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Bio-Battery

Aitham Balathripura
B. Tech Scholar,
Department of Electrical and Electronics Engineering,
Siddhartha Institute of Engineering and Technology,
Vinobha Nagar, Ibrahimpatnam, Hyderabad,
Telangana 501506, India.

S Rajesh
Assistant Professor,
Department of Electrical and Electronics Engineering,
Siddhartha Institute of Engineering and Technology,
Vinobha Nagar, Ibrahimpatnam, Hyderabad,
Telangana 501506, India.

ABSTRACT

When a glucose solution is poured into the white cubes, the Walkman begins to play. When an isotonic drink is poured in, a propeller starts to spin. In the summer of 2007, the Sony-developed bio battery was announced in newspapers, magazines, and TV reports, and evoked a strong response. Carbohydrates (glucose) are broken down to release energy and generate electricity.This bio battery, which is based on mechanisms used in living organism, is not only friendly to the environment but also has great potential for use as an energy source.This prototype bio battery has achieved the world's highest power output of 50 mW*2 when employed for a passive type*1 system. These research results were published at the 234th American Chemical Society National Meeting & Exposition in August 2007 and earned respect from an academic point of view.Sony successfully demonstrated bio battery powered music playback with a memory type Walkman and passive speakers (which operate on power supplied by the Walkman) by connecting four bio battery units in series. The case of this bio battery, which is made from an organic plastic (polylactate), is designed to be reminiscent of a living cell.

I.INTRODUCTION

A bio-battery is an energy storing device that is powered by organic compounds, usually being glucose, such as the glucose in human blood [1-3]. When enzymes in human bodies break down glucose, several electrons and protons are released.

Therefore, by using enzymes to break down glucose, bio-batteries directly receive energy from glucose [4-6]. These batteries then store this energy for later use. This concept is almost identical to how both plants and many animals obtain energy [7].

Although the batteries are still being tested before being commercially sold, several research teams and engineers are working to further advance the development of these batteries [8].

What is a Bio-Battery:

A bio-battery is known as a device in which the substrate material, organic or inorganic, is converted to electric energy. This conversion takes place with the help of various biological or biochemical agents, such as enzymes or micro-organisms [9].

The substrate is broken down in the presence of these agents to release protons and electrons [10]. The continuous circulation of these protons and electrons within the bio-battery generates electricity.

History:

As an electrical signal can induce a biological reaction; the reverse in is also true in most of the cases and in this way biological processes can be used to generate electricity for powering electrical equipment.

Even though the Bio fuel cells have been known for almost a century since the first microbial BFC(Bio fuel cells) was demonstrated in 1912,the first enzyme-based

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bio-fuel cell was reported only in 1964 using glucose oxidize (GOx) as the anodic catalyst and glucose as the bio-fuel.

II.Workings of Bio-Battery

Like any cell battery, bio-batteries contain an anode, cathode, separator and electrolyte with each component layered on top of another [11-12]. Anodes and cathodes are the negative and positive areas on a battery that allow electrons to flow in and out.

The anode is located at the top of the battery and the cathode is located at the bottom of the battery. Anodes allow electrons to flow in from outside the battery, whereas cathodes allow current to flow out from the battery [13].

Between the anode and the cathode lies the electrolyte which contains a separator. The main function of the separator is to keep the cathode and anode separated, to avoid electrical short circuits. This system as a whole, allows for a flow of protons (H+) and electrons (e-) which ultimately generates electricity.

Glucose:

Bio batteries are heavily based on the amount of glucose available. This glucose (sugar) can be provided from nearly anything, including soda, waste materials (such as old papers), or the glucose in living organisms.

The decomposition of materials to glucose (if they are not already in the proper stage) is the main step in getting the cycle started. Materials can be converted into glucose through the process of enzymatic hydrolysis. Enzymatic hydrolysis is the process in which cellulose (an insoluble substance) is converted to glucose by the addition of enzymes.Once glucose is present, oxygen and other enzymes can act on it to further produce protons and electrons.

Process:

Similar to how human bodies convert food to energy using enzymes, bio-batteries use enzymes to convert glucose into energy.When glucose first enters the battery, it enters through the anode. In the anode the sugar is broken down, producing both electrons and protons.

$$\text{Glucose} \rightarrow \text{Gluconolactone} + 2H^+ + 2e^-$$

These electrons and protons produced now play an important role in creating energy. They travel through the electrolyte, where the separator redirects electrons to go through the mediator to get to the cathode. On the other hand, protons are redirected to go through the separator to get to the cathode side of the battery.

The cathode then consists of an oxidation reduction reaction.This reaction uses the protons and electrons, with the addition of oxygen gas, to produce water.

$$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$$

There is a flow created from the anode to the cathode which is what generates the electricity in the bio-battery.The flow of electrons and protons in the system are what create this generation of electricity.

Need for Bio-Batteries:

In the field of electricity, a battery is a device that converts chemical energy to electrical energy. Different types of batteries are used in various electronic and electrical devices. However, these batteries contain certain chemicals such as compounds of lead and mercury, which are highly toxic in nature. Also, chemical batteries are prone to explosions, leakages, etc. These problems are not seen in the case of bio-batteries.

Therefore, bio-batteries have a great potential to be used as suitable alternatives or even replacements for chemical batteries in the future.

Types of bio-batteries:

Depending on the type of agents involved in the breakdown of the substrate, the main types of bio-batteries are –

- Enzymatic bio-battery - Biochemical agents, i.e., enzymes are involved in the breakdown of substrate (mainly sugars).
- Microbial bio-battery - Micro-organisms such as Escherichia coli, electric bacteria, etc., are

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involved in the breakdown of substrate (organic or inorganic).

In both types of bio-batteries, the breakdown of the substrate yields protons and electrons. The circulation of these protons and electrons within the bio-battery generates the conduction of electricity.

Other types of bio-batteries developed include cellulose-based bio-batteries, body fluid-based bio-batteries, etc. Even mitochondria (sourced from a suitable biological cell) can be used in a bio-battery, since they are regarded as the "energy powerhouses" of the biological cell.

Advantages:

Bio-batteries have various advantages over chemical batteries –

Quick recharging capabilities

Enzymatic bio-batteries which function on glucose can be recharged quickly due to fast action of the enzymes. Also, in a microbial bio-battery, glucose is an instantaneous source of energy. Therefore, the battery can be recharged extremely quickly. Chemical batteries cannot be charged as quickly as bio-batteries.

Clean, non-toxic source of energy

Sources of energy (susbstrate material) for the functioning of a bio-battery are completely renewable, non-polluting, as well as environmentally-friendly (wastewater recycled to produce electricity). Therefore, unlike chemical batteries, bio-batteries are a clean, non-toxic source of energy.

Extremely safe

Bio-batteries do not undergo explosions or leakages, which is not the case with chemical batteries. Therefore, bio-batteries are completely safe to use.

Applications:

Presently, bio-batteries are under development for greater improvement, versatility, and usage in various areas. Research is being carried out in this field of study. However, bio-batteries can have great potential applications in the following fields –

Electronic devices - Bio-batteries are being developed so as to be used in electronic devices such as laptops and mobile phones. Owing to their quick recharging capabilities, bio-batteries remain ideal replacements for chemical batteries in these devices. Bio-batteries also possess great potential to be used in electronic toys.

Medicine - Bio-batteries can find great usage in artificially-implanted medical devices such as artificial pacemakers, external hearing devices, battery-operated insulin pumps, etc. Digital thermometers and glucose meters (used by diabetics) can also be operated using bio-batteries.

Defence purposes - Bio-batteries have great potential to be used in the defence field for the purposes of surveillance, remote sensing, spying devices, etc.

Fuel synthesis - Scientists have developed a prototype of a solar-powered microbial device (combination of a bio-battery and a solar cell) which produces hydrogen gas. The energy sources for this combination device are wastewater and sunlight.

If this technology is further developed and used on a larger scale, wastewater can be efficiently recycled, and the increasing demand for clean, non-polluting fuel can be addressed.

VI. CONCLUSION AND FUTURE

The Bio batteries are High performing, stable, and reproducible enzymatic fuel cell technology developed over last 5 years. The Scaled-up demonstration of Bio-Battery powering electronic circuit (performed at both Power Sources and Army Science Confs).

Fully-integrated Bio-Battery charging prototypes are already developed. Funding secured from multiple Department of Defense (DOD) agencies for multiple target applications over the next 3-5 years.

While many exciting announcements have been made in the field of bio-batteries, it may be some time before we

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see them replacing nickel-cadmium, lithium-ion or the several other types of traditional batteries.

Even so, the small, flexible, long-lasting and environmentally friendly battery technologies discussed here show the great possibilities researchers see in bio-batteries, especially for the field of medicine. The technology generates electricity by turning shredded paper into sugar which in turn is used as fuel. If brought to market, the innovation could allow the public to top up the power of their mobile devices using waste material.

Compared to conventional batteries, such as lithium batteries, bio-batteries are less likely to retain most of their energy. This causes a problem when it comes to long term usage and storage of energy for these batteries. However, researchers are continuing to develop the battery in order to make it a more practical replacement for current batteries and sources of energy.

The bio-batteries are environmentally friendly as they did not use harmful chemicals or metals. . With that in mind, scientists seem to be exploring every possible option in bio-battery and fuel-cell technology.

They serve as a new form of energy that is proving to be environmentally friendly, as well as successful, in producing and reserving energy. Although the batteries are still being tested before being commercially sold, several research teams and engineers are working to further advance the development of these batteries.

Future Scope:

Improved design and performance leads to 50X higher volumetric power density over existing prototype .The longer-term goal in this area is to further enhance performance to ultimately develop batteries suitable for notebook computers and other mobile devices. While many technological challenges still remain, Bio Battery has great potential as a next-generation energy device.

Advantages include its excellent harmony with the environment as a product fueled by a carbohydrate (glucose) having high energy density. Sony will continue to work toward the commercialization of this technology in the near future, initially for use in toys and other low-power products.

Bio-batteries have a very bright future ahead of them as test productions and research have been increasing over recent years. They serve as a new form of energy that is proving to be environmentally friendly, as well as successful, in producing and reserving energy. Fully-integrated demonstrations are to be executed in close collaboration with customer, for relevant applications.

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