VIETNAM NATIONAL UNIVERSITY
HO CHI MINH CITY
HCMC UNIVERSITY OF TECHNOLOGY

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DISSERTATION INFORMATION

Title: **Fabrication of micro-/nano-structured polymeric tribomaterials for the development of high-performance triboelectric nanogenerators**

Major: **Materials Engineering** Major code: **9520309**

Ph.D. Candidate: **CHAU NGOC MAI**

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MAJOR CONTRIBUTION OF THIS DISSERTATION

The general objective of this dissertation is to successfully fabricate micro-/nano-structured polymeric tribomaterials for high-performance TENGs, systematically investigate the effects on the formation of micro-/nano-structures and their output performance when applied in TENGs, simultaneously develop these TENGs practical applications including wind energy harvester, ocean wave energy harvester, raindrop energy harvester, engine-vibration energy harvester, and self-powered finger motion detection sensor.

In this dissertation, four types of micro-/nano-structures have been successfully fabricated including honeycomb (*hc*-), convex (*c*-), spongy (*s*-), and convex-spongy hybrid (*cs*-) using polycarbonate (PC), polyvinyl chloride (PVC), polyimide (PI), and poly(vinylidene fluoride-*co*-hexafluoropropylene) (PVDF) via the improved phase separation (IPS) and IPS micromolding (IPSμM) methods. All types of structured tribosurfaces significantly enhanced output voltage and power density compared to flat membranes of the same materials, thus expanding the practical applications of TENGs.

The results indicated that the IPS can create highly ordered honeycomb pore arrays under appropriate fabrication conditions corresponding to each polymer type. In particular, *hc*-PC and *hc*-PI using the ChL/MeOH as solvent/nonsolvent system achieved a 2.6 and 5.83-fold improvement in output voltage compared to flat membranes, respectively. The multilayered *hc*-PVC membrane using the THF/MeOH as solvent/nonsolvent system reached a 2.5-fold improvement in output voltage over flat membranes at a polymer concentration of 10 wt. % and 5 vol. % MeOH. *c*-PI and *c*-PVDF exhibited the highest output voltages at concentrations of 10 wt. % and 13 wt. %, respectively, achieving approximately 2.5 and 2-fold improvement in output voltage compared to flat film. *s*-PVDF film (with the concentration of 50 $mg\cdot mL^{-1}$) using the acetone/water ratio of 95/5 improved the output voltage by 4 times compared to flat surface.

cs-PVDF with the highest voltage was fabricated at a PVDF solution concentration of 13 wt.%, spin-coating speed of 1200 rpm, and bar-coating PVDF solution concentration of 50 $mg\cdot mL^{-1}$ in acetone/water with the ratio of 95/5, improving the output voltage, instantaneous power density, and average power density by approximately 4, 5.3, and 10 times, respectively, compared to flat PVDF films, and enhancing contact-separation working durability by over 10,000 cycles compared to *s*-PVDF. This dissertation also demonstrated that *cs*-PVDF produced the most significant enhancement due to the convergence of advantages and mutual compensation for the disadvantages of the convex and spongy structures, including: (i) High structural integrity and stability; (ii) Increased effective contact surface area; (iii) Laterally deformation; (iv) Charge retention effect; (v) Enhanced triboelectric effect; (vi) High surface-area-to-volume; (vii) Charge retention effect as "charge-trapping reservoir".

With superior triboelectrification enhancement of micro-/nano-structured surfaces, this dissertation also successfully designed and fabricated practical TENG application models harnessing infinite natural oscillation sources such as ocean waves, wind, raindrop droplets, engine vibrations, and self-powered motion detection sensors.

The dissertation results have been published in 06 papers in ISI Q1 journals with a total impact factor index of 49.828 and 01 domestic paper recognized by the State Council for Professorship.

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