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World's First Success in High Temperature Operation for over 2,000 Hours
Using an MEA with a Fluorine-based Membrane

- Demonstrates Excellent Durability by 120 degree Celsius Continuous Operation -

Asahi Glass Co., Ltd.

Asahi Glass Co., Ltd. (Headquarters: Tokyo; President: Masahiro Kadomatsu) has succeeded in enhancing the durability of the Membrane Electrode Assembly (MEA), the core component of the Polymer Electrolyte Fuel Cell (PEFC). The newly developed MEA, which uses a new fluorine-based proton-conductive polymer composite, reduces the deterioration rate from 1/100 to 1/1000 compared to the conventional MEA. The newly developed MEA can be operated continuously for more than 2,000 hours at a high temperature of 120 degrees Celsius for the first time in the world. This has opened up the possibilities of applying a highly stable fluorine-based proton-conductive polymer to an MEA for automotive use which requires severe operating conditions such as high temperatures and low humidity.

The PEFC system has been receiving wide attention as a highly efficient next-generation clean energy system that emits neither carbon dioxide nor soot, and its market is estimated to be a few billion yen for the stationary type and over one hundred billion yen by 2010 for automotive use. While several manufacturers are already planning to market the stationary fuel cell cogeneration systems for residential use from the 2005 fiscal year, the PEFC system for automotive use still have some problems to be solved, such as durability under more severe operating conditions, before actual commercialization. Above all, being able to operate stably in low humidity and at high temperatures of over 100 degrees Celsius is regarded to be one of the most critical issues, whereas the standard operating temperature is 70 to 80 degrees Celsius for the PEFC system.

The MEA, one of the most important components for power generation in the PEFC system, uses fluorine- or hydrocarbon-based proton-conductive polymers. Asahi Glass has been engaged in research and development of polymers and MEA for fuel cells since 1992, using its basic technology for fluorine-based proton-conductive polymer manufacturing which is acquired through the development of ion exchange membranes (Flemion™) for chloro-alkali electrolysis. Compared to hydrocarbon-based proton-conductive polymers, fluorine-based proton-conductive polymers are much less likely to degrade, but on the other hand they are vulnerable to high temperature operation.

Although fluorine-based proton-conductive polymers hardly degrade, very slight decomposition does occur in severe operating conditions such as high temperatures and low humidity, and after a relatively short operation time the cell voltage drops rapidly, which has been a problem. In order to solve this problem, Asahi Glass has been conducting R&D at its Research Center, focusing on the following three points: development of highly thermostable fluorine-based proton-conductive polymers, development of highly durable polymer composites, and optimization of the MEA structure to reduce polymer decomposition.

The newly developed MEA, which uses a novelly synthesized proton-conductive polymer composite, allows continuous operation for over 2,000 hours at a high temperature of 120 degrees Celsius. When fluorine-based proton-conductive polymers decompose, usually fluoride ions generate.　As for the newly developed MEA, the generation rate is 1/100 to 1/1000 of that of the conventional MEAs, indicating that the newly developed MEA has a structure in which degradation is much less likely to occur.　The newly developed MEA, therefore, is expected to substantially increase the operating temperature of the PEFC systems from the standard 70-80 degrees Celsius to higher temperatures. This can be applied to PEFC for automotive use which requires durability under high temperature and low humidity environments.

Asahi Glass will provide the new MEA samples to automotive manufacturers for evaluation.　In addition to refining the MEA, Asahi Glass will establish mass production technology of monomer synthesis and polymerization that will reduce the manufacturing costs. Asahi Glass is aiming to commercialize MEAs for PEFC within a few years based on our proprietary expertise in the MEA technology.

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<References>

(1) The principle of power generation in fuel cells

A fuel cell is made up of an electrolyte and two electrodes, anode and cathode. Fuel such as hydrogen, hydrocarbons or alcohol, etc. which form ions easily is fed to the anode, and oxygen is fed to the cathode. A fuel cell can continuously convert chemical energy into electrical energy, using an oxidation-reduction reaction. The ions generated in a fuel cell differ according to the type of fuel cell, and usually hydrogen ions, carbonate ions, oxygen ions or hydroxyl ions are used.

(2) The polymer electrolyte fuel cell (PEFC)

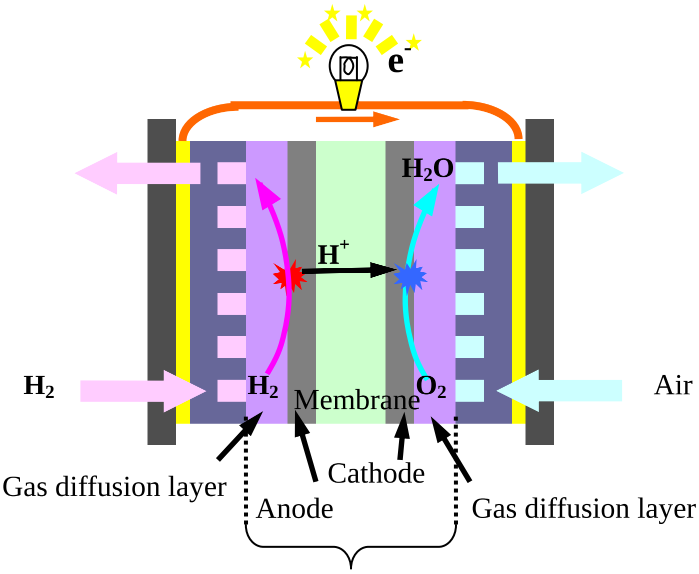
Fuel cells have an electrolyte through which ions pass. A fuel cell whose electrolyte is made of polymers are called polymer electrolyte fuel cell (PEFC). Because PEFC operates at low temperatures of 70 to 100 degrees Celsius in comparison with other fuel cells that operate at several hundreds to 1,000 degrees Celsius, it can start quickly, and is regarded as the most promising type of fuel cell for residential and automotive use.

(3) Power generation principle of the polymer electrolyte fuel cell (PEFC)

As fuels, hydrogen and oxygen are usually fed to the anode and the cathode, respectively. At the anode, the hydrogen dissociates into two hydrogen ions (i.e. protons) with the release of two electrons per hydrogen molecule. The proton transfers through the membrane to the cathode. At the cathode, the oxygen reacts with the proton, taking up electrons, to produce pure water. The electrons flow from the anode to the cathode through an external circuit as an electric current.

(4) MEA (Membrane Electrode Assembly)

An MEA, the critical part to power generation in PEFC, is made up of a membrane and catalytic electrodes which are attached to both sides of the membrane. Outside of the each catalyst layer, a sheet of carbon paper or carbon cloth called gas diffusion layer (GDL) is attached. The two catalyst layers are composed of a metal, such as platinum, loaded carbon and a polymer electrolyte that has a similar structure to the membrane. Fluorine-containing polymers and hydrocarbon polymers are available for polymer electrolyte, but from the point of durability, Fluorine-containing polymers are generally used. Although fluorine-based proton-conductive polymers hardly degrade, very slight decomposition does occur in severe operating conditions such as high temperatures and low humidity, and after a relatively short operation time the cell voltage drops rapidly, which has been a problem.



Membrane Electrode Assembly (MEA)

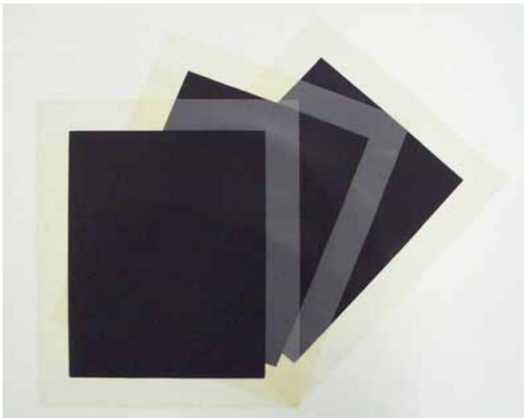


Photo of MEAs

(5) Fluorine-based proton-conductive polymers

As described in the power generation principle of the PEFC, a proton-conductive polymer is necessary to transfer the hydrogen ions (H^+), i.e. protons which form at the anode of PEFC. The material for this proton-conductive polymer is generally hydrocarbon and fluorine based, but from the durability point of view, fluorine-based polymer is more commonly used. Nevertheless, both the durability and thermostability of the conventional fluorine-based proton-conductive polymers are still insufficient and a more durable and thermostable polymer was required.

(6) Polymer composite

In order to produce a practical membrane using a polymer, compounding is necessary to augment strength and chemical stability. A compound comprising a polymer as the base material and other substances (e.g. other polymers, reinforcing materials, etc.) is called a "polymer composite."

(7) Ion exchange membrane for chloro-alkali electrolysis

Chloro-alkali electrolysis using fluorine-based ion exchange membranes is currently the primary method for producing caustic soda. The chemical structure of fluorine-based proton-conductive polymer membranes for ordinary fuel cells is similar to those of ion exchange membranes used in chloro-alkali electrolysis.

(8) Degradation rate

The degradation rate, which is an index for evaluating the MEA durability, is the rate at which an MEA degrades and its performance drops. In general, this refers to the rate of cell voltage decay, but here it shows the generation rate of fluoride ions formed by polymer decomposition.

(9) Fuel cell cogeneration systems for residential use

The fuel cell cogeneration system, also called combined heat and electric power system, can provide electricity and hot water simultaneously by using city gas or propane gas as fuel. In this system, fuel gas is fed into a device called a fuel reformer to produce hydrogen, which is used in the fuel cell system. Electricity is provided by the fuel cell, and waste heat recovered from the fuel cell and the reformer is temporarily stored in a hot water tank to be used for hot water supply and room heating.