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Overview of Proton Exchange Membrane Fuel Cell

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Abstract

Fuel cell is a technology which can transform chemical energy into electric energy, and has a good development prospect. The proton exchange membrane fuel cell is mainly introduced in this paper.

Keywords

Fuel cell, proton exchange membrane fuel cell.

1. Introduction

Fuel cell is a technology that converts chemical energy into electric energy. The whole process is green and environmental friendly. It does not produce any pollutants, and it has high efficiency and low noise. At the same time, fuel technology makes up for the small capacity of other energy methods, such as lithium battery, in principle slow charging and short life. Fuel cell has been recognized by the European Union as one of the green energy products to replace the traditional internal combustion engine in the future [1].

According to the types of electrolytes, fuel cells can be divided into basic fuel cell (AFC), proton exchange membrane fuel cell (PEMFC), phosphoric acid fuel cell (PAFC), molten carbonate fuel cell (MCFC) and solid oxide fuel cell (SOFC). Proton exchange membrane fuel cell (PEMFC) is widely used in various fields because of its low operating temperature, high conversion efficiency, high power density, fast start-up and environmental friendliness. Small as cell phone batteries, rechargeable batteries, large-scale power stations, fixed main and standby power supply for communication base stations, household cogeneration, mobile like automobiles, UAVs, underwater submarines, etc. This paper focuses on the following proton exchange membrane fuel cell technology [2].

2. Proton Exchange Membrane Fuel Cell

In addition to the general characteristics of fuel cells, proton exchange membrane cell (PEMFC) has the prominent characteristics of fast start, long life, high specific power and specific energy. PEMFC has received great attention and become the focus of current research. Electrocatalyst, proton exchange membrane, electrode and bipolar plate are important components of PEMFC, which have important influence on the performance and stability of PEMFC.

2.1. Electrocatalyst

PEMFC electrocatalyst is one of the key factors restricting its commercialization, so the study of electrocatalyst has become the main content of PEMFC. The main catalysts used in PEMFC are platinum catalysts, platinum alloy catalysts and non-platinum electrocatalysts.

At present, PEMFC uses platinum catalyst supported by activated carbon, carbon black and graphite carbon materials. It is an effective way to improve the utilization rate of platinum catalyst to make composite electrode material by dispersing platinum in different carriers.

Carbon nanotubes are considered to be a good catalyst carrier because of their large specific surface area and good conductivity.

Hydrogen from reforming hydrocarbons often contains CO impurities, which can poison the catalyst and greatly reduce its catalytic capacity. Through the synergistic action of Pt and Ru, the pt-ru catalyst has the ability to resist the toxicity of CO, making the battery maintain a high performance.

Considering the high price of precious metal platinum, many researches are devoted to the research and development of non-platinum electrocatalysts. Because transition metal macrocyclic chelates can promote the decomposition of intermediate H2O2 in ORR, which is conducive to the formation of water by the 4-electron pathway, it has become a research hotspot. The transition metal N4 chelate supported by activated carbon has high activity. The transition metal macrocyclic compounds are cheap and the main research direction in the future is to improve their stability and activity [3].

2.2. Proton Exchange Membrane

As the core material of the proton exchange membrane fuel cell, the proton exchange membrane plays a selective role in conducting protons from the cathode to the anode while blocking the fuel and oxidizer. The performance of the proton exchange membrane determines the performance of the fuel cell.

Proton exchange membrane is the core component of PEMFC, which is a selective permeable membrane. Proton exchange membranes play a dual role in fuel cells: as an electrolyte to provide hydrogen ion channels and as a medium to block bipolar reaction feedstocks, such as hydrogen/oxygen or methanol/oxygen. The main technical requirements for proton exchange membranes are: high proton conductivity, low gas permeability, good thermal and chemical stability, and high mechanical strength. The most commonly used proton exchange membrane is perfluorinated sulfonic acid membrane of C-F chain.

2.2.1. Perfluorosulfonic Acid Proton Exchange Membrane

At present, Nafion series membrane made by dupont company is the most widely used at home and abroad. Its main material is perfluorinated sulfonic acid type ion exchange resin, which has a similar structure to polytetrafluoroethylene. Its advantages are: strong chemical stability; High mechanical strength and high conductivity under high humidity; High current density at low temperature; Proton conduction resistance is small. However, perfluorosulfonic acid proton exchange membrane also has some disadvantages, such as: the rise of temperature will cause the decrease of conductivity, and the membrane is prone to biochemical degradation at high temperature; Monomer synthesis difficult, high cost, waste difficult to deal with; Expensive; Methanol leakage occurs easily when used in methanol fuel cell.

2.2.2. Non Perfluorinated Proton Exchange Membrane

Non-perfluorination is mainly characterized by the use of substituted fluoride instead of fluorinated resin, or the blending of fluoride with inorganic or other non-fluorinated compounds. For example, the early polytrifluoro-styrene sulfonic acid membrane could not meet the requirements of long-term use of fuel cells due to poor mechanical strength and chemical stability. Ballard, Canada, modified it to get BAM3G membrane, which has low sulfonate content and high working efficiency. The life of a single battery can be increased to 15000h, and the cost is much lower than Nafion membrane and Dow membrane, which is more acceptable.

2.2.3. Organic / Inorganic Composite Membrane

In order to effectively reduce the methanol permeation problem of direct methanol fuel cell membrane, inorganic materials are used as fillers. Because inorganic materials have good solvent resistance and high temperature resistance, they can effectively inhibit the swelling of

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membrane materials and prevent the permeation of methanol molecules. For example, filling ZrP and SiO2 into the microstructure of Nafion membrane through ion exchange reaction can effectively reduce methanol leakage of membrane material. Combining polymer materials with inorganic fillers to give full play to their advantages is one of the important development approaches of proton exchange membrane for batteries.

2.2.4. Proton Exchange Membrane with Aromatic Polymer as Main Chain

Proton exchange membrane with aromatic polymer as the main chain is prepared by using polymer materials with benzene ring structure in the main chain structure. The proton exchange membrane has the advantages of good thermal stability and electrochemical corrosion resistance. Through a certain post-processing process, the sulfonic acid group is introduced into the side chain structure to form the proton exchange function. Common materials include polyether ether ketone (PEEK), polyether sulfone (PES), polyphenyl ether (PPO), and their derivatives. For example, ph-speekdk and me-speekdk are the most promising membrane materials with higher mechanical strength and dimensional stability than Nafion 117. The permeation rates of methanol in these two membranes were only 6% and 15% of Nafion 117, showing excellent oxidation resistance in fenton reagent.

In addition, phosphorus-containing polymer membranes have also received great attention because their molecular structure contains cross-linked -- [P = N] --, which gives them good mechanical and thermal stability. At the same time, the crosslinking structure limits the swelling of the polymer, making the permeability of methanol molecule much lower than that of Nafion membrane.

2.2.5. Proton Exchange Membrane of All Vanadium Liquid Flow Battery

Vanadium Redox battery (VRB) USES Vanadium ions in different valence states to convert each other to achieve the storage and release of electric energy. By using the same elements to form the battery system, we can theoretically avoid the cross-contamination caused by the infiltration of different kinds of active substances between the positive half battery and the negative half battery, as well as the degradation of battery performance. All-vanadium liquid flow battery has obvious advantages in the following aspects: large lactation scale, long life, low cost and high efficiency.

The output power and storage capacity of the all-vanadium flow battery are independent of each other. By changing the amount of electrolyte in the storage tank, it can meet the demand of large-scale electricity storage and energy storage. By adjusting the serial number and electrode area of the single battery in the battery stack, the rated discharge power can be met.

Batteries are negative reactions are completed in the liquid phase, the charging/discharging process just change the state of vanadium ion in the solution, not the outside ion to participate in the electrochemical reaction, the electrode only transferred electron effect, itself does not participate in the electrochemical reaction, can theoretically infinite times any degree of charge and discharge cycle, greatly extend the service life of the battery.

In terms of the preparation of key battery materials, such as proton exchange membrane, conductive bipolar plate and other key battery materials, large-scale and low-cost production is carried out through localization. The all-vanadium liquid flow battery avoids the use of precious metal catalysts, which costs much less than chemical power sources such as fuel cells, and is suitable for applications of tens of kilowatts to several megawatts.

Since the active substances in the positive and negative semi-battery electrolyte are stored in different storage tanks, the self-discharge consumption during the electrolyte storage process is completely avoided, and the charging and discharging energy efficiency of the optimized battery system is up to 80%[4].

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2.3. Bipolar Plates

In a proton exchange membrane fuel cell, the role of the bipolar plate is to conduct current, balance heat, and provide a transmission path for the reaction gas. Bipolar plate materials shall be corrosion resistant, low density, high strength, heat conductor, electrical good conductor, easy to work and low cost. The best material for bipolar plate is graphite bipolar, which has the outstanding advantages of good electrical conductivity, high chemical and electrochemical stability. Graphite bipolar plate is mainly pure graphite bipolar plate, cast bipolar plate, expanded graphite bipolar plate. The cost and processing cost of pure graphite bipolar plate are very high. Carbon/polymer bipolar plate, metal bipolar plate cost is low, suitable for mass production. However, the metal bipolar plate is heavy, and the contact resistance with the electrode is large, and easy to produce ion pollution to the membrane and catalyst. Soft graphite density is small, processing size is not easy to accurately control. Generally speaking, the most widely used bipolar plate is graphite/polymer composite material, which on the one hand has good conductivity and gas tightness, on the other hand is lighter, easy to process, the cost is also much lower than pure graphite plate[5].

3. Conclusion

At present, whether from the level of national policy support, local government support, or from the perspective of fuel cell technology development, social capital flow and the development of production line chain, China's fuel cell industry is ready to develop, and the industry prospect is very considerable.

From the perspective of fuel cell system and stack technology, domestic fuel cell technology has gradually entered the international advanced level. Domestic fuel cell system and reactor enterprises are also increasing their horsepower, expanding production scale and developing new and more advanced technologies.

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