INTERNATIONAL JOURNAL OF HIGHER EDUCATION AND RESEARCH
IJHER, Vol., 8(2), 2018, 132-140.
www.ijher.com

IJHER
(ISSN 2277 260X)

CODEN:IJHER
ORIGINAL ARTICLE

# REVIEW PAPER ON BIO BATTERIES: POWERING THE NEXT GENERATION OF ENERGY

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Abstract
*Electricity is considered as an integral utility in today's world. One of the portable and convenient sources of electrical energy is a Battery. A bio battery or a bio fuel cell is an energy storing device that is powered by organic compounds, especially glucose. It generates electricity from renewable fuels providing a sustained, on-demand portable power sources. By using enzymes to break sown organic compounds, bio-batteries directly receive energy from them. Bio-batteries are alternative energy devices based on bio-electro catalysis or natural substrates by enzymes or microorganisms. This paper brings out an alternative solution to the conventional batteries which is not only a boon to the environment by being eco-friendly but also it is an end to worries about non-renewable and vanishing sources of energy; gives a through insight on this relatively revolutionizing and satisfying solution of energy storage through bio-batteries and provides an in-depth analysis of the same. Bio-batteries have potential adaptability to power the next generation of electronics, medical devices and hybrid vehicles, allowing for radical new designs and medical technologies. It is aimed at understanding and analyzing the properties and characteristics of Bio-Batteries; to study its advantages, potential applications, limitations and disadvantages.*
*Keywords: Bio battery, Bio-fuel cell, Enzymatic bio-battery, Microbial bio-battery.*

## 1. INTRODUCTION

A bio-battery is an energy storing device that is powered by organic compounds. Bio-Battery generates electricity from renewable fuels (glucose, sucrose, fructose, etc) providing a sustained, on-demand portable power source (Siddiqui and Pathrikar, 2013).As we know battery is a device that directly converts chemical energy to electrical energy. Bio batteries are energy-conversion devices based on bio-electrocatalysis leveraging on enzymes or micro-organism. A bio-battery is a device where substrate material that may be either organic or inorganic, is converted to electrical form of energy. This conversion takes place with the help of different biological or biochemical agents, such as micro-organisms or enzymes. The substrate is broken down in the presence of these agents to release protons and electrons. The continuous circulation of these protons and electrons within the bio-battery produces electricity (Vrudhula and Rakhmator, 2003).

Bio batteries are the fuel cells which are promising electrochemical generators of sustainable electrical power produced upon catalytic oxidation of gas or liquid fuels flowing through the cells (Hayre and Colella,2009). Usually they operate using noble metals to catalyse redox transformations of the fuel and oxidizer at the electrodes in the cell. Biofuel cells utilize biochemical approaches for catalysing these reactions to yield electrical power. They include two bioelectrocatalytic electrodes; an anode for oxidation of organic compounds and a cathode for reduction of oxygen, being an oxidizer consuming electrons transported through the electrical circuit from the oxidized fuel (Kavanagh and Leech, 2008). Purified enzymes or whole microbial cells are used to biocatalyze redox transformations at the electrodes and/or generate oxidizable substrates from raw organic substances. In the last decade the major fundamental problems of coupling between the biochemical and electrochemical processes, mostly related to the efficient interfacial charge transport using mediated or direct electron transfer between enzymes/ microbial cells and electrodes, were solved and the biofuel cells became feasible. Practical application of biofuel cells is still awaiting for solutions of most of these engineering problems require biochemical, microbiological or, in general, biotechnological approaches (Ramanavicius and Kausaite, 2005). One of the important potential applications of the biofuel cells is powering implantable biomedical devices. Miniaturized biofuel cells might be implanted in a human body to use naturally existing biochemical substances as fuel (e.g., glucose in a blood stream).Adaptive behavior of the implantable biofuel cell being self-regulated and producing electrical power on-demand would be an immense advantage for these bioelectronics devices. Such devices could be based on modified electrodes with switchable/ tunable activity (Heller, 2006).

## 2. NECESSECITY

This bio battery, is not only friendly to the environment but also has great potential for use as an energy source. Still, chemical batteries have challenging aspects of explosions, leakages and toxicity. These problems are not seen in bio batteries. Unlike fossil fuels, carbohydrates (glucose) are carbon neutral and do not contribute to increases in carbon dioxide. The important constraints like energy density, size/weight, instant recharge, flexible shape, renewable biocatalysts, room temperature operation, and readily available fuel source created the necessity of batteries which can be renewable and a continuous source of energy. The invention of Bio batteries contribute in goodwill of the environment but eliminating the shortfalls offered by traditional batteries made up of metal plates (Nanomedicine Development Center, 2009). Plants create both carbohydrates and oxygen by photosynthesis from carbon dioxide and water. Animals take up those carbohydrates and oxygen and utilize the mas an energy source and release carbon dioxide and water. Then this cycle starts again. Since the carbon dioxide is recycled in this system, the amount of carbon dioxide in the atmosphere does not increase. If electrical energy could be directly acquired from this cycle, we could obtain more environmentally friendly energy than that from fossil fuels. Furthermore, renewable energy sources such as glucose (which is present in plants and therefore abundantly available) have an extremely high energy density. Batteries containing heavy metals pose a danger to both the environment and human health. Bio batteries that have been developed in recent years need to be placed in separate compartments for waste separation. But in the near future, it may be possible to completely avoid metals in our batteries (Hayre and Colella, 2009).

Figure1: leakage in chemical batteries

## 3. SYSTEM MODEL

Electricity, as we already know, is the flow of electrons through a conductive path like a wire. This path is called a circuit. Batteries have three parts, an anode (-), a cathode (+), and the electrolyte. The cathode and anode (the positive and negative sides at either end of a traditional battery) are hooked up to an electrical circuit.

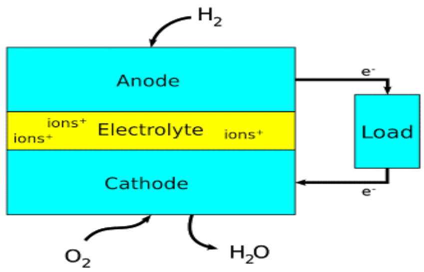
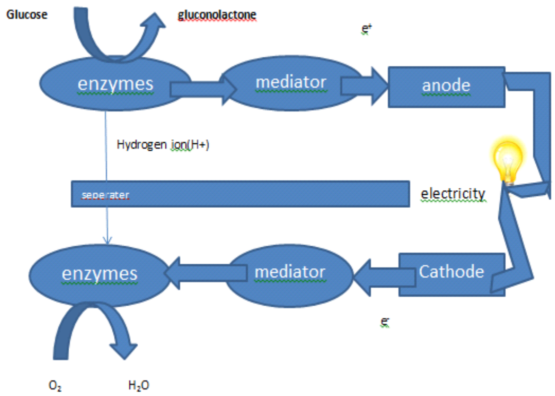



Figure2: system model of bio-batteries

The chemical reactions in the battery cause a buildup of electrons at the anode. This results in an electrical difference between the anode and the cathode. This difference is like as an unstable build-up of the electrons. The electrons tend to rearrange themselves to get rid of this difference. But they do this in a certain way (Siddiqui and Pathrikar, 2013). Electrons repel each other and tend to go to a place with fewer electrons. In a battery, the only place to go to is to the cathode, But, the electrolyte keeps the electrons from going straight from the anode to the cathode within the battery (Audette and Munukutla, 2009). When the circuit is closed (a wire connects the cathode and the anode) the electrons will be able to get to the cathode. In the picture above, the electrons go through the wire, lighting the light bulb along the way. This is one way of describing how electrical potential causes electrons to flow through the circuit.

The principles of the bio battery are based on the energy conversion mechanism in living organisms. Similar to how human bodies convert food to energy using enzymes, bio-batteries also uses enzymes to convert glucose into energy (Siddiqui and Pathrikar, 2013). A Bio-Battery battery consists of two different metals suspended in an acidic solution. They contain an anode, cathode, separator and electrolyte, which are the basic components of a cell battery. Each component is layered on top of another component. Anodes and cathodes are the negative and positive areas on a battery. The anode is located at the top of the battery and the cathode is at the bottom of the battery. Anodes allow electrons to flow in from outside the battery, whereas cathodes are devices that allow current to flow out from the battery.



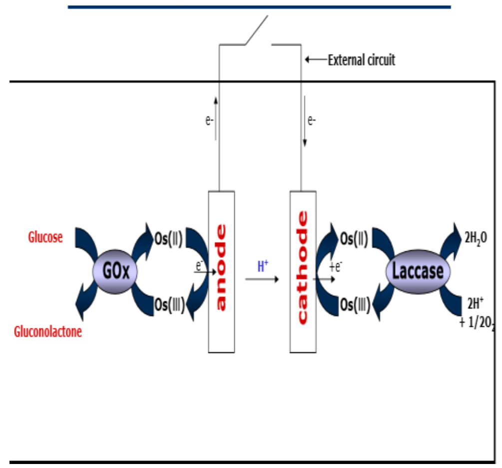




Figure3: process of energy release in bio batteries        figure 4: schematic of bio battery

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 generate electricity. The movement of protons has a moving force that pushes, this movement is called current. When this moving force (current) is measured, it is measured it what is called voltage or volts (Barton , Gallaway and  Atanassov, 2004).

When glucose first enters the battery, it enters through the anode. In the anode the sugar is broken down, producing both electrons and protons.

Glucose → Gluconolactone + $2H^+$ + $2e^-$ [1].

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.

$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$ [18].

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 (Siddiqui and Pathrikar, 2013).

## 4. ADVANTAGES OVER EXISTING BATTERIES

The ability of Bio-batteries to allow an instant recharge is comparatively high. In other words through a constant supply of sugar, or glucose, bio batteries are able to continuously keep themselves charged without an external power supply with high fuel flexibility like sugar, alcohol, diesel, ethanol, blood ,wastewater etc (Siddiqui and Pathrikar, 2013). 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 (Kannan and Renugopalakrishnan, 2013). Other advantages include high energy density, reduced size/weight, flexible shape, renewable biocatalysts, room temperature operation, readily available fuel source. Bio batteries are also a source of non-flammable and non-toxic fuel. This provides a clean alternative renewable power source. i.e. excellent harmony with the environment. Likewise, Sources of energy (substrate 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. Bio-batteries do not undergo explosions and leakages, which is not the case with chemical batteries. Therefore, bio-batteries are completely safe to use (Siddiqui and Pathrikar, 2013).

## 5. CONCLUSION

The Bio batteries are high performing, stable, and reproducible enzymatic fuel cell technology developed over last decade. While many exciting announcements have been made in the field of bio-batteries, it may be some time before we see them replacing nickel-cadmium, lithium-ion or the several other types of traditional batteries. In this paper, I have proved the bio batteries as a eco-friendly source of energy, non-explosive battery, non-toxic source of energy and more efficient source of energy , Even so, the small, flexible, long-lasting and environmentally friendly battery shows the great possibilities. The bio-batteries are environmentally friendly as they do 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.

## 6. FUTURE SCOPE

Fully-integrated Bio-Battery charging prototypes are already developed. While many technological challenges may still remain, Bio Batteries have great potential as a next generation energy storing device. Since there is glucose in human blood, some research facilities are also looking towards the medical benefits of bio-batteries and their possible functions in human bodies. Although this has yet to be further tested, research continues on the subject surrounding both the material/device and medical usage of bio-batteries (Siddiqui and Pathrikar, 2013).

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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