A novel urine-activated microbattery

Bo Jin*,** , Hal-Bon Gu**

*College of Materials Science and Engineering, Jilin University, China

**Department of Electrical, Chonnam National University, Korea

Abstract : The novel urine-activated microbatteries have been successfully demonstrated. In this microbattery, a magnesium (Mg) layer and copper chloride (CuCl) in the filter paper are used as the anode and the cathode, respectively. A stack consisting of a Mg layer, CuCl-doped filter paper and a copper (Cu) layer sandwiched between two plastic layers is hot-pressed into the microbatteries at 100 ℃. The microbatteries can be activated by adding a droplet of human urine. The experimental results show that the microbattery can deliver a maximum voltage of 1.4 V and maximum power of 1.96 mW for the 1 kΩ load resistor.

Key Words : Human urine, microbatteries, Filter paper, Copper chloride, Magnesium

1. Introduction

The field of microelectromechanical systems (MEMS) and biomicroelectromechanical systems (bioMEMS) has received the intensive development. Because many MEMS devices are integrated with the electronic circuits, the development of micropower sources for microsystems is fairly urgent [1]. The micropower sources aim at generating power at the micro scale. In the past decade, the extensive research has been focused on micropower sources including the micro fuel cells [2], the micro solar cells [3], the acid-activated microbatteries [4] and the water-activated microbatteries [5].

Nowadays, the urine [6] is often chemically analyzed for the health screening and the diagnosis of diseases. In the past few decades, many researchers have developed several means of monitoring the urine glucose concentration [7], multianalyte sensors [8] for the detection of hypoxanthine, xanthine and uric acid, and an enzyme sensor for urea detection [9].

In this paper, the human urine-activated microbatteries have been successfully fabricated by the plastic hot-pressing technologies. The fabrication process and the performance of microbatteries are described and discussed.

2. Experimental

CuCl is mixed with the appropriate distilled water, stirred for a long time, and finally made into the suspension solution. A sheet of the filter paper is immersed in the CuCl suspension solution, dried in air, and cut into small pieces.

The microbatteries are fabricated by the plastic hot-pressing technologies. The fabrication process is as follows. Firstly, the transparent plastic film is coated with an adhesive. Secondly, a Cu layer is bound and used as the positive electrode. Thirdly, the CuCl-doped filter paper and three Mg ribbons are stacked onto the Cu layer, thereafter covered on the top by a transparent plastic film with an adhesive layer. Finally, the whole layer is hot-pressed into the microbatteries at 100 ℃. A urine supply slit and an air exhalation slit are made on the upper transparent plastic film. In a microbattery, three Mg ribbons are used to provide greater reaction area.

3. Results and discussion

The working principle of the urine-activated microbattery is presented in Figure 1. Mg and CuCl are used as the anode and the cathode, respectively. The Cu layer acts as an electron-collecting layer. When a droplet of human urine is added to the microbattery, the urine sops through the filter paper between the Mg and Cu layers. The chemicals dissolve and react to generate electricity.

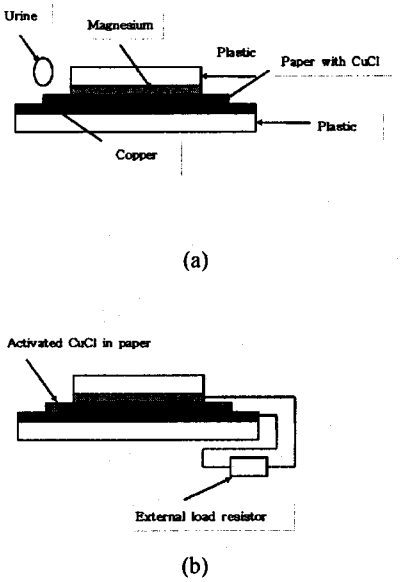

Figure 1. Working principle of the urine-activated microbattery.
(a) before activation and (b) after activation

The output voltage of the microbatteries with the load resistors of 1 kΩ and 10 kΩ after activation by 0.2 ml of human urine is shown in Figure 2. The output voltage of the microbattery with the 10 kΩ load resistor reaches the maximum voltage of 1.43 V, decreases with time and declines to 1.1 V after 120 min. The output voltage of the microbattery with the 1 kΩ load resistor reaches the maximum voltage of 1.4 V, decreases with time and drops to 0.78 V after 120 min. In both cases, The decrease of output voltage is due to the increase in the internal impedance of microbatteries and polarization reaction. The maximum power is 1.96 mW for the 1 kΩ load resistor and 0.2 mW for the 10 kΩ load resistor.

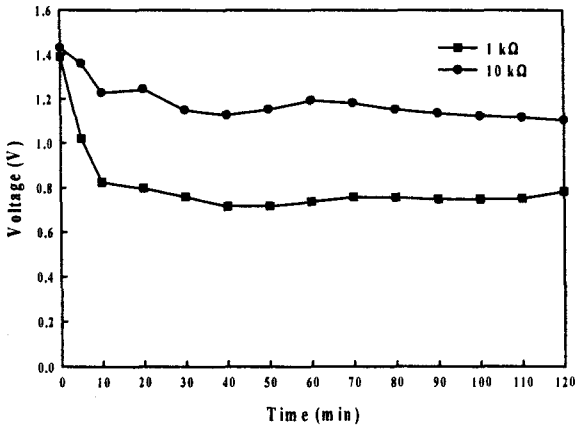

Figure 2. The output voltages of the microbatteries with the load resistors of 1 kΩ and 10 kΩ.

Effects of more urine on output voltage are shown in Figure 3. It shows voltage when a droplet of 0.2 ml is added after the microbatteries are tested with the load resistor of 1 kΩ for 24 h and 48 h, respectively.

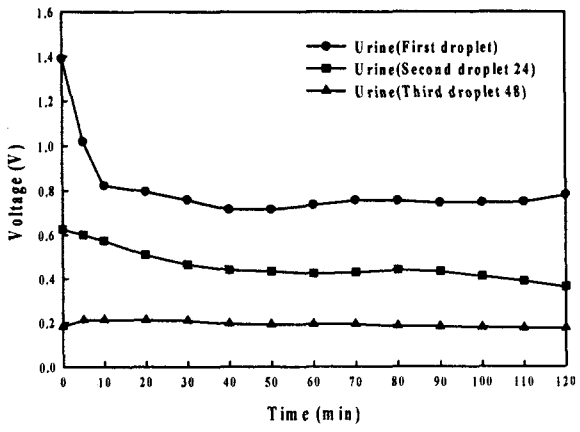

Figure 3. Effects of more urine on output voltages.

after adding the second droplet of 0.2 ml, The output voltage decreases with time. The maximum voltage is 0.63 V for the second droplet and 0.18 V for the third droplet. After 120 min, the voltage is 0.36 V for the second droplet and 0.18 V for the third droplet. The voltage retains a constant voltage of 0.18 V for the third droplet. The above results show the microbatteries can be activated several times by adding a droplet of human urine and generate power.

4. Conclusions

The novel urine-activated microbatteries have been successfully demonstrated. The microbatteries can be activated by adding a droplet of human urine. The experimental results show that the microbattery can deliver a maximum voltage of 1.4 V and maximum power of 1.96 mW for the 1 kΩ load resistor.

Acknowledgments

This work was supported by the RRC-HECS, Chonnam National University.

References

[1] P. B. Koeneman, I. J. Busch-Vishniac and K. L. Wood, J. Microelectromech. Syst. Vol. 6, p. 355, 1997.

[2] A. H. Epstein and S. D. Senturia, Science, Vol. 276, p. 1211, 1997.

[3] J. B. Lee, Z. Chen, M. Allen and A. Rohatgi, J. Mocroeletromech. Syst. Vol. 4, p. 102, 1995.

[4] K. B. Lee and L. Lin, MEMS International Conf. p. 236, 2002.

[5] K. B. Lee, F. Sammoura and L. Lin, MEMS International Conf. p. 387, 2003.

[6] S. K. Strasinger and M. S. D. Lorenzo, Urinalysis and Body Fluids, 1994.

[7] H. D. Park, K. J. Lee, H. R. Yoon and H. H. Nam, Comput. Biol. Med. Vol. 35, p. 275, 2005.

[8] J. -M. Zen, Y. -Y. Lai, H. -H. Yang and A. S. Kumar, Sensors Actuators, Vol. 84, p. 237, 2002.

[9] F. Mizutani, S. Yabuki and Y. Sato, Biosens. Bioelectron. Vol. 12, p. 321, 1997.