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Urine Pollution Control and Power Generation by using Fuel cell

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Abstract: Many issues that we are facing today are energy crisis and various forms of pollution during generation of electricity. This project promises a technology of converting the urea to hydrogen which is further converted into electricity before urea gets hydrolyzed to ammonia, which leads to gas phase ammonia emission and catalyses the formation of ammonium nitrate and sulfate in the environment, reason behind the many health problems such as bronchitis, asthma attacks and premature death. Hence we give away a remedy through this project to decrease the dependence on traditional energy sources, lessen the detrimental impacts on environment plus considerably lower down the cost of sewage water treatment. Such problems can be to tackle by using the most abundant waste on earth that is human urine as a source of energy. Urea as an important constituent of urine is a major pollutant constituent. The electrolysis of urine gives us pure hydrogen which is fed into fuel cells. Fuel cell converts this hydrogen and oxygen into water, hence produces electricity of voltage about 0.7 V. This electricity can be stored in lead acid battery, which can be further utilized for light load applications at various public establishments. This project provides a new ray of hope for achieving multiple goals simultaneously i.e. not only generation of electricity but also control of pollution due to the urine. The byproduct, water, from fuel cell can be used latter on for irrigation purpose. This system can be taken into use at public places like malls, schools, hospitals etc.Same experiment can be carried out with cattle's urine as it is observed that it contains more urea which is require in electrolysis process to obtain hydrogen .

Keywords: Urine, Electrolysis, Fuel cell, Hydrogen, Electricity.

I. INTRODUCTION

Urine is basically an aqueous solution containing more than 95% water, the other constituents, according to decreasing concentration are urea 9.3 g/L, chloride 1.87 g/L, sodium 1.17 g/L, potassium 0.750 g/L, creatinine 0.670 g/L and other different dissolved ions, inorganic and organic compounds. On average urine production in adult humans is 1 – 2 L per day, by taking into consideration state of hydration, activity level, environmental conditions, weight, and health parameters. The biggest and most valuable content of urine other than water is urea, an organic source of H, C, O, and N. water with more urea (urine) is commonly released into rivers, ponds, lakes and tributary from wastewater handling plants operated by Municipal Corporation. Our paper promises a technology of converting urea to hydrogen which is further converted into electricity before urea gets hydrolyzed to ammonia, which leads to gas-phase ammonia emissions and catalyzes the formation of ammonium nitrate, ammonium sulfate. These gases are the reason for many health problems. Hence we give away a remedy through this paper to decrease the dependence on conventional energy sources, minimize the damaging impacts on environment plus considerably lower down the cost of sewage water treatment.

II. HYDROGEN AS A FUEL

As pure hydrogen does not occur naturally, it takes a significant amount of energy to manufacture it. There are different ways to produce it, such as electrolysis and steam-methane reforming through water to separate the hydrogen and oxygen atoms. This method can use wind, solar, geothermal, hydro, fossil fuels, biomass, and many other resources. Once manufactured, hydrogen is an energy carrier (i.e. a store for energy first generated by other means). The energy can be delivered to fuel cells and generate electricity and heat, or burned to run a combustion engine. Hydrogen fuel can provide motive power for cars, boats and airplanes, portable fuel cell applications or stationary fuel cell applications, which can power an electric motor and as reliable alternative to illuminate periphery of various public establishments such as schools, bus stops, hospitals, railway stations etc. in terms of surrounding street lights, billboard lightings.

III. ELECTROLYSIS OF URINE FOR GENERATION OF HYDROGEN

Urea is an organic compound whose chemical formula is: CON2H4 or (NH2)2CO. It is indogenously produced compound formed by protein and amino acid catabolism. It gets produced in liver due to ammonia, which is obtained during removal of amino group from urine molecules as urine is amino compound. Approximately 20–35 gram of urea is extracted through human urine per day, as in "[1]".

Urea (an important ingredient of urine) contains four hydrogen atoms per molecule. During electrolysis process these molecules are broken apart, paving a new economic way for the oxidization of urea with the help of nickel based electrode. To disintegrate these molecules, a potential difference of 0.37V and power supply of 22KW per gram of hydrogen gas needs to be applied across the electrolytic cell, as in "[2]".On the other hand 1.23V voltage supply is needed to obtain hydrogen from water by electrolysis. Hence the former source of hydrogen is cheaper and economical, as in "[3]".

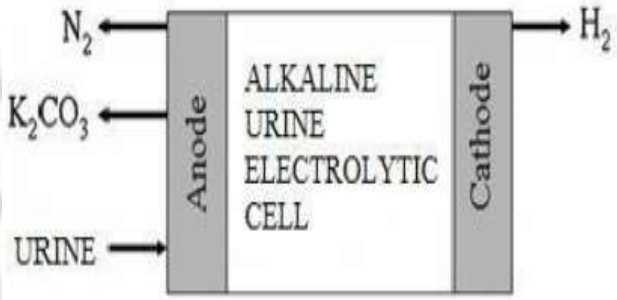


Figure 1: Schematic Representation of direct urea (urine)-to-hydrogen process.

Anode reaction: CO (NH2)2 + 6OH- → N2 + 5H2O + CO2 + 6e-

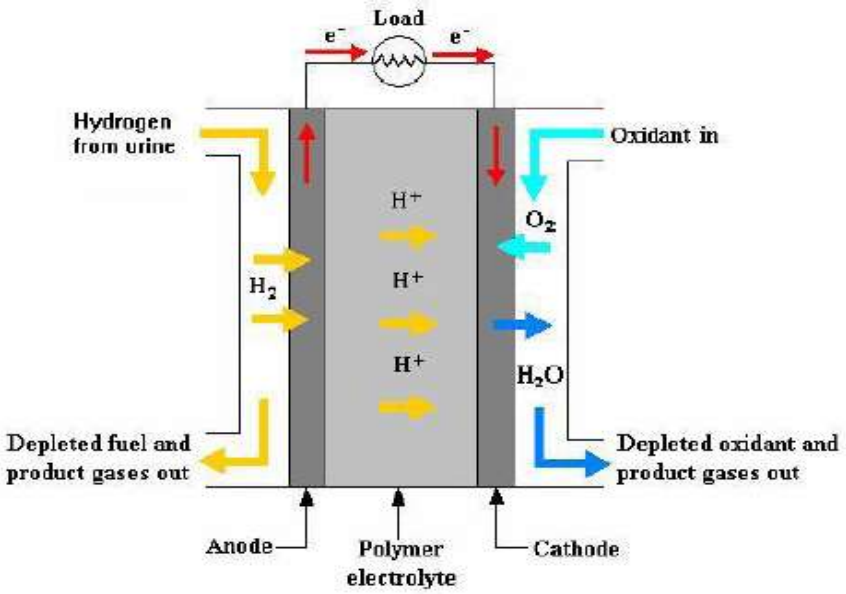
Cathode reaction: 6H2O + 6e- → 3H2 + 6OH-

Overall reaction: CO (NH2)2 + H2O → N2 + 3H2 + CO2

These reactions take place at normal ambient temperature and under normal pressure conditions. During the electrochemical process adsorption of urea takes place on the surface of nickel electrode, which allows the electrons required to break up the molecule. Pure hydrogen is produced at the cathode, while nitrogen in conjunction with trace of oxygen and hydrogen is available at the anode. The carbon dioxide produced during this reaction is not found in the gasses since it reacts with the potassium hydroxide present in the solution to give potassium carbonate. On the other hand Nitrogen gets yielded from the anode marking removal of nitrate from wastewater and thus reduction of reduction of water takes place at cathode and hydrogen is produced as the final output as in "[4]".

IV. GENERATION OF ELECTRICITY USING HYDROGEN

A fuel cell is an electrochemical device which combines hydrogen and oxygen to generate electricity, heat and water. The hydrogen is obtained from electrolytic cell by hydrolysis of urine. On the other hand the demand of oxygen is accomplished through surrounding air. As fuel cell is an electrochemical device hence works without combustion which facilitates zero emission in the environment. The fuel cell has no dynamic (moving) parts hence it is a reliable source of electricity, heat and water, as in "[5]".



In a normal fuel cell, hydrogen is given continuously to the anode (negative electrode) chamber and an oxidant (i.e. oxygen from the air) is delivered constantly to the cathode (positive electrode) chamber. Electric current starts flowing on account of electrochemical reactions proceeding at electrodes.

Two important parts of the fuel cell are –

Electrodes – meant for catalyzing the electrochemical reactions Electrolyte – act as a bridge for the transposition of hydrogen ions from anode to cathode. Here PEM – polymer electrode membrane serves the purpose of electrolyte. It helps in transfer of protons from anode to cathode, but restricts the flow of electrons through it. The instant hydrogen is imparted to the fuel cell it gets oxidized at the anode (negative electrode) to give away two H+ ions (protons) and 2 electrons for each hydrogen molecule. This phenomenon is termed as electrochemical reaction. The chemical reaction for the same is given below:

$2H2 \rightarrow 4H+ + 4e-$

The above produced free electrons flow through the load from anode to cathode constituting electric current. On the contrary, the protons produced as a result of oxidation at anode passes through the Proton Exchange Membrane (also known as Polymer electrolyte membrane) to the cathode side of the fuel cell. The electrons cannot get through the PEM, hence preferably they pass through the electric load (e.g., the electric motor on an automobile) before reaching the cathode (positive electrode) thus completes the electric circuit by following the least resistance path. Oxygen invades the fuel cell at the cathode terminal and concatenates with the hydrogen ions and the electrons to impart water by the reduction reaction given below:

$O2 + 4H+ + 4e- \rightarrow 2\ H2O$

Oxygen acts as oxidizing agent in this reaction, hence gets reduced. In a nutshell, hydrogen and oxygen molecules are the reactants and H2O is the byproduct:

$$2H2 + O2 \rightarrow 2\ H2O$$

The fuel cell is essentially a device that provides the platform for these electrochemical reactions and acquires and employs the electrons to generate electricity. This swift aggregation of elements also generates heat indicating that the process is not 100% efficient. The average operating temperature of PEM Fuel cell is about 80°C (176°F). Theoretically maximum voltage that can be achieved from the fuel cell is 1.23 volts. However it is the ideal electrochemical potential of the reduction half-cell reaction which takes place at the cathode. But due to internal resistance, diffusion losses, and voltage losses are getting manifested as heat making 1.23Volts unattainable. Practically the potential difference obtained across the fuel cell is 0.6 – 0.7volts.Thus the efficiency of a typical fuel cell lies in the range of 50-55% as in "[6]".

V. STORAGE BATTERY

The working principle of battery is based on conversion of chemical energy into electrical energy with the help of electrochemical discharge reactions. Batteries are rated in terms of their nominal voltage and ampere-hour capacity. The storage option which is being utilized over here is DCLA (Deep cycle lead acid battery) which is a secondary type of battery that can be recharged using a dc source. As compared to normal Lead acid battery, these batteries have thicker active plates, with higher-density active paste material and thicker separators. Since they have thicker battery plates, it imparts them the ability to be discharged heavily and also make them resistant to corrosion through extended charge and discharge cycles. DCLA batteries have earned a good name in the field of renewable energy storage options as their price per kilowatt-hour of storage is low, in context with alternative battery types such as lithium-ion and nickel-metal hydride.

VI. MERITS AND DEMERITS

Since basic raw material for this technology is urine which is easily available in huge quantity. The consumption of power for electrolysis of urine is comparatively lower than electrolysis of water. Hydrogen gas obtained by electrolysis is pure hence no further purification is required. Because of electrolysis of urine the burden of high expenditure of sewage treatment comes down suddenly. This technology has got huge potential to be used as a reliable alternative to illuminate periphery of various public establishments such as schools, bus stops, hospitals, railway stations etc in terms of surrounding street lights, commercial lightings, and mobile as well as electric vehicle charging units. However this technology requires a handsome amount of initial investment and skilled maintenance.

VII. CALCULATIONS AND RESULT

World's population: 7,183,074,776 (7.18 billion) [7]
India's population: 1,270,272,105 (1.27 billion) [8]
Voltage required for electrolysis of Urine per molecule =0.37V
Voltage required for electrolysis of water per molecule =1.23 V
Average individual urine production= 1.5 Litres
Gross urine production in India= 1.5×1,270,272,105 = 1905408158 litres
Hydrogen obtained per litre of urine= 2grams [9] = 0.028256litres
Fuel cell rated at 2KW, requires H2 inlet flow=30
Nanolitre/min

VIII. CONCLUSION

The source urine required for applying this technology is easily available across the world making it universally adaptable. The green technology acts as an effective tool for considerable reduction of carbon footprints, deescalating the overdependence on conventional electricity sources and increasing the possibility of sustainable development to a satisfactory limit.

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