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The arbitrary graphical surface charge of FEP realized by tap water

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Abstract:

In recent years, the liquid-solid contact triboelectric nanogenerator for low-frequency water energy harvesting has been widely studied, but there are still many areas worth exploring for the contact electrification phenomenon between the water-electret interface, which is the crux of capturing the energy. For the first time, we propose a novel method to change the electrification capacity of electrets in contact with water by using oxygen plasma technology. Patterned surface potential distribution map is drawn by extracting and analyzing the data obtained from the probe scan. The outcomes of this work offer new insights of contact electrification phenomenon between the water-electret interface.

Experiment:

In this study, a three-layer sample in Figure 1(a) was used as the experimental object. Cu tape was pasted on the bottom of the FEP, and PET with the shape of the alphabet was placed on the top of the FEP as a mask. Then this sample was put into YZD08-5C oxygen plasma cleaner for 10 minutes under 100W treatment power. After oxygen plasma treatment, the PET mask on the FEP surface can be removed.

By measuring the surface potential characteristic point distribution on the FEP surface, it can be found that the surface potential with oxygen plasma treatment is always maintained around 0V, while the FEP surface without oxygen plasma treatment could obtain surface potential from -300V to -470 V. The Model 347 surface potential measuring instrument controlled by a dual-axis stepping motor can read the graphical surface potential distribution of FEP surface after water impact and charging. In this study, we utilize the NPU-shaped PET film to mask the FEP surface to obtain the graphical surface potential distribution diagram shown in Figure 1(b).

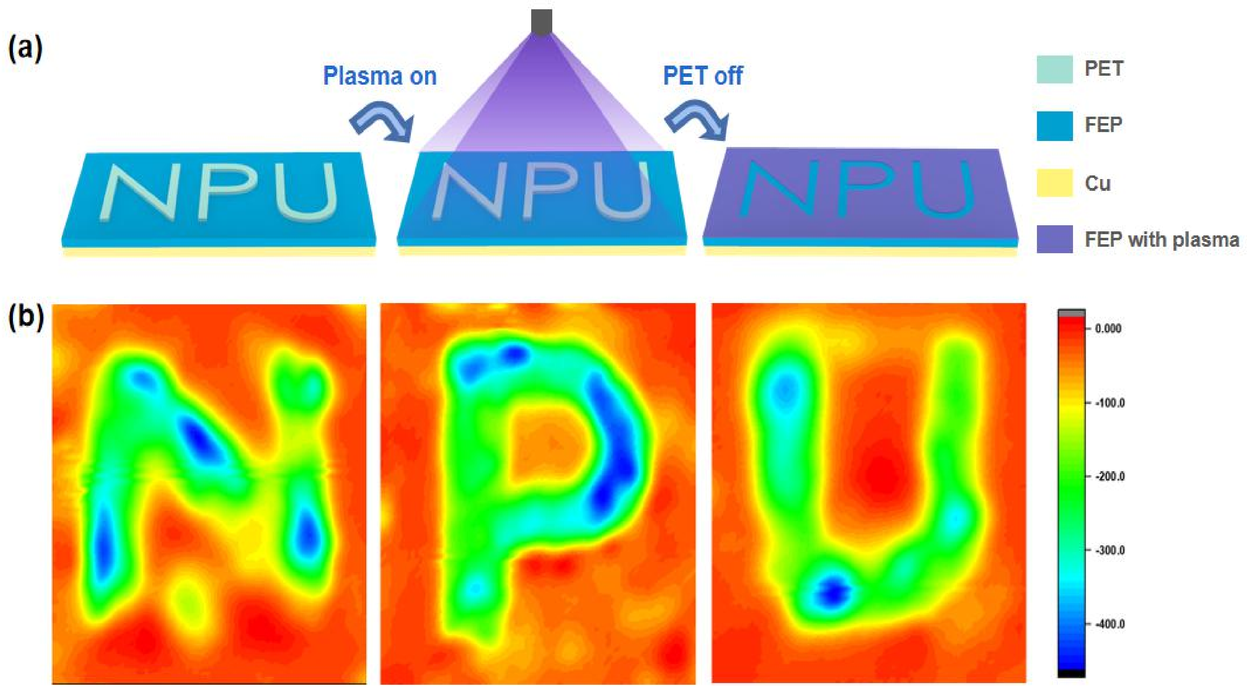

Figure 1.
(a)Flow diagram of achieving NPU-shaped oxygen plasma treatment
(b)Making water flow impact the treated FEP surface, and measure the potential distribution on the FEP surface with Model 347 to acquire the NPU-shaped potential distribution map

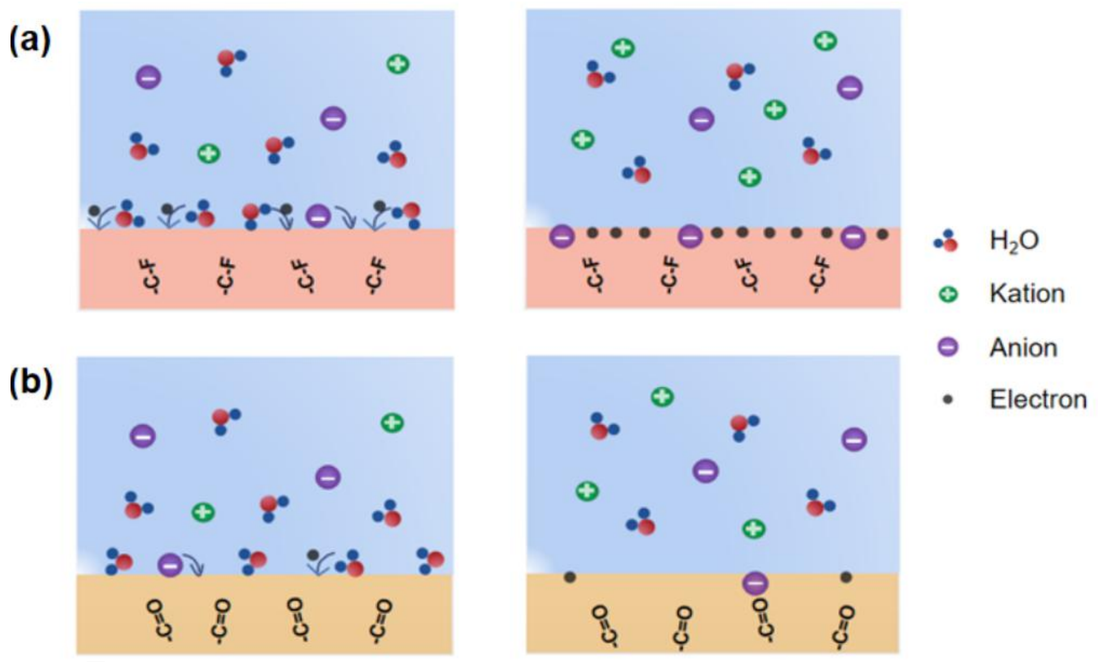

Figure 2.
(a)Schematic diagram of contact electrification mechanism between water and FEP
(b)Schematic diagram of contact electrification mechanism between water and FEP treated by oxygen plasma.

Results and Discussion:

The mechanisms of electron transfer and anion adsorption are shown in Figure 2. For untreated FEP, it is mainly composed of -CF group and $-CF_3$ group. Due to the electronegativity of F atom, it attracts shared electron pairs near C atom to itself, making the central C atom of the fluorocarbon group tend to attract electron, so that the whole group becomes an electron withdrawing group. When water flow impacts the surface of the FEP, the atoms in the water molecule's electron cloud and the fluorocarbon group's electron cloud overlap, and the electrons in the water are captured. At the same time, water molecules can ionize H_3O^+ and OH^- ions, and the negatively charged OH^- ions will spontaneously adsorb on the surface of the electret.

For the FEP film treated with oxygen plasma, a large number of fluorocarbon groups on the surface are replaced by carbonyl groups. Since the common electron pair of carbon and oxygen in the carbonyl group has no obvious deflection, the ability to obtain electron of water will reduce greatly. When water flow impacts the FEP surface that have been treated by oxygen plasma, the electron transfer and the ionization adsorption mechanism cannot occur because of the similarity of the electronegativity between water and the carbonyl group on the electret surface.