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A literature review on EELS – Intrinsic characteristic of producing electric current

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ABSTRACT

An eel scientifically known as Anguilliformes is a fish consisting of ray fins which belong to the Actinopterygii family i.e. family of eels in freshwater. It has 8 suborders, 19 families and 119 genera, and somewhere around 800 species. Eels have various intrinsic and extrinsic characteristics which alter and develop when they grow physically. Eels have an elongated structure (long length fish) with a length ranging from 5cm to 4m and weighing from 30g-25kg (in adults). Eels swim by generating waves from their body structure. They can swim in both forward and reverse directions forming body waves. They generally reside in deep waters or sea in holes called "eel's pit". Some of the eels may stay at freshwaters but they too will come back to the seas for breeding. There are two types of eels that are commonly seen one is deep-sea spiny eels and the other is the electric eels producing an electric current of high voltage. Both these characteristics of eels help them from protecting themselves from predators. This review paper considers the lather characteristics of the eels of producing electric current using their own intrinsic characters and how they behave during the act of producing current

Keywords: *Eels, Anguilliformes, Actinopterygii, Intrinsic Characteristics, Eels Pit, Electric Eels, Deep Sea Spiny Eels*

1. INTRODUCTION

In the past so many years the scientists, engineers, researchers have done a series of work in knowing the different living and non-living beings which can produce electricity. The main intension of these researches were how these species or animals can produce the electric energy biologically, physically and chemically what all are the changes seen in the structure of the body and how they react to this characteristic feature. Now this bioelectricity can be mimicked to produce artificial electric energy.

In the research they found out that a good number of fishes for ex eels, electric star fish can produce electric current this helped them to find their prey, protect themselves from other hunters. A number of research work is done on mimicking the structure of these kinds of fishes to produce artificial electricity. Inspired by the structure of the eels and the electrocytes in them various research is done nanofluidic devices and artificial batteries were designed which are mentioned in the report section below.

2. REPORT/LITRATURE

Fishes producing electric current are most common than people think. In underwater where there is less light the electric fishes uses these electric signals to communicate, navigate and find out at what distance their prey is. There are nearly 350 species of fishes have atomic structure which can produce electric signals. They are divided into two groups the weakly electric fishes which could produce 1 volt of electricity and strongly electric fishes like eels which can produce up to 600volts of electricity. How does these fishes produce electricity? Basically if they sense something it might be prey, hunter etc. They form a signal this signal is sent to electric organs or disk shaped cells called as the electrocytes. Before the electric signal reaches the organ the electrocytes will be positive charge outside and negative charge inside as soon as they receive the signal they change the pattern now one side of electrocyte is positively charged from outside and negatively charged inside but the far side has the opposite charge pattern these alternative charges draws current turning the electrocyte into a biological battery. Now these electrocytes are arranged in a series and all the charges reaches them at the same time so these typically acts as a series of battery forming huge current. Now through

continuous charges from series of electrocytes they form electric field which can travel for over a distance easily. Now using this concept of bioelectricity produced from the eels various research for bio mimicking (imitating the biological features of a species) these characters so as to produce artificial current is done.

In the year 2008 Jian XU et al.1 have made various research on the artificial cell formation from the biological ion concentration gradient using nanotechnology .where the make use of nanoscaled membranes to produce artificial current. They explain about cell membrane which consists of various nanoscale conductors in form of pumps and channel through which they have designed an artificial cell for the current generation.

In year 2014 Yong Yan et al. 2 have made various studies on the concentration cells which can last long by holding charge and can produce more current. Here they explain about concentration cell. Half of this concentration cell consists of different reactants though having same material which form equilibrium with the concentration cell. As the entropy increased of these cells it was converted into flow of electricity with voltage output which could be determined by the Nernst equation. Here they make use of the molecules of the citric acid having electrode reactions which are tethered onto magnetic nanoparticles and sharp gradients one of the permanent magnet is placed external to the cell using this they produced cells which could produce current of higher voltage up till 0.5 V and can work for over 100 hours. The advantages seen were they did not produce any harmful by products when corrosion of electrodes and the nanoparticles can be regenerated by again coating it with citric acid. Setup and the Nernst equation used to determine the current is shown in figure 1 and 2 below.

$$E = -\frac{0.05916}{z}\log\frac{C_{cathode}}{C_{anode}}$$

Fig 1: NERST equation to find current

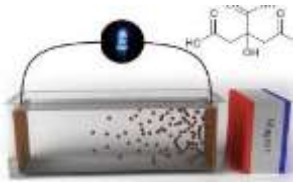

Fig 2: shows p-n junction producing electric current

In the year 2017 Jinzhao Ji et al. 3 have proposed a research on osmatic power generation using 2D nanofluidic membrane pairs using similar principles as that of the Jian XU et al.1. But they have worked on the generation of energy from osmatic energy in living begins. They stated that every living organism has ability to convert the intercellular energy into useful osmatic energy with nanoscale ionic conductors in the form of ionic pumps or ionic channels this is known as bioelectrogenesis. He created a charged 2D nanofluidic membrane pairs influenced by the eels structure of producing electric current. Now the reason why he used instead of the 1D material is because it reduces the ion transport resistance and high packing density of nanochannels. The 2D membrane uses the principles of reverse elctrodialysis system containing negatively and positively charged nanochannels called as the graphene oxide membrane (GOM). The negative charge is up till -123 mC/m2 and positive charge will be up till +147 mC/m2.

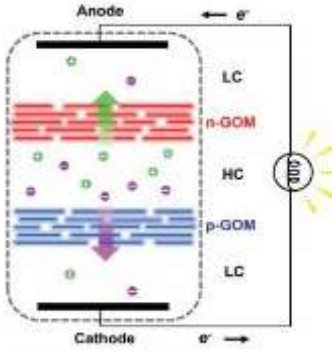

Fig 3: Eels cell

Here the cell consisted of the three compartments with two way transmembrane of n-GOM and p-GOM and a cathode and a anode at respective positions. In the cells the cations pass through the negatively charged GOM and the aniod pass through the positively charged GOM. This system creates the superposed electrochemical potential difference creating current. Also they use electrolytes like the salt solution and other liquids like the industrial waste water, fruit juices etc. These GOM sheets has to be charged to get n-GO and p-GO i.e. positively and negatively charged GOs recharged after a period of time by two step chemical reaction and using nanosheets. These cells can be used in vast medical applications and in tiny devices.

In the same year 2017 Thomas B.H. Schroeder et al. 4 have prepared a research paper on soft power source from stacked hydrogels by mimicking the characteristics of eels. Initially it explains the major 3 characteristics of the electric organ of eels which has to be considered to produce the current from stacked hydrogels or to make an artificial electric organ. The first one is the electric organ consists of thousands of ions arranged in series which are spread long and have thin electrical cells called as electrocytes which covers up to 80% of its body. These stacked eletrocytes in series can produce current up to 600V. For mimicking this characteristics the four composition of hydrogels are used consisting of an anterior (refers to front section of body), posterior (refers to back section of the body), intercellular section and extracellular salt section. A combination of 4 gels can produce 130-185 mV and a stack of these hydrogels of around 2449 gels produced 110V of current. The second feature of the electric organ was that all these gels had to be activated at the same time to produce so much current which was filled using certain fluids. Here the signal nerve slows down the activation for the cells near the command nucleus so that by the time the signal reaches the end cell the cell near the command nucleus activates simultaneously. The third feature of the electric organ is regeneration of large gradients of Na+ and K+ ions. This

was done by maintaning gaps between each hydrogels before actuation. The regenration in the artifical electric organ was done applying the current to the electrodes which could regenrate 90% of the ions even after 10 discharges.

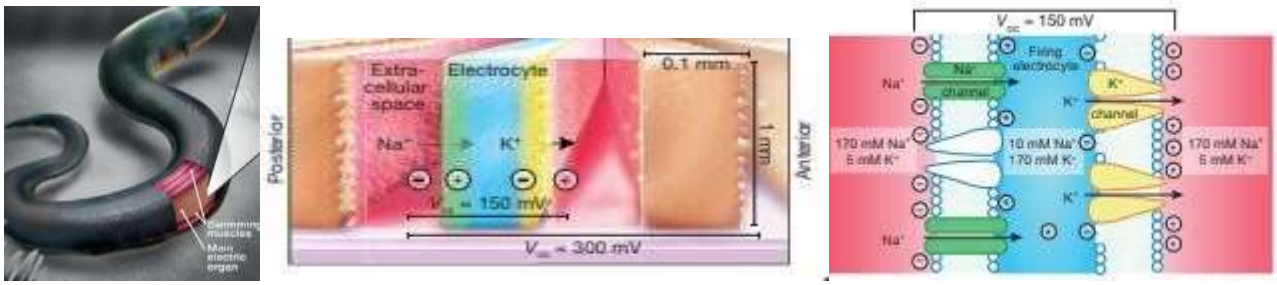

Fig 4: Internal sturcture arrangement in eels/eel cell

In working the posterior section consists of the sodium ions and anterior section consists of the potassium ions where the elctrocyes passes through low resitivity intercellular and extracellular layers to generate electricity. In this paper they have also explained about various advancement techniques which can be adopted to increses the efficiency of this artifical organ like using unfold solar plates with hydrogels etc.

In 2018 Xin Sui et al. 5 have engineered a nanochannel membranes with diode like behavior for enrgy conversion with wide range of PH. Though there are many inventions relating to the nanofluidic devices but fabrication of ion selective membrane with high power density was still a challenge. So they found out a assymetric nanochannel membrane with diode like transport behaviour with high performance and could also work with wide range of PH values. They were made from carboxyl groups and anodic alumina oxide (AAO). The electrocytes contains primary membrane one which is innervated and another non-innervated containing huge amount of proteins in the form of ion channels and pumps. So inspired by these they made nanochannel from nanoporous polymeric membrane with carboxyl group and AAO which helped ion selectivity, ion regulation and mechanical support to the membrane. Here they make use of synergistic effect that the sumation of all the energies is taken as a whole for varied PH values this helps in enrgy conversion. So here what it does is it unblockes the positive voltage and blocks the negetaive voltage and regulates the ion flow in unidirection. Further to this in reverse bias the back current is blocked and preserved to avoide power dissipation. The size of the layers of membrane overlap each other which leds to more ion permselctivity. With changing in PH values the charges with AAO and carboxyl oxide also changes and they adjust to those PH values respectively which is explained with different values by them.

3. CONCLUSION

From various research and observation we can see that there are various living organisms with structure and characteristics which can produce electricity especially eels and these characteristics can be used for advancement in various processes through continuous research and by biomimetic. Though these species becomes dangerous for the organisms around them but this feature have also led to various experiment in understanding how the nature can produce electricity. And closely studying about these characteristic features various bio mimicking to create artificial cells or structures which could produce electric current. Over the past so many years with changes in technology we can see how the bio mimicking has evolved and improved with various different methods. We see how from concentration cell scale the process is carried out till nanoscale cells or membranes. And there are yet various scopes on theory stating how nature produce electricity which can be researched. Also these have varied applications in terms of medical, engineering, scientific, research, biotechnology and other fields which use current as energy.

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