection, a series of relevant explorations are performed in each electrocatalyst and support materials for ORR, together with that: (i) alloying platinum with different transition metals to extend the specific activity and reduce the value of electrocatalysts (ii) developing extremely active non-precious metal or metal compound electrocatalysts with low cost (iii) looking out new-type support materials to extend site centers.

Recently, the quantity of research associated with nonprecious metal electrocatalysts has greatly increased because of its popular price, regulable morphological structure and high electrocatalytic activity compared with metal electrocatalysts, like transition metal oxides, metal phosphides, metal sulfides, similarly to carbon-based materials. Among these advanced electrocatalysts, porous carbons are widely applied in several analysis fields as conductor materials and chemical change supports for energy storage devices, fuel cells, adsorbents, drug delivery carriers, etc. They feature plentiful attractive properties together with high surface area, high conductivity, low cost, abundant porosity, and corrosion resistance, which might be thought of as the most ideal supports or Pt-free electrocatalysts for ORR in fuel cells.

There are numerous ways to get extremely porous carbon-based electrocatalysts, like direct carbonization of polymeric aerogels, electrospinning fiber technique, pyrolysis of organic precursors with physical or chemical activation, and nano casting with solid templates (such as zeolites and mesoporous silicas). Although the activated porous carbons possess a high surface area, the disordered structures caused by broad pore size distribution might limit their accessibility [3]. In consequence, it's essential to explore a correct precursor for the preparation of metal-free carbon-based electrocatalysts with high specific surface areas, giant pore volumes, and correct chemical stabilities for ORR. MOFs as the novel precursors of extremely porous carbon-based electrocatalysts have attracted great consideration. Their distinctive intrinsic structures offer a chance to get higher surface areas (≈10 000 m2 g−1) than different porous materials, like zeolites and C, etc.

Distinguished from the operative conditions and high energy consumption of traditional artificial strategy, the carbon-based materials from carbonized MOFs as electrocatalysts offer various advantages: (i) The structure, composition, and performance of MOFs possess versatile tunability as a result of they'll be modularly designed consistent with the targeted properties by self-assembly of metal ions/clusters and bridging organic ligands; (ii) it's simple to implement heteroatom-doped carbon materials with completely different nonmetals or metal components, and this could be attributed to the ultrahigh extent, numerous pore size distribution, and ordered porous structure of MOFs, that are simple to adsorb organic molecules.

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To improve the electron-transport property and ORR catalytic activity, single/dual heteroatom-doped carbon-based electrocatalysts are wide fancied, and they are segmental into 2 types of forms, namely, nonmetal-doped porous carbon materials (e.g., N, S, B, and P) and metal-doped porous carbon materials (e.g., Fe, Ni, Co, and Cu), and that they exhibit additional active sites and increased electrocatalytic activity for ORR [4]. The theoretical and practical studies have verified that the intrinsic characteristics of functionalized carbon materials, like inner microstructures and compositions, electronic options, surface and partial chemistry properties, may well be effectively adjusted by acceptable incorporation of heteroatoms, which continually ends up in a lower energy barrier of oxygen adsorption and activation or considerably improved electrocatalytic activity of ORR.

In terms of the structure of carbon-based electrocatalysts, coming up with gradable nanopore structures cannot solely enhance the mass transport and expose additional active sites for chemical action however additionally retain additional solution ions and high electrical conductivity. Another effective strategy for extremely active ORR electrocatalysts is to confine catalytic sites at intervals a pervious however strong shell (such as extremely porous carbon materials) and induce a localized high instant concentration for the quick heterogeneous chemical action. MOF-derived heteroatom-doped carbon-based electrocatalysts may be well designed for such a structure.

Throughout a thermal activation method, organic linkers of MOF precursors will be converted into carbon, whereas the inherent frameworks are going to be maintained to create an extremely porous structure of electrocatalysts, without secondary carbon supports or pore-forming agents [5]. The as-prepared MOF-derived heteroatom-doped carbon electrocatalysts continually possess a high surface area, uniformly distributed active sites and an excellent electrical conductivity, that is helpful to quick mass transport and electron transfer. In recent years, heteroatom-doped MOF-derived carbon-based electrocatalysts have been developed quickly.

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