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Aris Ansori

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Enhanced Performance Triboelectric Nanogenerator With Strach Biopolymer Composite Interface Layer

Aris Ansori*
Ph.D. Student of Departement Mechanical engineering,
Brawijaya University
Department of Mechanical engineering,
Universitas Negeri Surabaya
East Java, Indonesia
*arisansori@unesa.ac.id
Orchid: 0000-0001-8760-5093

Teguh Dwi Widodo
Departement of Mechanical engineering,
Brawijaya University
East Java, Indonesia
widodoteguhdwi@ub.ac.id

Sudjito Soeparman
Departement of Mechanical engineering,
Brawijaya University
East Java, Indonesia
sudjitospn@ub.ac.id

Denny Widhiyanuriyawan
Department of Mechanical engineering,
Brawijaya University
East Java, Indonesia
denny_w@ub.ac.id

Abstract— **Triboelectric nanogenerator is a potential mechanical energy conversion technology developed for future energy conversion. The increase in TENG output power is affected by the dielectric film. In addition, the damage to the surface of the film becomes an obstacle to increasing the output power. In this study, we propose the structure of Composite Biopolymer Electrolytes which is an activation method of increasing the contact surface interface to maximize the output performance of TENG. Method of doping starch biopolymer matrix with metal oxide TiO_2. The doping effect of TiO_2 nanoparticles increases physical resistance, increasing surface roughness which allows air voids between the two contact surfaces during electrification contact. The results showed that the starch-TiO_2 electrolyte biopolymer composite film had a rougher surface than the starch film with Ra values of ~380 nm and ~195 nm and; Rq ~495 nm and ~250 nm, triboelectrification process is improved with an output performance effect of ~170 $mW.m^{-2}$**

Keywords-triboelectric nanogenerator, contact interface, composite biopolymer, starch-TiO_2

I. INTRODUCTION

Energy harvesting technology that utilizes small-scale mechanical energy is very interesting to be developed, such as wind energy or wave energy. In 2012 Wang conducted research on triboelectric nanogenerator (TENG) which is operated by the coupling effect of triboelectrification and electrostatic induction [1]. TENG is operated by four basic working modes, namely; vertical contact separation, sliding contacts in the plane, single electrodes, and free-standing triboelectric layers [2]. The TENG unit consists of an electrode and two triboelectric films having different electron affinities (electronegative and electropositive) which are attached to the surface of the electrode. Physical contact between two dielectric films induces a triboelectric charge which can result in a potential drop when separated by mechanical forces, which promotes the flow of electrons between the electrodes via an external circuit [3]. according to the previous TENG material study, the triboelectric film material in addition to functioning as a friction material also plays a role in storing charge during the electrification contact process. improvement of triboelectric material properties as an effort to improve the output performance of TENG.

Triboelectric film material doping method as an effort to improve interface contact which has an impact on increasing electrification contacts, triboelectric film capacitance, and air breakdown problems. Doping metal oxide, ferroelectric, ferromagnetic, and other filler materials into the polymer matrix can increase the interfacial contact. in addition, the modification can increase the polarization, frictional strength, surface roughness.

Modification of the polymer matrix bond and filler with different types and weight ratios has an effect on the properties of the composite film, are thus proposed in polymer-based composite matrices to increase the permittivity of the composite, which will increase the interfacial polarization. TENG performance can be determined from the friction contact film material. Efforts to realize high-performance TENG can be through the selection of the right friction film contact partner. [4]. However, the choice of frictional contact material is still limited to the intrinsic properties of the material which still hampers the performance of TENG.

a strategy to increase surface contact can overcome the problem of air breakdown which causes charge neutralization and has an impact on decreasing TENG output. Several

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methods of enhancing film surface contact have been developed to increase TENG's output power, such as; the use of micro or nano surfaces [5-6], composite film materials [7-8], insertion of polymeric fillers [9-12], and surface modification by chemical functionalization [13-15]. However, surface damage can occur during the contact electrification process which causes a decrease in the TENG output power.

Modification of the surface of the film can maintain the charge density, so it is necessary to develop materials that have an effective surface to maintain the surface charge density [16-17]. the manufacture of composite materials as an effort to increase the surface resistance of the film. In addition, the composite structure can improve surface contact. meanwhile, composite materials can be formed by polymer matrices and fillers. The surface properties of composite films can be formed by combining the properties of the polymer matrix with the filler, variations in the weight of the filler can affect the surface properties.

Previous studies have shown that different composite formulations can improve the output performance of TENG. however, there are still many uses of synthetic polymers, such as PDMS and PVDF. [18-19]. In addition, previous studies have shown that the problem of surface damage to the film can be suppressed by using films that have high interfacial contact, so that electrolyte biopolymer composites can be a solution to overcome problems as a friction surface interface layer. Properties of electrolyte biopolymer composites, such as; good Interfacial contacts; high thermal stability; high ionic conductivity is expected to overcome the problem of surface contact in the TENG contact electrification process.

In this study, we fabricated a TENG positive friction surface film from the composite. wherein, the composite is made of starch polymer matrix and TiO_2 filler, in addition, to form the composite electrolyte, LiCl electrolyte salt is added. The high surface charge density is caused by the increase in frictional contact due to the presence of nano filler on the surface. In addition, the TENG output power also increases due to the reduced water breakdown effect

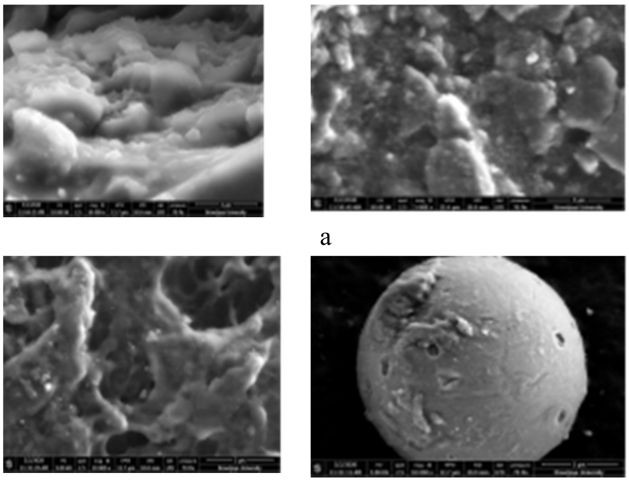
II. EXPERIMENTAL METHOD

A. Materials.

Cassava tubers, TiO_2 nanopowder (Purity: 99%, APS: 20 nm) were purchased from Nanoshell, Wilmington, DE 19808, USA. 3. Brand Lithium Chloride (LiCl), Aquades, Glycerol, NaOH, HCl, and NaCl

B. Fabrication starch film process

Cassava tubers (Manihot esculenta) were peeled and cut into small pieces, then homogenized in a blender, sifted, and left for decantation. After 4 h, the supernatant was removed and the precipitate was lowered by resuspension (1:1) methanol: water solution. The starch obtained was dried at 60^0 C for 24 hours. The dry starch was diluted in distilled water to form a 5% (w/w) starch solution. This solution is partially hydrolyzed in dilute hydrochloric acid (0.1 N) adjusting the pH to 2.0. Addition of glycerol in a ratio of 1: 3 (glycerol: dry starch)). The starch solution was homogenized by stirring for 15 minutes at 95^0 C. Then, the solution was neutralized in a dilute sodium hydroxide (0.1 N) adjusting the pH to 10 to stop the hydrolysis. Finally, starch solution (7% (w/w)) was poured on a petri dish containing aluminum foil substrate and placed in an oven at 40^0 C.


a

b

Fig. 1 Surface film (a) starch (b) strach-TiO_2 composite

C. Process of starch biopolymer composite electrolytes

The composite film was made by mixing the formulation of 6 g of starch nanopowder, 5% TiO2 (w/w) filler, stirring mechanically until homogeneous and dissolved in 100 ml of distilled water. Then the solution was stirred with a magnetic stirrer at a temperature of 95 0C for 30 minutes. The suspension was added with glycerol (1.5 g) heated to a boiling point for 15 minutes while continuously stirring until it formed a gel. during cooling to a temperature of 20^0 C added electrolyte salt LiCl (1% w/w). The solution that forms a gel is poured into a petri dish. The drying of the film was carried out at a temperature of 50°C for 45 hours using an oven.

D. Characterization and measurement

Testing the surface morphology characteristics of the electrolytic composite film using a Field Emission Scanning Electron Microscope (FE-SEM, FEI Quanta FEG 650) test. The surface roughness characteristics of the film were measured using atomic force microscopy (AFM) to obtain the surface roughness average (Ra) and surface average height deviation (Rq).

III. RESULT AND DISCUSSION

The results of SEM morphology photos and surface roughness testing with atomic force microscopy (AFM) are shown in Figure 4 (a) starch film and (b) Strach-TiO_2 composite film. SEM test results showed that the surface of the starch-TiO_2 composite film with a non-uniform texture, where the Ti granules were evenly distributed on the surface of the film. meanwhile, the surface of the starch film shows a surface with a uniform surface texture. the average surface roughness (Ra) and surface height (Rq) from the atomic force microscopy (AFM) test results show that the average value of Ra and Rq of strach-TiO_2 composites compared to strach film results in higher values of Ra = ~380 nm and ~195 nm and; Rq = ~495 nm and ~250 nm.

The results of the photo surface and roughness test analysis showed that the addition of TiO_2 NP to the starch polymer matrix caused a surface bond between the matrix and filler. increasing the surface roughness value of the composite strach-TiO_2 film due to the addition of TIO_2 NP. an increase in the surface roughness of the film has an impact on increasing triboelectrification, thereby increasing the output performance of TENG 170 mW/m^2.

IV. CONCLUSION

The bonding matrix of starch polymer and TiO_2 on the strach-TiO_2 composite showed greater surface texture and surface roughness than the pure starch film. The use of composite films with the addition of metal oxides on the starch increases the electron vacancy holes, where the increase in the triboelectric effect of strach-TiO_2 is increased compared to pure starch In addition, the increase in surface roughness of the film can increase the film contact when the triboelectrification contact process significantly from the composite strach-TiO_2 film test can result in an increase in voltage of ~220 V and a short-circuit current of 110 mA.

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REFERENCE

[1] F. R. Fan, Z. Q. Tian, Z. L. Wang. Flexible triboelectric generator. Nano Energy (2012) 1(2) 328-334

[2] S. Niu, Z. L. Wang. Theoretical systems of triboelectric nanogenerators. Nano Energy (2015) 14 161-192.

[3] S. Wang, L. Lin, Z. L. Wang. Nanoscale triboelectric-effect-enabled energy conversion for sustainably powering portable electronics. Nano Lett. (2012) 12(12) 6339-6346.

[4] X. Cao, Y. Jie, N. Wang, Z.L. Wang, Adv. Energy Mater., 6 (2016) 1600665.

[5] Z.B. Li, H.Y. Li, Y.J. Fan, L. Liu, Y.H. Chen, C. Zhang, G. Zhu, ACS Appl. Mater. Interfaces, 11 (2019) 20370-20377.

[6] Y. Jie, X. Jia, J. Zou, Y. Chen, N. Wang, Z.L. Wang, X. Cao, Adv. Energy Mater., 8 (2018) 1703133.

[7] W. He, Y. Qian, B.S. Lee, F. Zhang, A. Rasheed, J.E. Jung, D.J. Kang, ACS Appl. Mater. Interfaces, 10 (2018) 44415-44420.

[8] X. Du, Y. Liu, J. Wang, H. Niu, Z. Yuan, S. Zhao, X. Zhang, R. Cao, Y. Yin, N. Li, C. Zhang,

[9] N. Cui, L. Gu, Y. Lei, J. Liu, Y. Qin, X. Ma, Y. Hao, Z.L. Wang, ACS Nano, 10 (2016) 6131-6138.

[10] Q.Z. Guo, L.C. Yang, R.C. Wang, C.P. Liu, ACS Appl. Mater. Interfaces, 11 (2019) 1420- 1425.

[11] D. Park, S. Lee, C.V. Anh, P. Park, J. Nah, Nano Energy, 55 (2019) 501-505.

[12] Y. Jie, Q. Jiang, Y. Zhang, N. Wang, X. Cao, Nano Energy, 27 (2016) 554-560.

[13] S.H. Shin, Y.H. Kwon, Y.H. Kim, J.Y. Jung, M.H. Lee, J. Nah, ACS Nano, 9 (2015) 4621-4627.

[14] S. Wang, Y. Zi, Y.S. Zhou, S. Li, F. Fan, L. Lin, Z.L. Wang, J. Mater. Chem A, 4 (2016) 3728-3734.

[15] S. Wang, Y. Xie, S. Niu, L. Lin, C. Liu, Y.S. Zhou, Z.L. Wang, Adv. Mater., 26 (2014) 6720-6728.

[16] X. He, H. Guo, X. Yue, J. Gao, Y. Xi, C. Hu, Nanoscale, 7 (2015) 1896-1903.

[17] M. Lai, B. Du, H. Guo, Y. Xi, H. Yang, C. Hu, J. Wang, Z.L. Wang, ACS Appl. Mater. Interfaces, 10 (2018) 2158-2165.

[18] Z. Fang, K.H. Chan, X. Lu, C.F. Tan, G.W. Ho, J. Mater. Chem. A, 6 (2018) 52-57.

[19] J. Chen, H. Guo, X. He, G. Liu, Y. Xi, H. Shi, C. Hu, ACS Appl. Mater. Interfaces, 8 (2016) 736-744.