UTM Faculty of Mechanical Engineering UNIVERSITI TEKNOLOGI MALAYSIA THE ENGINEER STORY

e-ISSN: 3009 - 0792 Volume 7, 2024, 19-23

THE IMPACT OF A LATERAL SLIDING TRIBOELECTRIC NANOGENERATOR ON ENERGY HARVESTING

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ABSTRACT

Lateral sliding triboelectric nanogenerators (TENGs) have emerged as a promising technology for harvesting energy by exploiting the triboelectric effect to convert mechanical energy into electrical energy. The different selection of triboelectric materials has led to an evaluation of the potential of nylon and PTFE fabrics as TENG materials. The main objective of this study was to investigate the performance of these triboelectric materials in the lateral sliding mode. This study focuses on the impact of latex gloves on the voltage produced and its effect on increasing the frequency oscillation. In addition, this study focused on determining the voltage and current using copper as a conductor. This study shows that, for the current measurement, the voltage generation of the nylon/PTFE/Cu TENG by manual hand sliding with a latex glove is 6.8 V, and the current is 1.8 uA with a frequency oscillation of 2 Hz. The generation of voltage and current measurements was positively affected by latex gloves. To generate a voltage of up to 17 V, the experiment was repeated with a hand-sliding frequency oscillation varying from 1 to 6 Hz.

KEYWORD

triboelectric nanogenerator, TENGs material, copper, frequency, lateral sliding mode.

INTRODUCTION

The use of portable sensors has significantly increased owing to the emergence of the Internet of Things and advancements in technology (Dias and Paulo, 2018; Kwak et al., 2019; Citra et al., 2023). Currently, wearable sensors are used in devices to monitor human health. The sensors can be included in various types of sportswear and accessories to gather data on human performance metrics such as body temperature, heart rate, exercise duration, and speed (Song et al., 2020; Geng and Huo, 2022). The primary concern when utilizing these sensors is the power supply. These sensors are powered by batteries and must be regularly replaced and recharged. Charging and replacing batteries can have a significantly negative impact on the environment. Energy harvesting is an ideal source of mechanical energy owing to its high availability. For a few decades, electrostatic, electromagnetic, and piezoelectric effects have been the subject of extensive research, making them well-established transduction mechanisms for mechanical energy harvesting. Triboelectric nanogenerators (TENGs), a novel form of energy-harvesting technology, have surfaced in recent years to capture ambient mechanical motions. The TENG has a novel and unique mechanism that uses coupling between the triboelectric effect and electrostatic induction. A more concise understanding of the performance of triboelectric nanogenerator materials and conductor materials in the lateral sliding mode (LS-TENG). This study aims to examine and determine the influence of factors such as latex glove and conductor testing on the voltage and current produced by the LS-TENG. This study also examined the effects of different sliding frequencies on the output voltage of the LS-TENG.

Fundamental principal modes of triboelectric nanogenerators

The triboelectric effect is a well-known phenomenon in which a material becomes electrically charged upon frictional contact with another material. When two distinct materials come into contact, certain portions of their surfaces form a chemical bond, known as adhesion and charge transfer, from one material to the other to balance their electrochemical potential.

Lateral sliding mode

Triboelectric charges are also generated on the two surfaces of the dielectric film when they slide parallel to the surface. To completely balance the field produced by the triboelectric charges, lateral polarization is introduced along the sliding direction, driving the electrons on the top and bottom electrodes to flow. An AC output is produced by periodically sliding apart and closing. This is the TENG in the sliding mode.

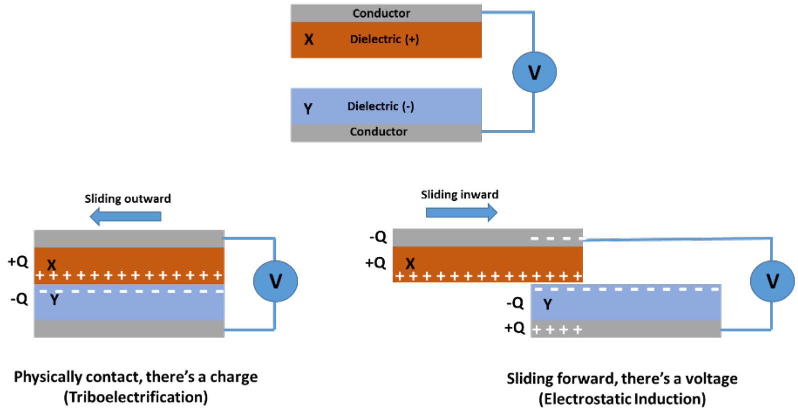

Figure 1: Design and functionality of TENG in lateral sliding mode (LS-TENG). The positive triboelectric materials move inward and outward, making contact with the negative triboelectric material and separating it.

MATERIAL AND METHODOLOGY

Construction of LS-TENG

The selection of triboelectric materials is based on the triboelectric series, which has significantly different triboelectric charge polarities (positive and negative). The textiles were polytetrafluoroethylene (PTFE), and nylon served as the positive and negative dielectric materials for the LS-TENG device. Copper foil (Cu) was chosen as the conductor material for triboelectric pairs. The thickness of the materials was measured using digital Vernier calipers in several areas to determine the average thickness. Nylon with a thickness of 0.041 cm was selected as the positive triboelectric material, and PTFE with a thickness of 50 mm was selected as the negative triboelectric material because it is readily available on the market. The materials are cut into rectangular shapes about 10 cm and 15 cm long and wide, respectively Figure 2. he conductor materials, copper foil with conductive adhesive on one side, are placed in the centre of the dielectric material and have a length of 15 cm and a width of 5 cm

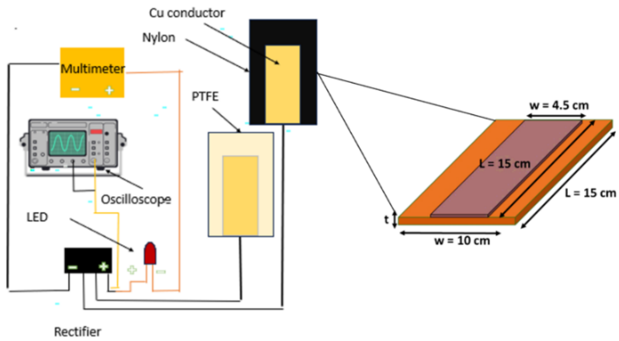

Figure 2: Schematic representation of LS-TENG dimensions and with thickness

RESULT AND DISCUSSION

Effect of latex gloves on voltage produced.

These results demonstrate the performance of these triboelectric material pairs. The performance of the LS-TENG materials was tested on slides with a hand without a latex glove (bare hand) and with a latex glove. The output voltage generated without a latex glove is 3 V (Figure 5(a)), while the voltage generated with a latex glove is approximately 6.8 V (Figure 5(b)). Furthermore, the current generated when the LS-TENG materials were slid with gloves was 1.8 µA. The current was measured using a multimeter. As reported by Wang et al. [21], the output performance was higher when the porous PTFE S-TENG was impacted with latex than when it was impacted with bare skin. This can be mainly attributed to the large difference between PTFE and latex in their ability to attract electrons and the rough surface of the latex glove. One potential positive effect of using latex gloves when sliding on a triboelectric nanogenerator is the reduction in friction between the sliding surfaces. This can lead to smoother and more efficient movement, thereby improving the overall functionality and energy production of the nanogenerator.

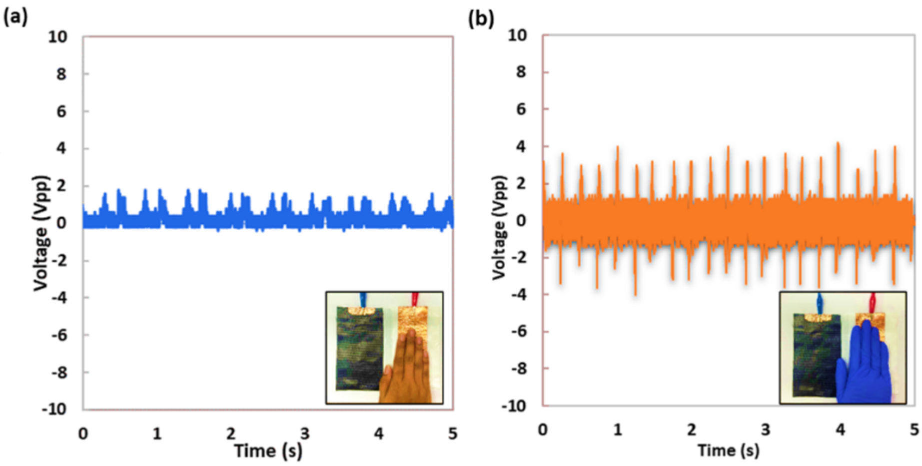

Figure 3: The output voltage generated by LS-TENG manually sliding in two scenarios: (a) barehanded (without latex glove) and (b) with a latex glove

Effect of increasing the frequency oscillation.

The frequency test results between 1 and 6 Hz are shown in Fig. 6. The frequency increases proportionally with the augmentation of material contact, leading to a greater occurrence of electron transfer and triboelectrification. As the frequency approaches 1 Hz, the voltage is approximately 3.4 volts (Figure 6(b)). Conversely, when the frequency reached 6 Hz, the voltage increased to 17 V (Figure 6(c)). According to these findings, a gradual increase in voltage changes the frequency with increasing strength of the hand slides. Therefore, frequency is crucial in determining the number of voltage triboelectric nanogenerators (TENGs). An increase in the frequency of contact and separation cycles and the contact frequency improves the potential for charge separation and electron transfer.

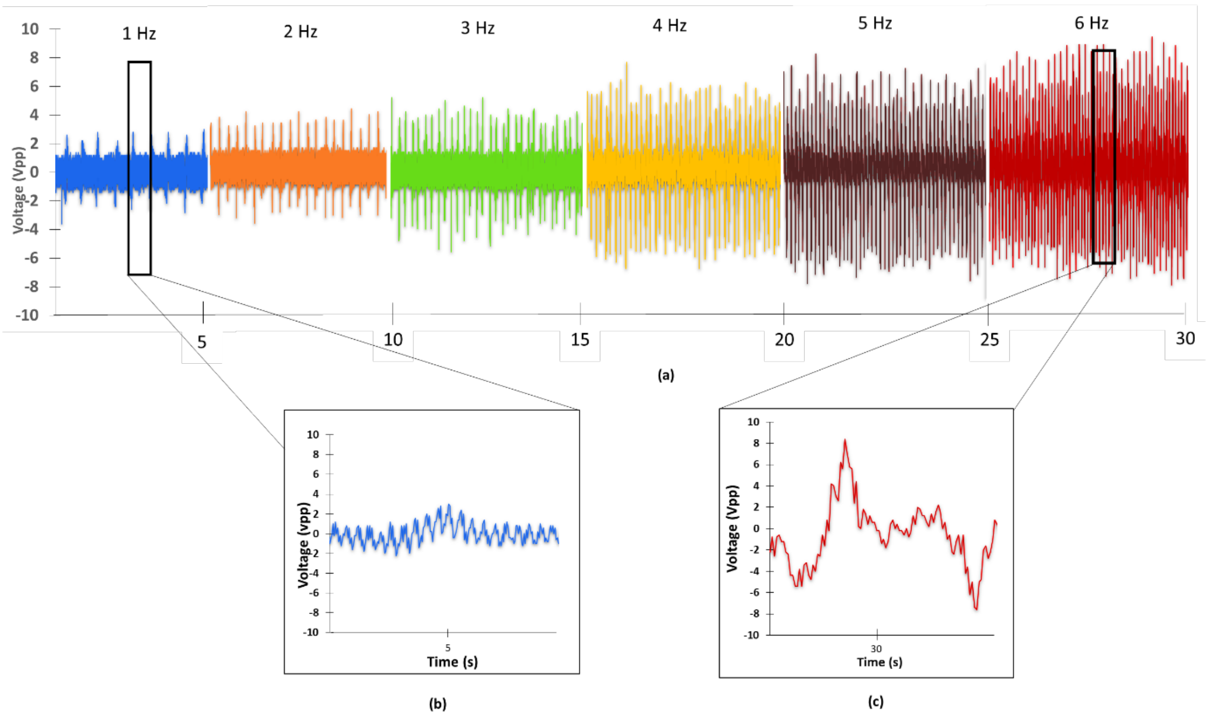

Figure 6: Zoom version of the voltage waveform generated at a 1 Hz frequency. Voltage graph generated during the test with oscillations at various frequencies between 1 Hz and 6 Hz. c) Zoomed-in representation of the 6 Hz voltage waveform.

CONCLUSION

In summary, the use of latex gloves was identified as one of the factors contributing to the TENG performance. There was a direct correlation between the speed of the hand slides and the voltage generated, indicating an effective connection. The output voltage produced by the hand slides with a latex glove is 6.8 V higher than that produced without latex, which is 2.4 V at a frequency oscillation of 2 Hz. The output current measured with a multimeter also showed that the latex glove produced a higher value of 1.8 µA than the sliding without a latex glove. The output voltage of the LS-TENG increased with increasing frequency, up to 17 V at 6 Hz. These results indicate that the LS-TENG sliding mode enables a larger contact area between the surfaces, thereby enhancing the charge generation capability of the nanogenerator. Furthermore, the sliding mode reduces wear and tear on the triboelectric materials, thereby improving the durability of the nanogenerator.

ACKNOWLEDGEMENT

This work was supported by the Universiti Kuala Lumpur under a Short-Term Research Grant (STRG 22015) in collaboration with Science & Technology Research Institute for Defence (STRIDE).

REFERENCE

Dias, D., & Paulo Silva Cunha, J. (2018). Wearable health devices—vital sign monitoring, systems and technologies. Sensors, 18(8), 2414.

Chithra, S., Shajahan, E. S., & Zacharias, J. (2023, May). Performance Comparison of Sliding Free-standing Mode Triboelectric Nanogenerator (TENG) Based Sensors for IoT applications. In 2023 International Conference on Control, Communication and Computing (ICCC) (pp. 1-6). IEEE.

Kwak, S. S., Yoon, H. J., & Kim, S. W. (2019). Textile-based triboelectric nanogenerators for self-powered wearable electronics. Advanced Functional Materials, 29(2), 1804533.

Geng, F., & Huo, X. (2022). A Self-Powered Sport Sensor Based on Triboelectric Nanogenerator for Fosbury Flop Training. Journal of Sensors, 2022.

Song, Y., Min, J., Yu, Y., Wang, H., Yang, Y., Zhang, H., & Gao, W. (2020). Wireless battery-free wearable sweat sensor powered by human motion. Science advances, 6(40), eaay9842.