Toxic Gas-Free Synthesis of Extremely Negative Triboelectric Sulfur Copolymer Blends Via Phase Separation of Fluorine-Rich Polymers

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Smart Nano-Device Laboratory

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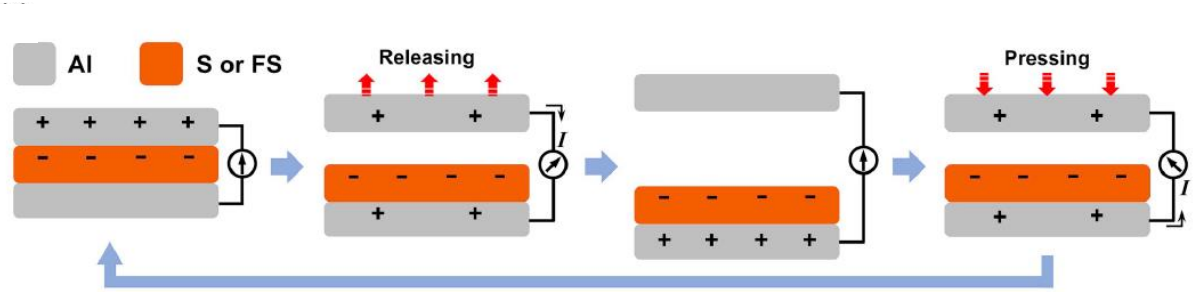
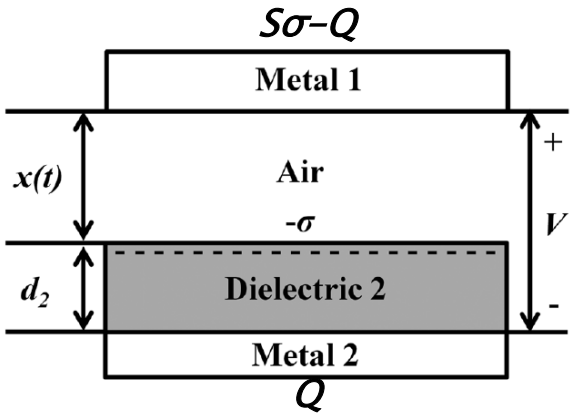
Triboelectric Nanogenerator(TENG)

TENG Device Working Principle



Theoretical model for contact mode TENG



Simiao Niu et al. Journal of RSC. (2013)

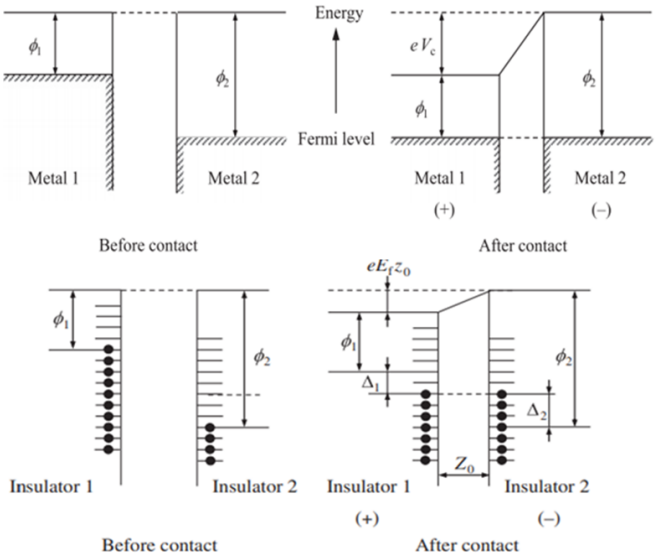
$$V = E_2 d_2 + E_{air} x(t)$$
$$= -\frac{Q}{S\epsilon_0}\left(\frac{d_2}{\epsilon_r} + x(t)\right) + \frac{\sigma x(t)}{\epsilon_0}$$

$$V_{oc} = \frac{\sigma x(t)}{\epsilon_0} \quad (\because Q = 0)$$

$$\sigma = \frac{Q}{S} = D = \epsilon_0 \epsilon_r E$$

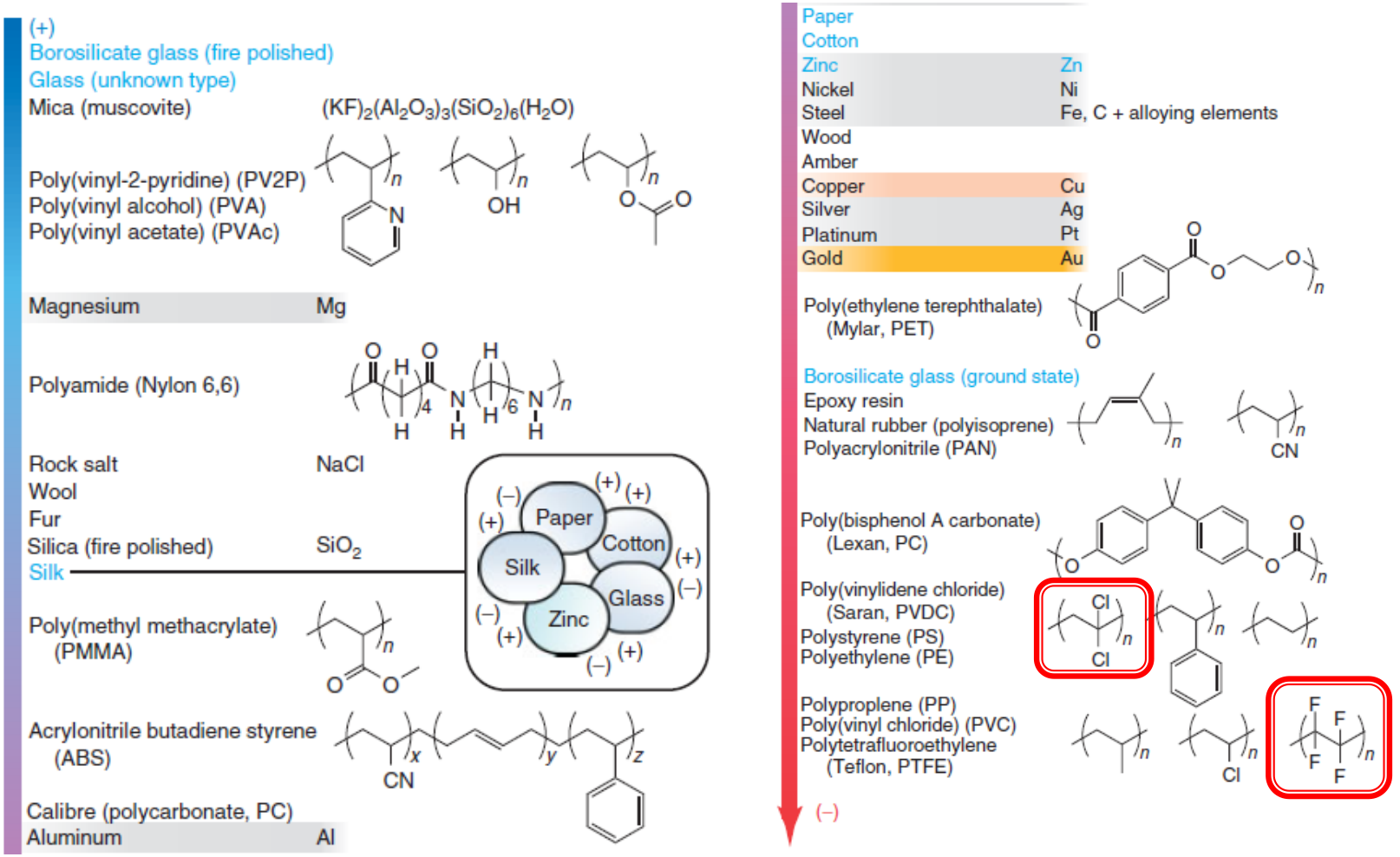
$$\therefore V_{oc} \propto \epsilon_r$$

Contact Electrification



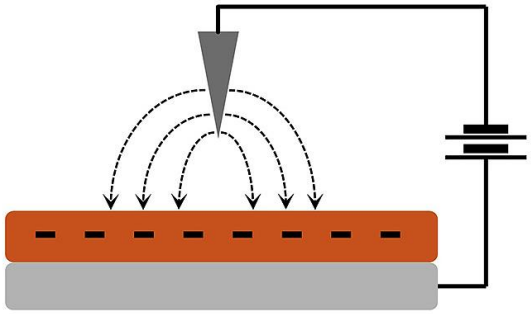
S. Matsusaka et al., Chem. Eng. Sci. 65, 5781 (2010).

Triboelectric Series

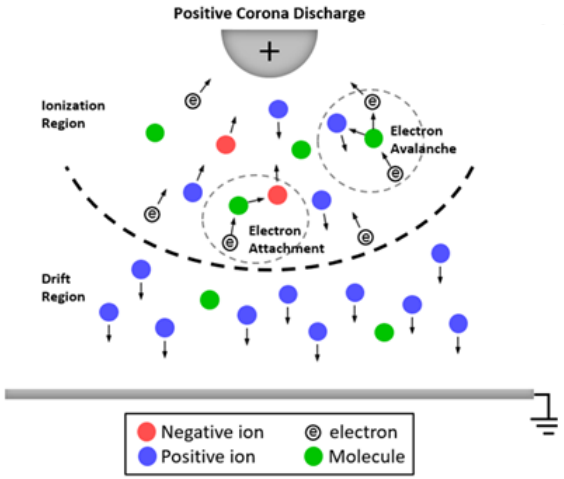


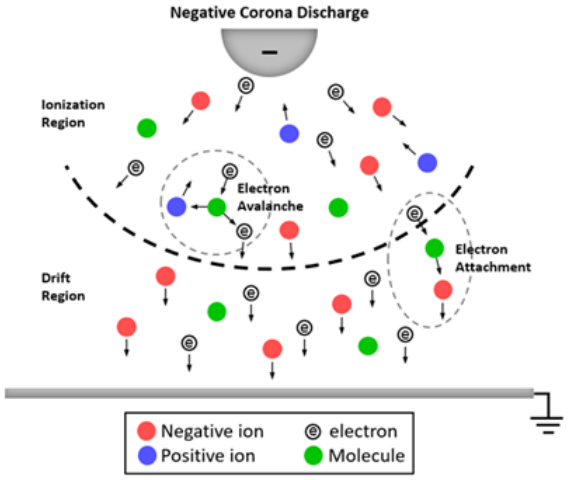
D. M. Gooding, G. K. Kaufman, Tribocharging and the Triboelectric Series, Encyclopedia of Inorganic and Bioinorganic Chemistry, Vol. 1-9, 2014.

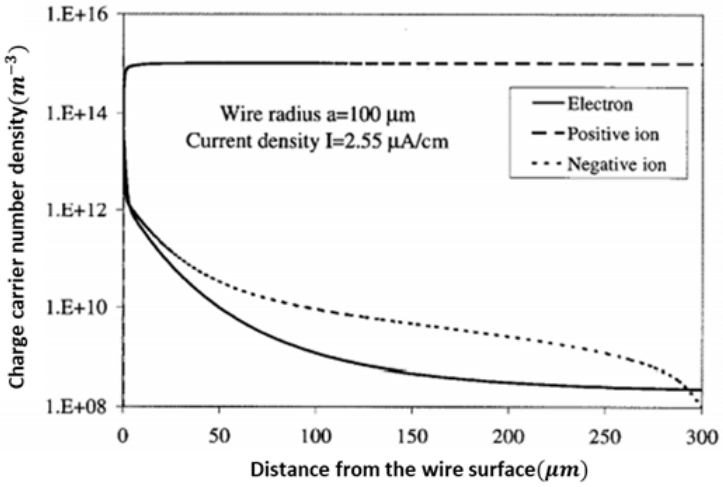
Corona Treatment

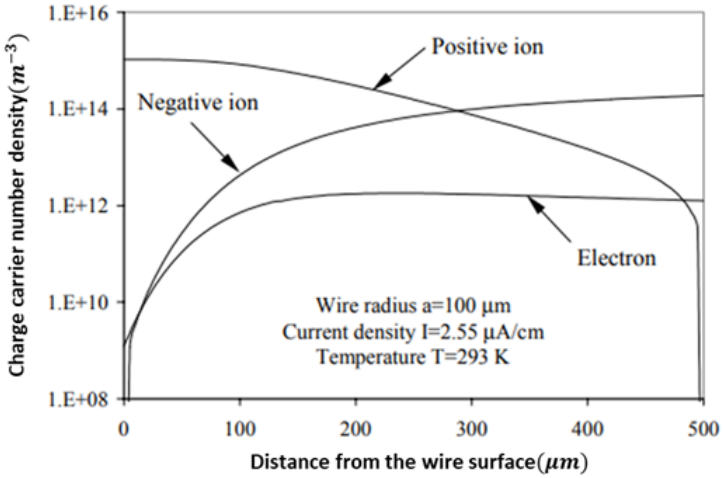


Corona Treatment





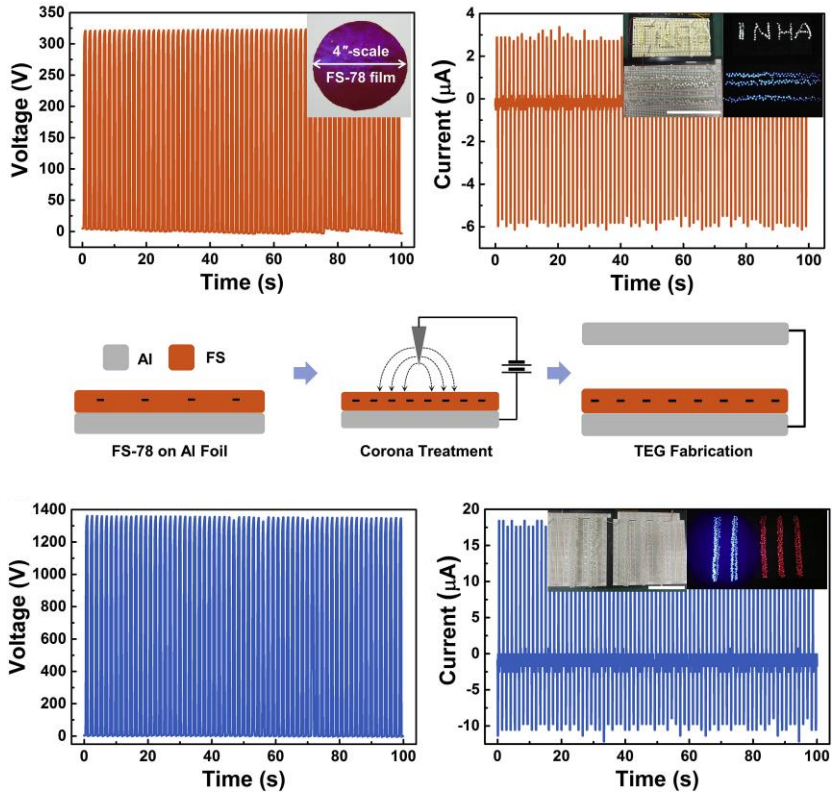




J. Chen et al., Plasma Chem. and Plasma Process. 22, 199 (2002).
J. Chen et al., Plasma Chem. and Plasma Process. 23, 83 (2003).

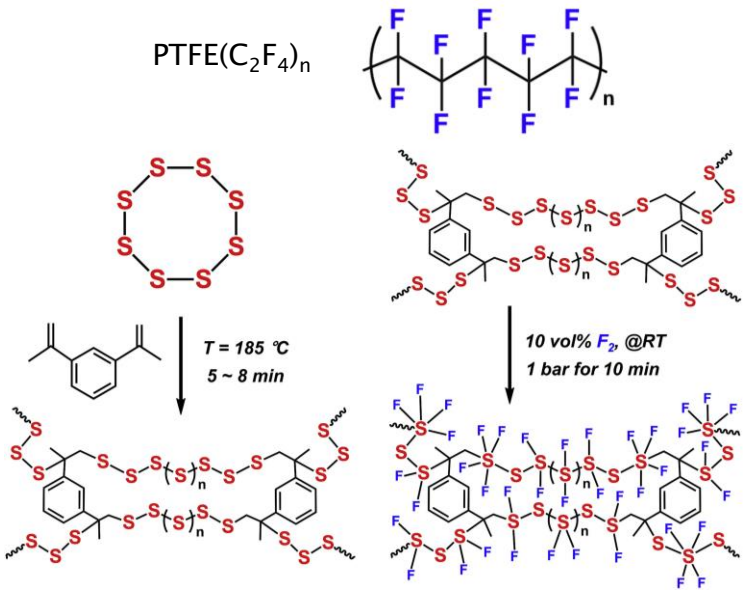
Previous research

Halogenic elements electron affinity (EA = -270~-349 kJ/mol)
Carbon electron affinity (EA =-122kJ/mol)
Sulfur electron affinity (EA =-200kJ/mol)

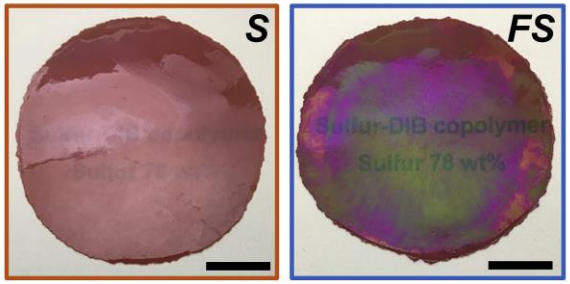


Fluorinated Sulfur copolymer film TENG 출력

PTFE(C_2F_4)$_n$



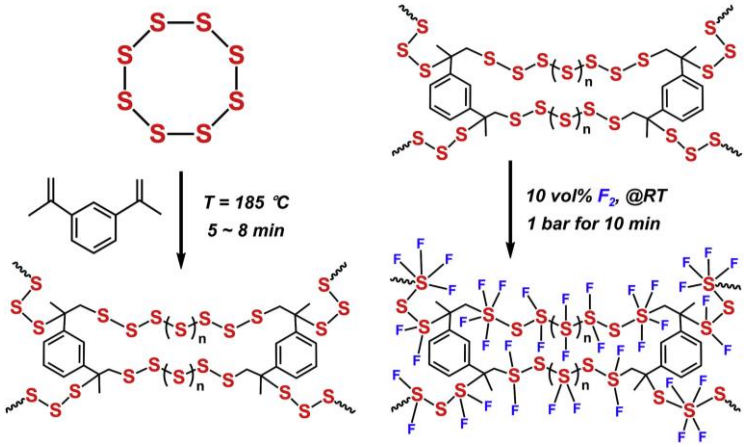
Fluorinated sulfur copolymer



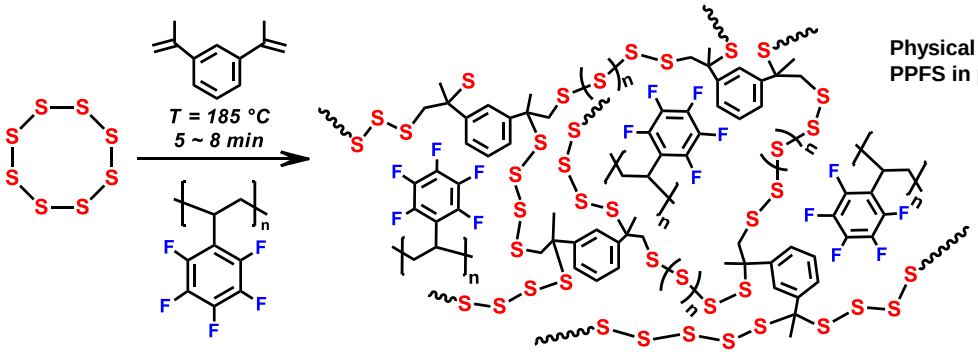
Sulfur copolymer film(좌)
Fluorinated Sulfur copolymer film(우)

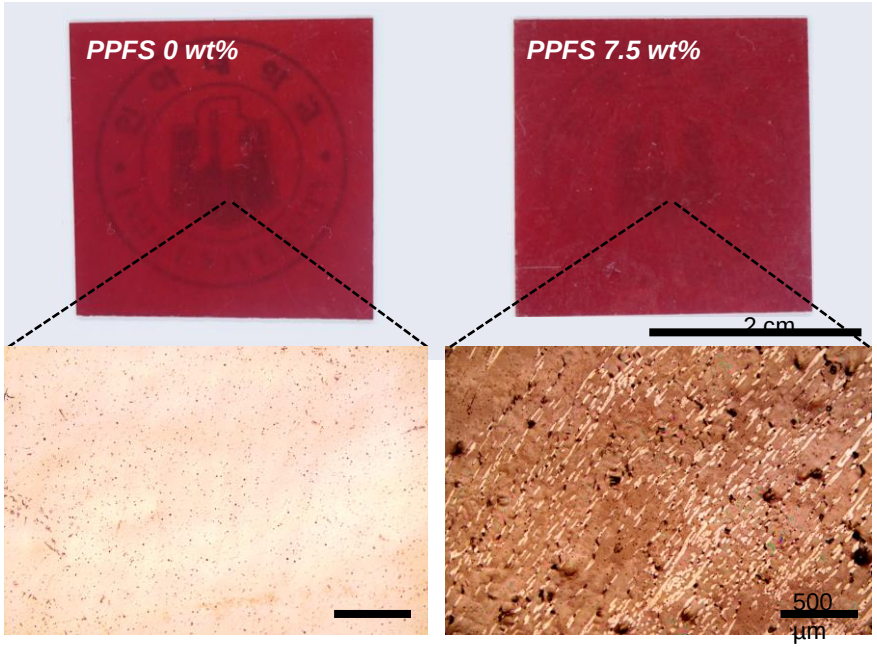
J.H. Lee, K.H. Kim, M. Choi, J. Jeon, H.J. Yoon, J. Choi, Y.S. Lee, M. Lee, J.J. Wie, Rational molecular design of polymeric materials toward efficient triboelectric energy harvesting, Nano Energy 66 (2019), 104158

Synthesis of the PPFS blends using poly(S-r-DIB) and PPFS



Fluorinated sulfur copolymer

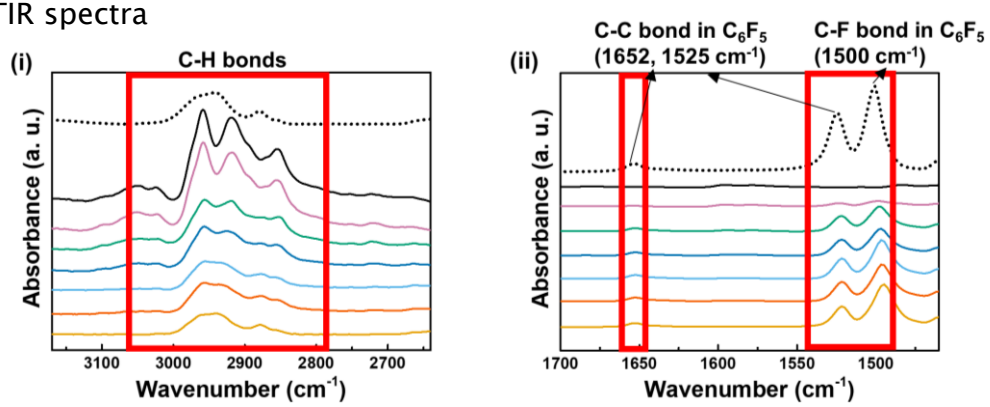




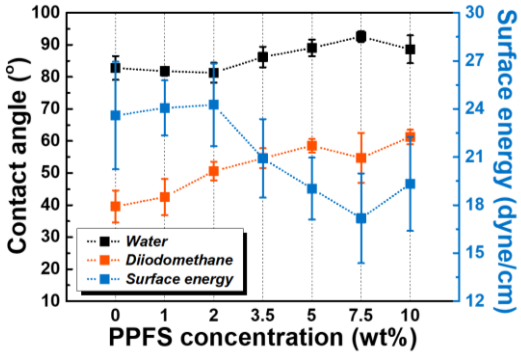
PPFS blended sulfur copolymer

Surface analysis

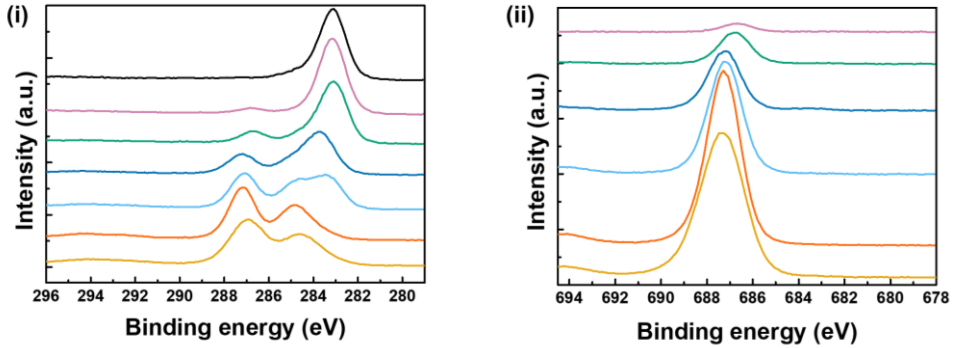
ATR-FTIR spectra



Contact angles

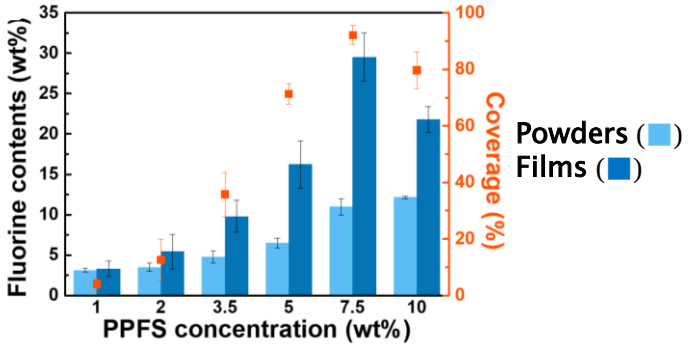


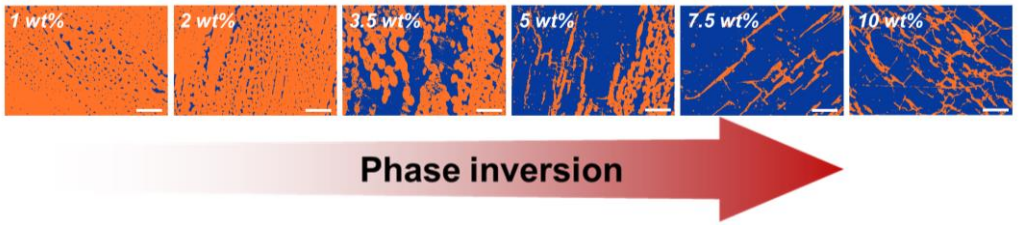
XPS profiles



(▬ ▬ ▬) PPFS, (▬) PPFS 0 wt%, (▬) PPFS 1 wt%, (▬) PPFS 2 wt%, (▬) PPFS 3.5 wt%, (▬) PPFS 5 wt%, (▬) PPFS 7.5 wt%, and (▬) PPFS 10 wt%

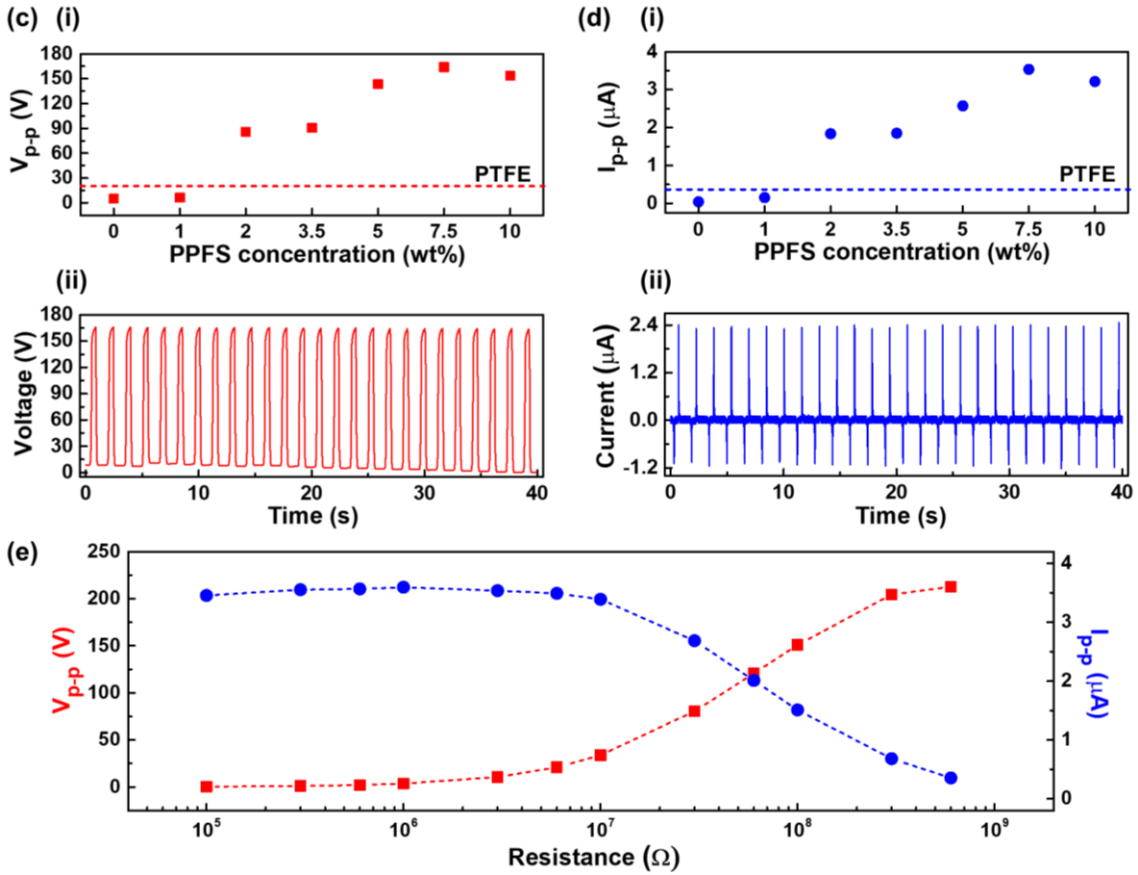
Fluorine contents as determined using EDS analysis



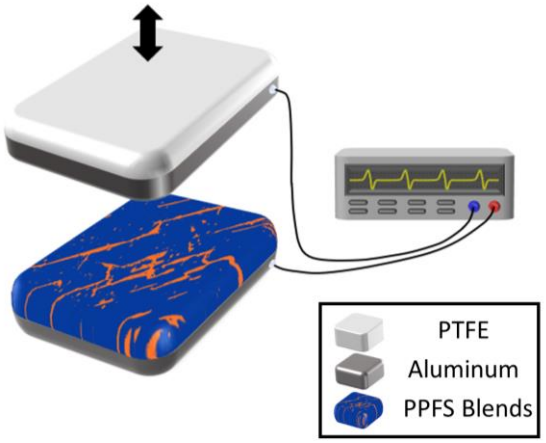


Triboelectric performance

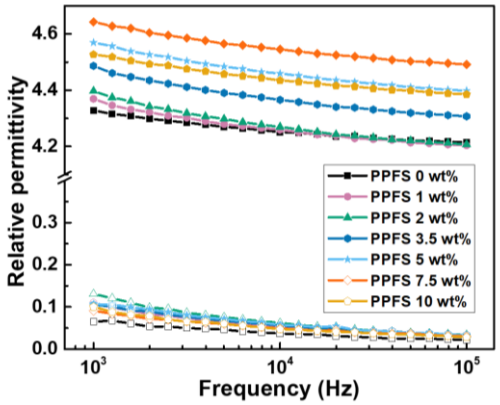
Peak-to-peak voltage and current of PPFS 7.5 wt%



Triboelectric device

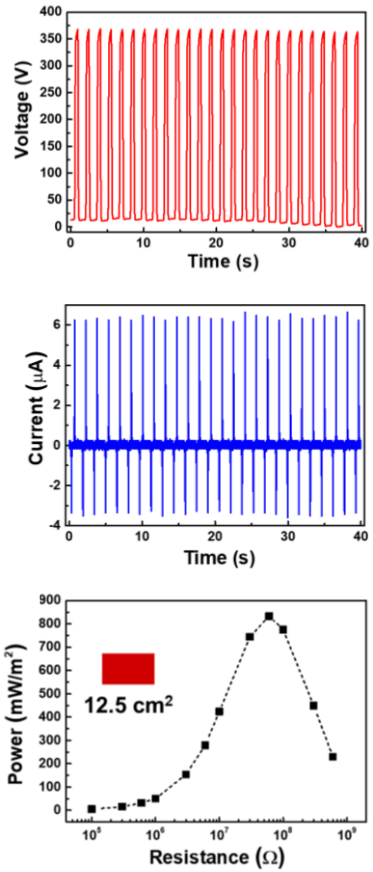


Permittivity

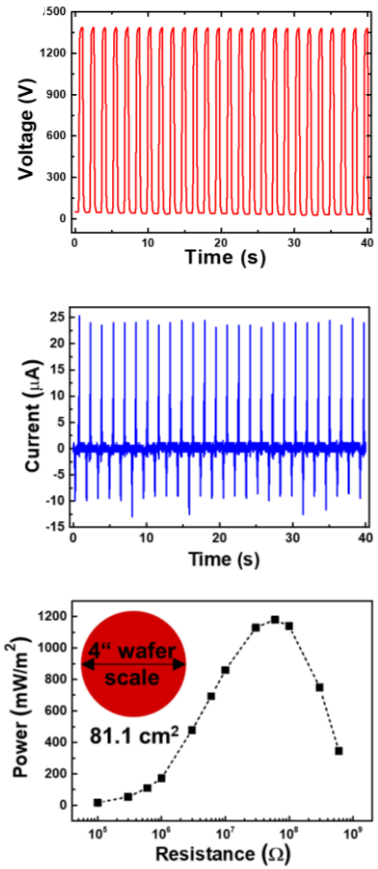


Maximized triboelectric performance of a corona treated TENG

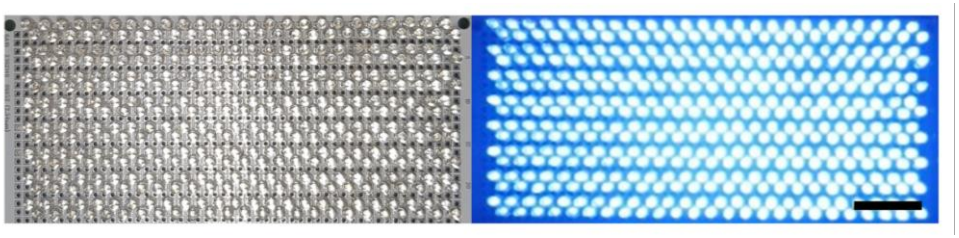
12.5 cm2 size



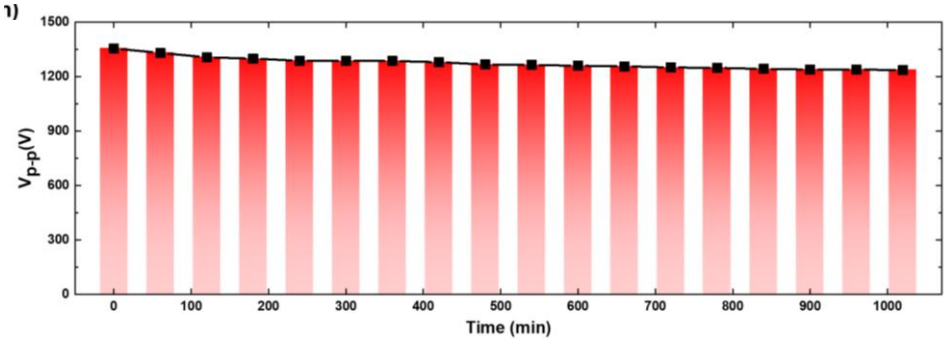
81.1 cm2 size



Utilization of the large-scale TENG (81.1 cm2) for the illumination of 400 series-connected blue



Long-term voltage measurements of the large-scale TENG



Conclusion

- 전자 친화력에 대한 정보를 기반으로 고성능 마찰 대전 발전 소자 제작. 전자 친화력이 작은 탄소 대신, 전자친화도가 큰 황을 이용하여 중합체를 제작.
- Open circuit Voltage는 1366V의 전압 출력을 얻었고 630개의 LED의 직접 전원 공급으로 좋은 성능을 보임.
- Sulfur copolymer는 석유 정제 부산물인 황으로 합성. 저비용·친환경 공급원인 TENG 신소재를 찾는 과정.

감사합니다