For the past several years, many venture companies have been developing fuel cells adaptable for portable devices in the U.S. and in Europe. In Japan, the development has just started by some electronics makers. It is easy to imagine that the competition between these companies will become more and more intensified in the next few years.

However, fuel cells currently under development require a lot of improvement on fundamental characteristics to meet the demands of portable device makers.

The targets of current development of these fuel cell technologies are roughly categorized as follows; (1) a polymer electrolyte membrane, (2) an electrode, (3) a fuel, and (4) a system structure in which to lay the parts mentioned above. Among these, most makers put emphasis on the development of materials, or (1) to (3). Many specialists point out that once good materials are developed, it will be easy to solve other problems. In fact, recent research achievements successively released by several makers are mostly focused on the material developments.

Most of the research experts are searching for new materials for a polymer electrolyte membrane. Many of them assert that once they obtain a highly effective membrane, the development of a fuel cell for a portable device will be completed soon after.

Why is a new material for a membrane needed? Because the existing membrane is not suitable for the "Direct Methanol System", which is considered to be a most promising system for a portable fuel cell. The existing membrane which is used widely in fuel cells functions all right when hydrogen is fed as a fuel, but when methanol is directly put in, methanol can go through the membrane without having a reaction, and naturally disappears as time goes by without making any electric current. This is called the crossover phenomenon.

The second active development is of electrode materials. Platinum coated on an anode has an important catalytic function of separating electrons from hydrogen. The speed of this reaction, a critical factor which affects the cell discharge power, is proportional to the surface area of platinum particles. Therefore, increasing the effective particle size of platinum and the improvement of the coating technologies are the main critical elements in the development.

The third target is the fuel itself. It is a widely spread belief that using methanol as a fuel is best for a portable fuel cell. In fact, most of the portable fuel cell developers in the U.S. and Europe are concentrating on the development of the Direct Methanol System. However, some specialists have a divergent view.

"Why using methanol? It has more problems than benefits," says Seijiro Suda, a professor of Department of Environmental & Chemical Engineering of Kogakuin University. In his Chemical Energy Laboratory, fuel cells using "borohydride-based fuel", a compound of hydrogen and boron, are under development.

Using borohydride, a fuel cell can have the significantly high voltage of 1.64V, where that of a methanol system is 1.24V. "If we use hydrogen peroxide as a source of oxygen supply in the cathode side, it is possible to obtain the theoretical voltage of 2.25V. It works at ordinary pressure and temperatures. I can't imagine using other fuel for a portable fuel cell," Professor Suda appeals.

Considering that the effective voltage of a current trial fuel cell of methanol system is up to 0.3 to 0.4V, the voltage of this new type of fuel cell is marvelous. Suda's research group has already succeeded in making a prototype fuel cell applying borohydride-based fuel, and 1.6V of the effective voltage per cell has been proved.

This borohydride-based fuel cell has more advantages over the methanol system. First of all, borohydride-based fuel does not have the crossover phenomenon. Methanol discharges a small amount of poisonous chemical compounds such as formaldehyde as a result of the reaction, but borohydride does not have this problem either. Many material makers, who are surprised at the characteristics of borohydride-based fuel such as high discharge voltage and no crossover phenomenon, are visiting Professor Suda every day.

In the borohydride-based fuel cell, a protide, a negative ion of hydrogen (H-), is used for the electrochemical reaction. A protide electrochemically contains two electrons per proton, and releases twice as many electrons in one chemical reaction as ordinary hydrogen reactions.

For the catalyst, Suda's group is also targeting the use of hydrogen absorbing alloys which are much less expensive than platinum which is being used for the existing system.

Professor Suda has been studying hydrogen absorbing alloys for more than 20 years. At first, the development of a fuel cell started as an application of hydrogen absorbing alloys in his laboratory. However he and his group gave up studies of that kind once for all, because they concluded that metal hydride fuel cells are too heavy to apply to automobiles.

"I was devoted to the research and development of hydrogen absorbing alloys for more than 20 years, but succeeded in only one; Ni hydrogen secondary batteries. Other than that, nothing matured or materialized or commercialized. We finally reached conclusions from a long period of study; hydrogen absorbing alloys are applicable to only (1) electrodes, (2) hydrogen deduction materials, and (3) catalysts. We use hydrogen absorbing alloys for the electrodes of the borohydride-based fuel cells, making the best use of them," says Professor Suda.

By using hydrogen absorbing alloys instead of platinum, it is possible to lower the cost. By his calculation, two to three yen per gram for hydrogen absorbing alloys, where it is 2000 to 3000 yen for platinum.

They are conducting research and development of making a prototype borohydride-based fuel cell for portable devices by March 2002. It will be effective for 60 hours for a laptop computer, and for one month for a cellular phone on standby.

However, there is one issue. There is no production infrastructure for borohydride-based fuels, and this makes the fuel currently expensive. It is 6000 to 7000 yen per kilogram, where methanol is only 400 to 900 yen. To commercialize borohydride-based fuel cells, the production cost of borohydride must be reduced.

For this reason, they are conducting research and development of reclaiming the used borohydride solution. By his calculation, if the fuel is reusable for a few hundred to a few thousand times, the cost of one kilogram of borohydride can be reduced to around 600 to 700 yen.

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