ISSN 2618-1584 Vol. 4, Issue 14: 49-54, DOI: 10.25236/FMSR.2022.041407

Study on the Bioelectricity of Human's Urine

Chung-Hsing Chao*

Department of Intelligent Vehicles and Energy, Minth University of Science and Technology, Hsinchu, Taiwan
davidee@o365mitust.edu.tw
*Corresponding author

Abstract: *Human urine can be used to test the urine bioelectricity by taking a graphite electrode pair out of dry cells, putting fresh urine into a small cup, and assembling a urine bioelectricity. A number of conditions of the human body were analysed, including family relationships, age, gender, health status, diet habits, and how much water one drinks during a day. Additionally, we examined the electrical properties of not fresh urine depending on the number of days it was stored with or without refrigeration. A cotton cloth soaked with urine is used to change the form of urine for testing to prevent liquid urine inconvenience. By examining the discharge characteristics of human urine, we can better understand our health status through this study.*

Keywords: *Urine health, Bioelectricity, Electricity generation*

1. Introduction

When humans urinate, urine is excreted from the body through the urethra as a by-product of metabolism from the kidneys. In human urine, 95% to 97% is water, while 3% to 5% is solid, such as nitrogen-containing waste, electrolytes, toxins, pigments, hormones, and unusual ingredients. There are at least 3,079 compounds in human urine, most of which are foreign chemicals. As a result of the cellular metabolism, there are many by-products that are rich in nitrogen waste, including urea, uric acid, and creatinine. Water-soluble chemicals are excreted from the body in these byproducts. In healthy adults, urine output is between 1500 and 2500mL per day, and pH is between 5.5 and 7, with an average of about 6.5[1]. Human urine tests can detect nitrogenous wastes. Our dietary intake of food and fluid is the primary cause of variation in urine composition, and these variables of health condition are taken into account if we are to accurately predict electrochemical reaction rate, physical composition, and chemical composition of urine.

Applying human urine's electrochemical reaction holds great potential directly converts biomass into electricity [2,3,4]. This study introduces is an electrochemical device that takes advantage of the metabolic processes of humans to directly convert organic matter into electricity. Anaerobic digestion, gasification, and fermentation are other bioenergy conversion processes [5]. Urine bioelecticity has the advantage of reducing sludge production, being simple, low-cost, and operating under ambient conditions. As well, urine bioelectrity requires no energy input for aeration if fresh urine is supplied as long as the cathode is not passively recirculated via an open-chamber device. Nitrogen, phosphate, and potassium can also be recovered from urine as a valuable feedstock for power generation [6]. According to the research of [7,8], urine can electrolyze to hydrogen more easily because water to electrolyze water needs 1.23 volts applied to the cell [7] while urine only needs 0.37 volts or hydrolysis to generating hydrogen [8]. Urine enzymatically hydrolyzed to ammonia and carbon dioxide. He et al. [9] also found that ammonia is then oxidized at the anode of the urine batteries to generate mainly nitrite and in smaller amounts nitrate in the urine electrolyzed process.

Human urine tests in clinical applications today include the gross color, turbidity, and odor of urine, and if it needed to urinalysis which chemically analyzes the urine and quantifies its constituents. Seldom, a culture of the urine required unless a urinary infection of bacteria is suspected because bacteria in the urine are unusual. In clinical applications, a microscopic examination of the urine may be helpful to identify organic or inorganic substrates and help in the diagnosis. Because human urine contains proteins and other substances, there are useful for medical therapy and some ingredients in many prescription drugs [10]. Postmenopausal women's urine is rich in gonadotropins that can yield stimulating follicle hormone and luteinizing hormone for fertility therapy [11]. Also, urine after days of storage which usually used as a natural fertilizer, it will change the color and turbidity change, compared to fresh human urine.

ISSN 2618-1584 Vol. 4, Issue 14: 49-54, DOI: 10.25236/FMSR.2022.041407

In medicine, fresh human urine after excretion can also be used to produce urokinase which is used clinically as a thrombolytic agent [12]. Urine includes large quantities of nitrogen of urea and potassium, and the composition in urine varies with food, in particular, nitrogen content in urine is related to the protein in the diet---a high protein food shows in high levels of urea. Because urine is high in nitrogen, especially there can be over 10% in a high protein diet, low in phosphorus of only 1%, and moderate in potassium as 2-3%. The diseases of diabetes, cancer, and gout seem to affect the power generation characteristics of urine.

2. Methods

Urine is generated by the cellular metabolism, which produces several by-products including urea, uric acid, and creatinine that must be cleared from the bloodstream. Following this, these by-products exchange water-soluble chemicals excreted by the body through the blood. A heterocyclic compound of carbon, nitrogen, oxygen, and hydrogen, uric acid has the chemical formula C5H4N4O3. Besides being a reducing agent, it releases ions and salts such as urates and acid urates, such as ammonium acid urate, to form water-soluble electrolytes. The organic compound urea has the chemical formula CO(NH2)2, which is a breakdown product of proteins. There are two NH2 groups attached to a carbonyl group (C=O) in this amide. By electrolysis, uric acid is electrochemically redox reacted and produced ions as a result of oxidation and reduction reactions. Salt solutions can be made by ionic movement, then the generated chemical reactions will be contacted by the carbon electrodes. From this reaction it can be concluded that electrons, ions, and electrolyte solutions are swapped around between molecules when carbon electrodes are connected to a 3V dry cell. A bioelectricity test was conducted on urine samples with the circuits electrically connected in series and parallel, respectively, to measure power output. With an external load of 1000kOhm in parallel, open circuit voltage was measured; short circuit current was measured with an external load of 1Ohm in series. Depending on the resistance of the external loads, the power and voltage drop of the test cell for current flow are affected. I=V/R, where V, R are voltage and resistance, can be used to determine the corresponding current (I) by Ohm's law. In all experimental measurements, we calculated the mean percentage change in urine test for each condition, and we considered samples stable if the 95% confidence interval was within 5%.

3. Result and Discussion

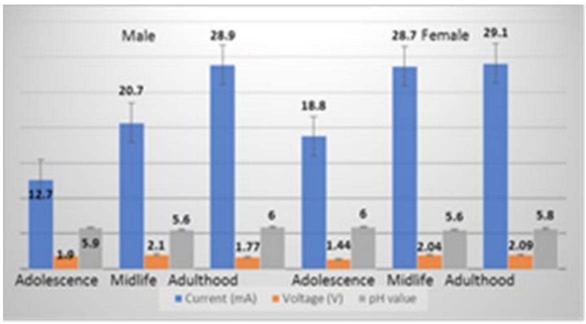

Figure 1: Comparison of the electricity and pH values of urine in different gender, age, and family groups.

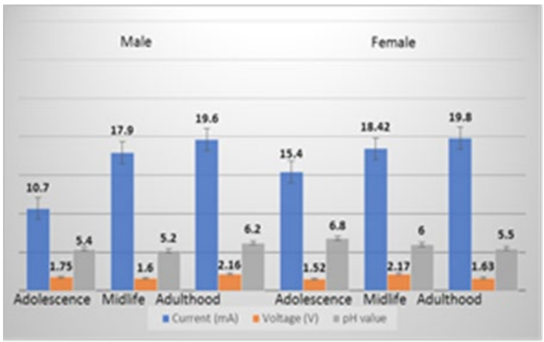

Figure 2: Comparison of the power electricity and pH values of urine in different age and gender of the same family groups.

ISSN 2618-1584 Vol. 4, Issue 14: 49-54, DOI: 10.25236/FMSR.2022.041407

Figs.1 and 2 show that the urine current, voltage, and pH of the elders (and the middle-aged) were significantly higher than those of the child (based on the experimental results of the same family). A vegetarian family's current, voltage, and pH values have relatively similar values regardless of age and gender; they follow the same trend as the average of the previous 30-family samples.

Our body's health is checked through our urine during a health checkup. Fig.3 compares the pH and power of urine in healthy people and those with gout, cancer, and diabetes. Healthy urine has a pH of 6.5, but urine from diabetics, cancer patients, and gout patients has a pH between 5 and 6, which is lower than that of a healthy person's urine. Healthy people and gout patients have similar electrical characteristics; diabetic patients' electrical components, however, are weak; cancer patients' urine also has weak electrical characteristics. During urination, diabetics release too much water, resulting in colorless urine. Water content may be responsible for the poor electrical characteristics of urine in diabetic patients. Therefore, urine's ability to generate power seems to be affected by the type of disease.

A liver metabolism of RNA, DNA, and food-derived sputum forms uric acid, part of which is excreted through urine, part of which is in the blood. When the blood uric acid rises, it precipitates in joints and soft tissues, causing gout, which is a form of uric acid that crystallizes as an inflammatory reaction. Blood uric acid can rise when the cell's metabolism increases, and the kidneys excrete it. The kidneys can also produce urate or uric acid stones if they expel high levels of uric acid and encounter appropriate acidity. Over 12 mg/L of uric acid results in swelling of the toes, pain, high blood pressure, arthritis, and high uric acid values may lead to kidney damage if not followed up for a long period of time.

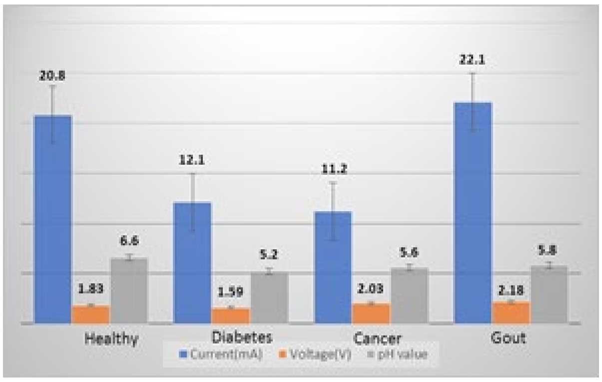

Figure 3: Comparing the power electricity and pH value for unhealthy people's urine.

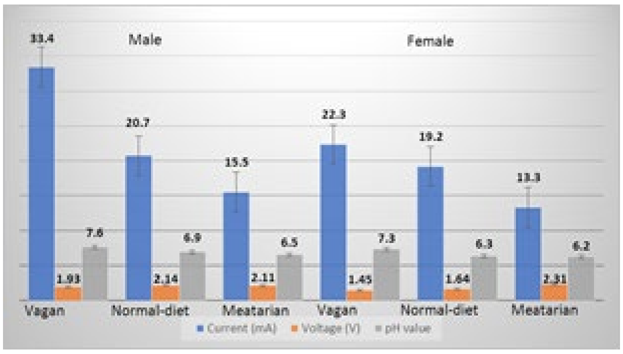

Figure 4: Compare urine’s power generation characteristics and pH values of people with different dietary habits.

Diet has a significant impact on the pH value of urine, according to the literature. Protein in urine lowers the pH value. Often, the urine pH is higher than 6 when there is more vegetable food consumed. In Figure 4, we found that both men and women have high pH values in their urine, and there is no significant difference between the two values. A semi-vegetarian diet produces the best electrical effects; a meat-based diet has the worst effects regardless of gender. It may be because males consume different foods than females in each group of eating habits that men's urine is more electrically conduction than women.

The female vegan in this experiment has been a full vegetarian for a long time. Animal proteins are abundant in meat. According to the literature [13], if a diet lacks balance of nutrients, electrolyte imbalance will result in the body; whether this will indirectly affect the electrical properties of urine is

ISSN 2618-1584 Vol. 4, Issue 14: 49-54, DOI: 10.25236/FMSR.2022.041407

worth exploring. Literature [10] shows that carnivores who consume more meat have lower pH values on average; however, our results indicate that the habit of consuming meat does not affect urine pH in a significant way. It is found that vegans have unusually high urine currents and pH values, and the results of repeated testing do not differ from the results of the samples.

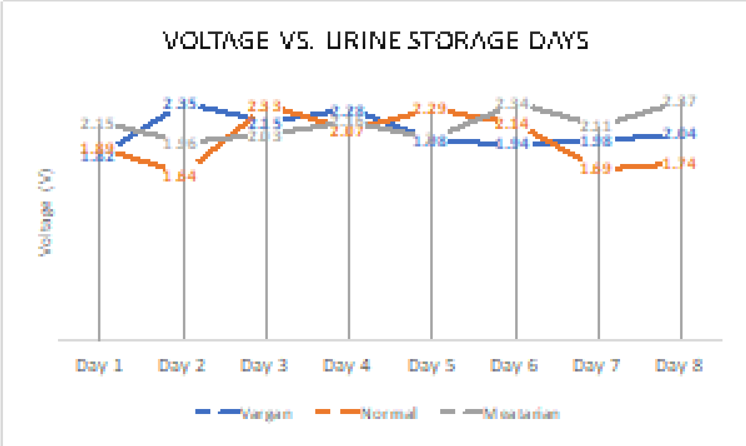

Figure 5: Compare urine's storage time on the power generation characteristics and pH values of vegan diet habit.

We all used fresh urine in the previous experiments, but whether it is fresh or not will also affect its electrical and pH properties. In Figure 5, the voltage of urine is not affected by the number of days it has been stored at room temperature; although the value has risen and fallen, it is not statistically significant.

Additionally, Figure 6 shows that the pH of the urine is not affected by the number of days, even though the pH fluctuates up and down.

A few days after putting the urine at room temperature, we observed white precipitation of uromodulin (Tamm-Horsfall protein, THP). It has been shown in the literature [13] that the white matter in the urine is a glycoprotein, the most important protein in human urine. Low urinary opsonin levels can be used to predict kidney stones.

The urine glass bottle taken from the refrigerator did not precipitate after refrigerated storage. Figure 7 shows that a refrigerated storage time of greater than 3 days reduces the fluctuation of the current generated by power generation. While refrigerated urine has a slightly better electrical effect, the number of days stored in cold environment or room temperature does not significantly affect power generation characteristics.

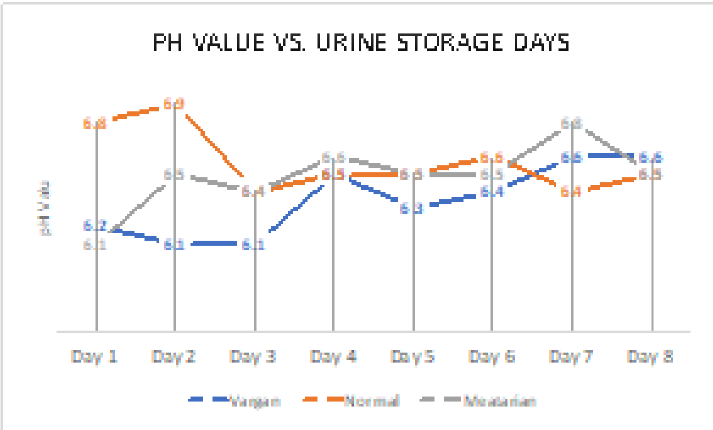

Figure 6: Compare urine's storage time on the current response.

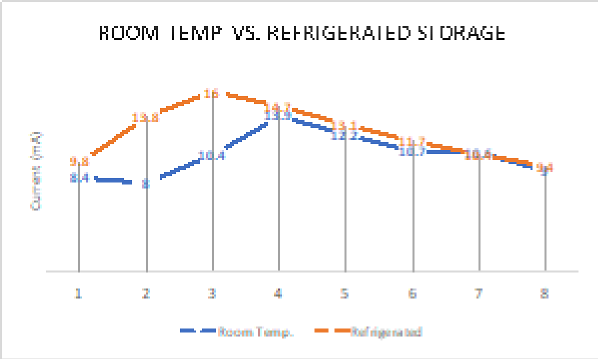

Figure 7: Compare urine's storage time on the pH response.

From above, we illustrate urine as an electrolyte which contains calcium, chloride, potassium, and sodium [14], so its concentration is reduced, resulting in a reduction in power generation efficiency. To compare the effects on power generation characteristics and pH value, we formulated urine electrolyte solutions with half of the brine, distilled water, tap water, seawater, and half of the urine. In this experiment, saline water has the two-fold salinity of seawater of 35,000 ppm has a salinity of 70,000 ppm, equivalent to 70 grams of salt per liter or kilogram of water, below the saturation level of 0.357 grams of salt per milliliter of water at room temperature [15].

In Figure 8, we found that power generation is higher with urine containing salt water; second is urine containing seawater; second is urine containing tap water; and lowest is urine containing distilled water. Since the two electrolytes are combined, the concentration of the electrolyte is increased, and the power generation is increased. While seawater contains salt as well as saline, it is not as electrically conducting as urine-saline, since the salt content in seawater is half that of saline. When tap water and distilled water are used, urine concentration will decrease, resulting in a reduction in electricity. Male urine had better electrical properties than female urine in each group of additive experiments. There is little variation in pH between the groups of experiments, regardless of what they are.

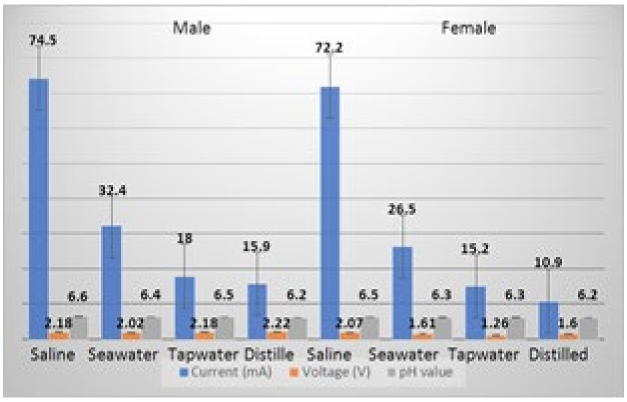

Figure 8: Comparison of electrical and pH values of diluted urine concentration.

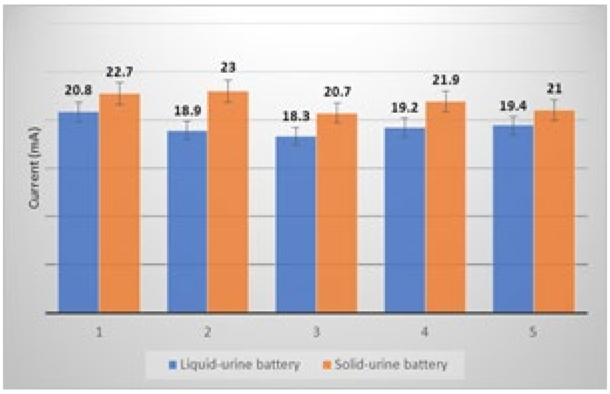

Figure 9: Comparison of electrical current response after solidification of urine.

To make the solid-urine battery more convenient to carry and test the electrical reaction of urine

ISSN 2618-1584 Vol. 4, Issue 14: 49-54, DOI: 10.25236/FMSR.2022.041407

adsorption, we added cotton to absorb urine after the liquid-urine battery was modified. As in the previous procedure, pour 20 ml of urine into the case and add the cotton to absorb the urine to cure the urine bioelectricity. In Figure 9, the current of cured urine bioelectricity was higher than that of liquid urine bioelectricity. Solid-state and liquid urine bioelectricity produce different amounts of power, primarily because liquid-state batteries provide a relatively high open circuit voltage while solid-state batteries generate a relatively high output current. Cotton increases chemical reaction surface area, and diffusion resistance increases, which reduces the voltage.

4. Conclusion

This study uses the principle and assembly of urine bioelectricity to understand the potential of clinical and to give them new mission value. We compare gender, age, physical condition, and electrical properties; explore differences in electrical effects between diet, drinking habits, and shelf life; explore differences in electrical effects between diet, drinking habits, and shelf life. Finally, the application of different urine storage conditions in room temperature and refrigerated environment and concentrations was proposed. We found that the internal conditions of the human body include blood relationship, age, gender, vegetarian diet, water consumption, and health status, which significantly affect the experimental results and make a comparison. When urine bioelectricity is detected, trying storing urine in cotton will provide interesting results whenever urine bioelectricity is detected.

References

[1] Rose, C. Parker, A. Jefferson, B. Cartmell. E. (2015) The Characterization of Feces and Urine: A Review of the Literature to Inform Advanced Treatment Technology, Critical Reviews in Environmental Science and Technology. 45 (17), 1827-1879.

[2] Hasan, W. Ahmed, Salim. K.M. (2014) Generation of Electricity Using Cow Urine, International Journal of Innovation and Applied Studies. 9(4), 1465-1471.

[3] Chouler, J. Padgett, G.A. Cameron, P.J. Preuss, K. Titirici, M.M. Ieropoulos, I. Lorenzo. D. (2016) Towards effective small scale microbial fuel cells for energy generation from urine, Electrochimica Acta. 192, 89-98.

[4] Ren H., Lee, H.S. Chae. J. (2012) Miniaturizing microbial fuel cells for potential portable power sources promises and challenges, Microfluidics and Nanofluidics. 13, 353-381.

[5] Ieropoulos, I. Greenman, J. Melhuish. C. (2013) Miniature microbial fuel cells and stacks for urine utilization, International Journal of Hydrogen Energy. 38, 492-496.

[6] Ieropoulos, I. Ledezma, P. Stinchcombe, A. Papaharalabos, Melhuish, G.C. Greenman. J. (2013) Waste to real energy: the first MFC powered mobile phone. Physical Chemistry Chemical Physics. 15, 15312–15316.

[7] Wilkinson. M. (2009) Urine turned into Hydrogen fuel, Chemistry World, July 2.

[8] Giri, A. (2017) Army scientists discover power in urine, U.S. Army Research Laboratory, September 12.

[9] He, Z. Kan, J. Wang, Y. Huang, Y. Mansfeld, F. Nealson. K.H. (2009) Electricity Production Coupled to Ammonium in a Microbial Fuel Cell. Environmental Science & Technoligy. 43, 3391–3397.

[10] Simerville, J.A. Maxted, W.C. Pahira. J.J. (2005) Urinalysis: a comprehensive review. American Family Physician, 71(6), 1153–1162.

[11] Rui, H. Lan, M. Hong. L. (2013) Clinical Effects of a Natural Extract of Urinary Human Menopausal Gonadotrophin in Normogonadotropic Infertile Patients, International Journal of Reproductive Medicine, 2013, Article ID 135258, 4 Pages.

[12] EI-Gengaihy, A.E. Abdelhadi, S.I. Kirmani, J.F. Qureshi.A.I. (2007) Thrombolytics, Comprehensive Medicinal Chemistry II, 6, 763-782.

[13] Lau, W.H. Leong, W.S. Ismail, Z. Gam.L.H. (2008) Qualification and application of an ELISA for the determination of Tamm Horsfall protein (THP) in human urine and its use for screening of kidney stone disease. International Journal of Biological Science. 4(4), 215–222.

[14] Winter. S.D. (1981) Measurement of urine electrolytes: clinical significance and methods. Critical Review in Clinical Laboratory Science. 14(3), 163-187.

[15] Elizabeth, Iris. R.S. (2015) Fundamentals of Chemistry: Solubility. Department of Chemistry. 2000, University of Wisconsin. Retrieved 22 April 2015.