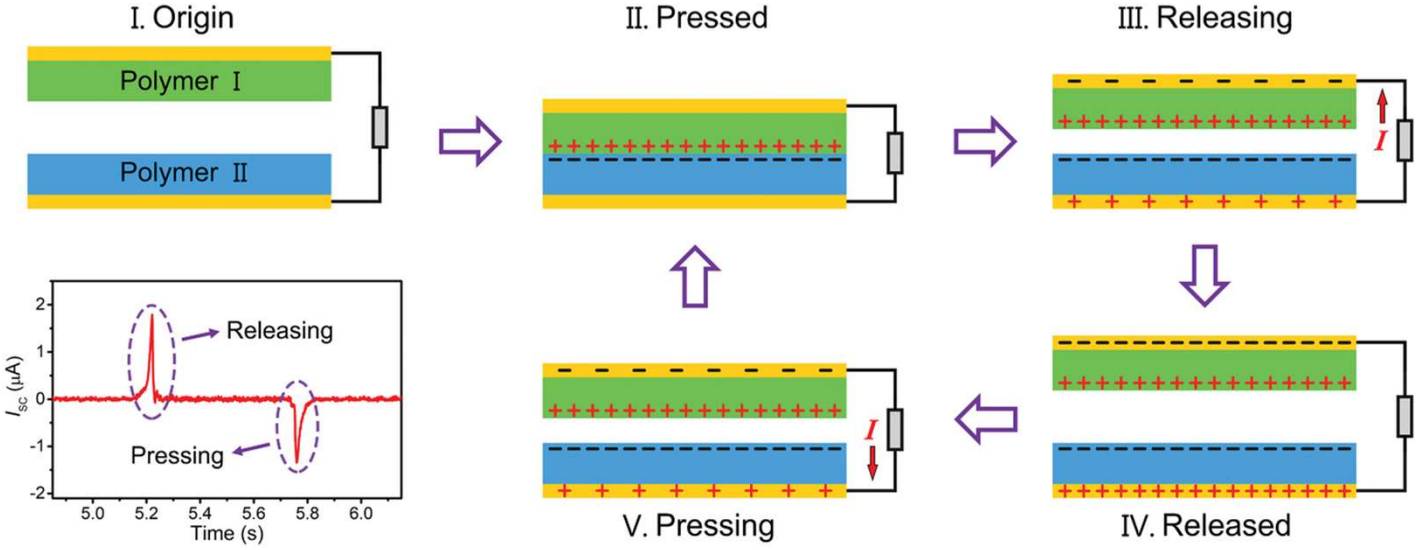
내부 코로나 디스차징 방법을 이용한 코팅 구조 TENG 연구

스마트나노소자 연구실
박 상혁

Triboelectric nanogenerator (TENG)



Gauss's law

$$\text{Inside Dielectric 1}: E_1 = -\frac{Q}{S\varepsilon_0\varepsilon_{r1}}$$

$$\text{Inside the air gap}: E_{air} = \frac{-\frac{Q}{S} + \sigma(t)}{\varepsilon_0}$$

$$\text{Inside Dielectric 2}: E_2 = -\frac{Q}{S\varepsilon_0\varepsilon_{r2}}$$

Electrical potential

$$V = E_1 d_1 + E_2 d_2 + E_{air} x$$

$$V = -\frac{Q}{S\varepsilon_0}\left(\frac{d_1}{\varepsilon_{r1}} + \frac{d_2}{\varepsilon_{r2}} + x(t)\right) + \frac{\sigma x(t)}{\varepsilon_0}$$

Voc (Open-circuit voltage)

$$V_{OC} = \frac{\sigma x(t)}{\varepsilon_0}$$

Isc (Short-circuit current)

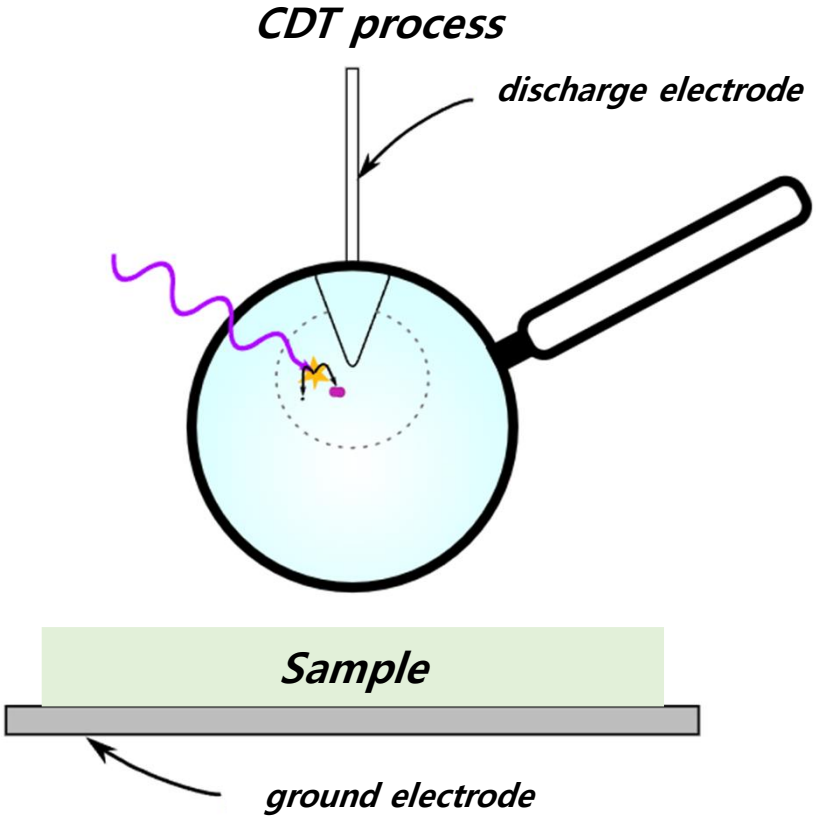
$$Q_{SC} = \frac{S\sigma x(t)}{d_0 + x(t)} \qquad I_{SC} = \frac{dQ_{SC}}{dt} = \frac{S\sigma d_0 v(t)}{(d_0 + x(t))^2}$$

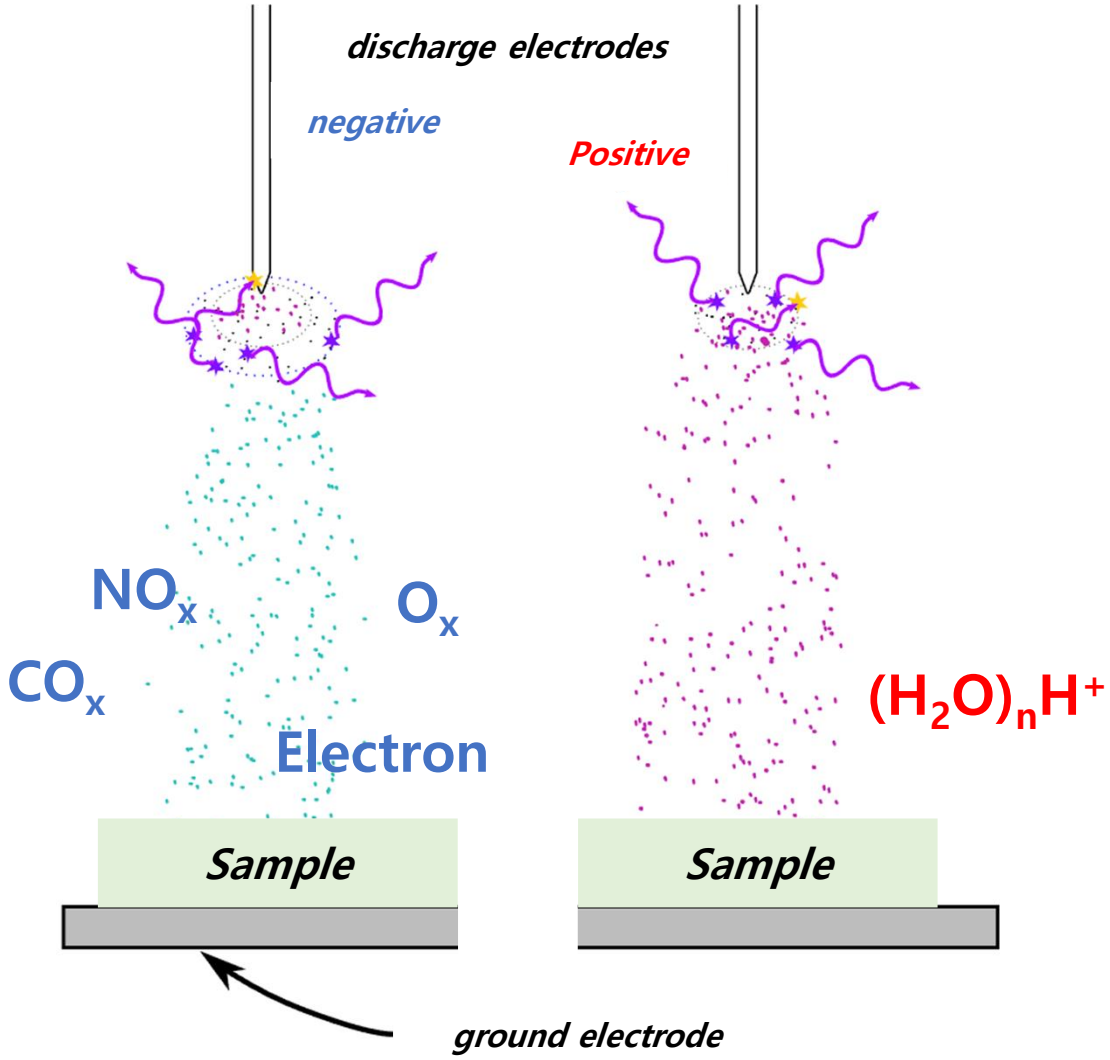
** If the **motion speed (v)** and **maximum distance (d)** are constant,*

$$V_{oc}, I_{sc} \sim \sigma$$

(Surface charge density)

Corona discharge treatment (CDT)





** The CDT process **increases the surface charge** of the sample.*

Research objectives

TENG output improvement

Surface charge Improvement

Corona discharge treatment (CDT)

Unstable surface condition:

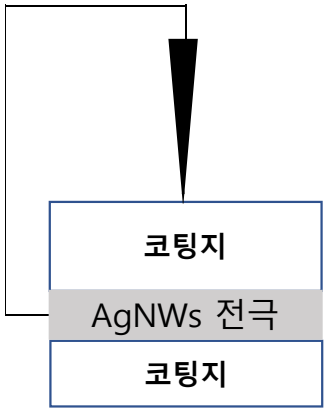
*Decreased output over time
*Easy charge discharge on surface

Another treatment method:

Interlayer-corona discharge treatment (i-CDT)

Surface CDT (s-CDT) : Laminated structure with AgNWs

*** Laminating structure**



*** Laminating film**

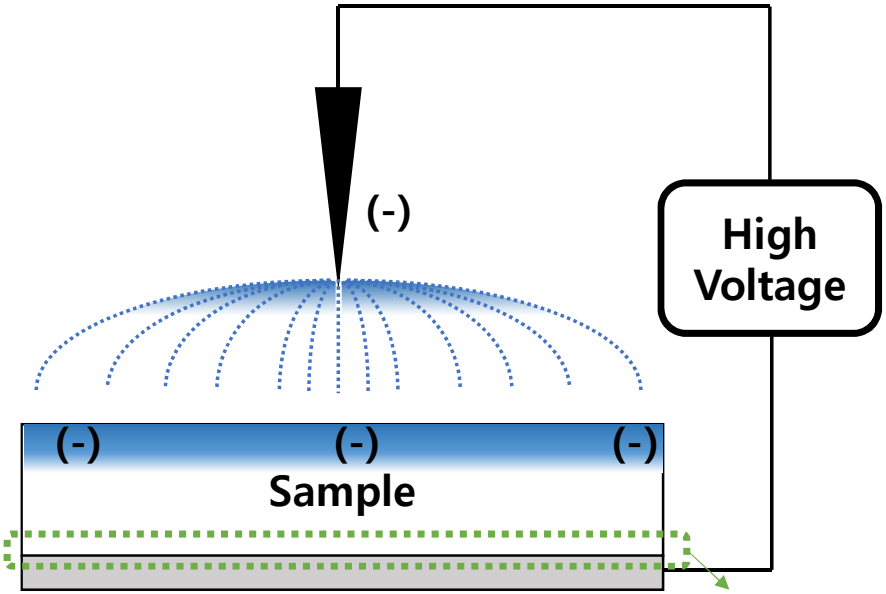
Contact electrification part (Surface part)

PET

PE/EVA

Electrode deposition part (interlayer part)

Negative surface-CDT

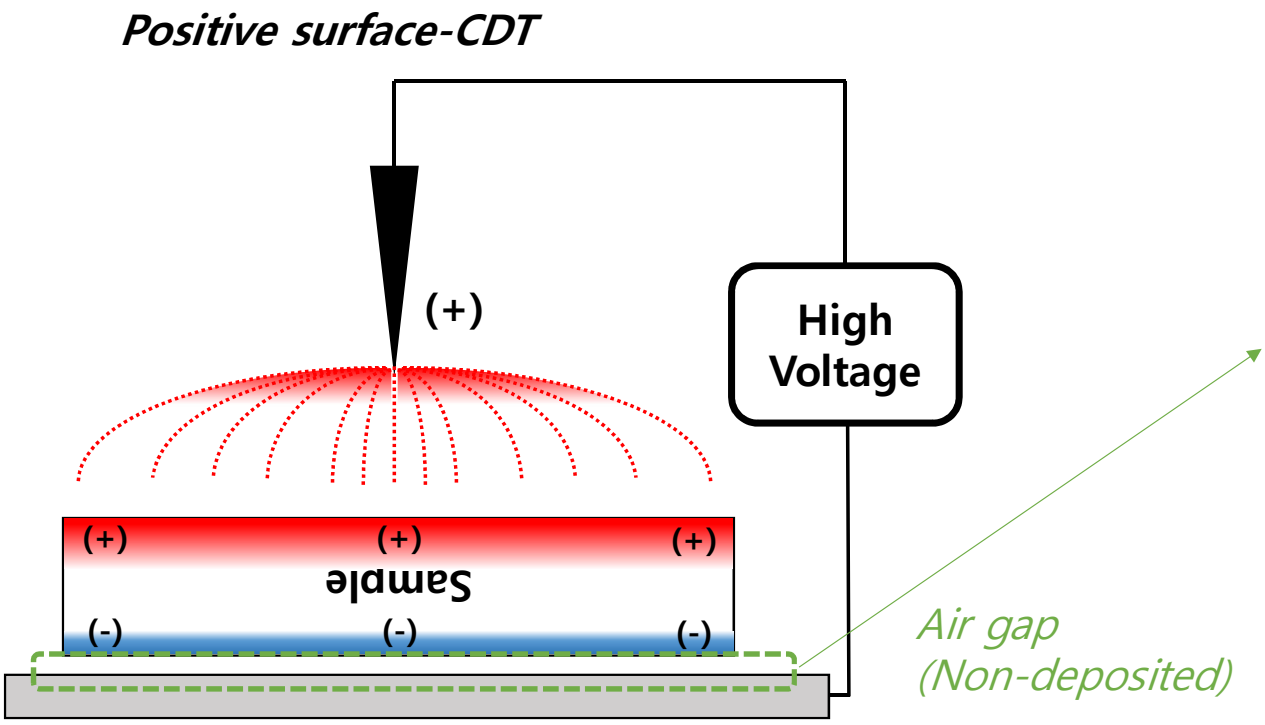


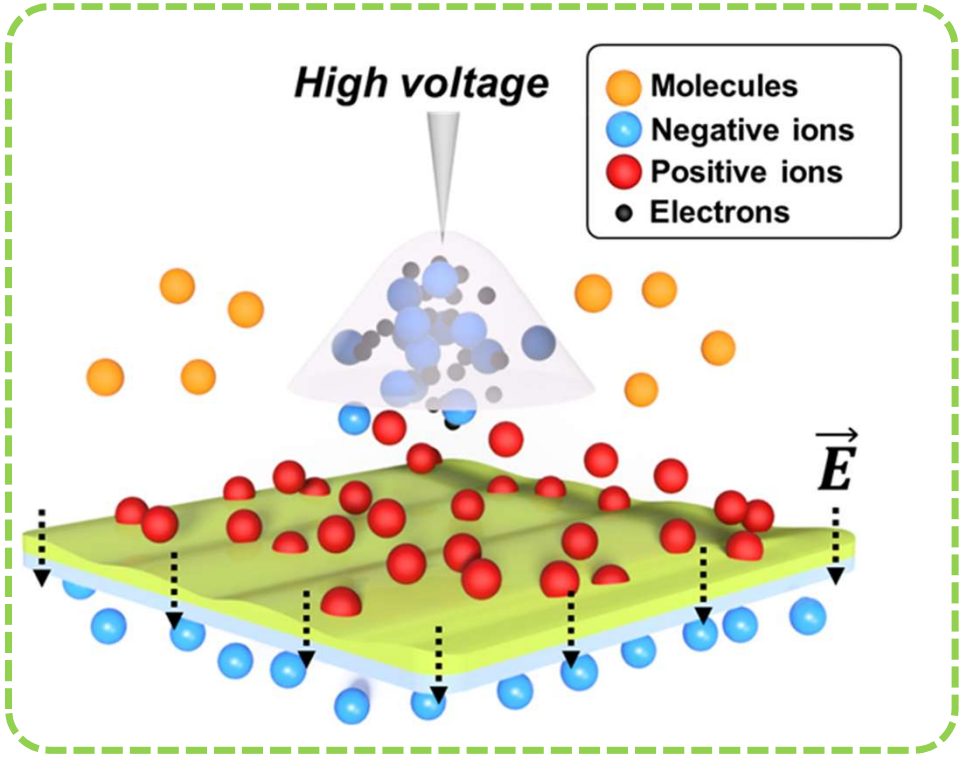
** Deposited electrode*

Discharge Tip Bias : **Negative (-)**
Charge on the sample surface : **Negative (-)**

=> **It's the same sign as each other.**

Interlayer CDT (i-CDT)





Discharge Tip Bias : **Positive (+)**
Charge on the sample surface : **Negative (-)**

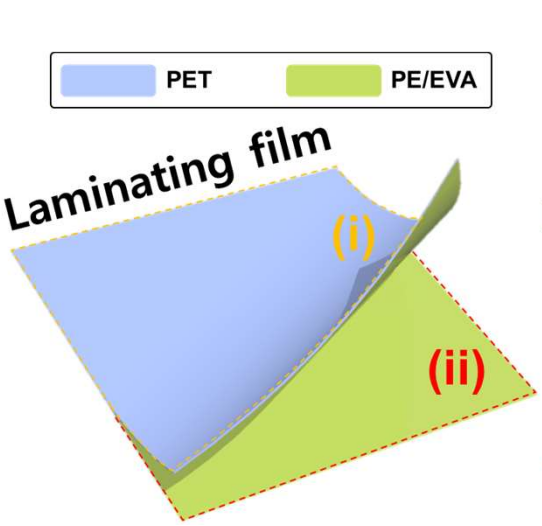
=> **It's the opposite sign as each other.**

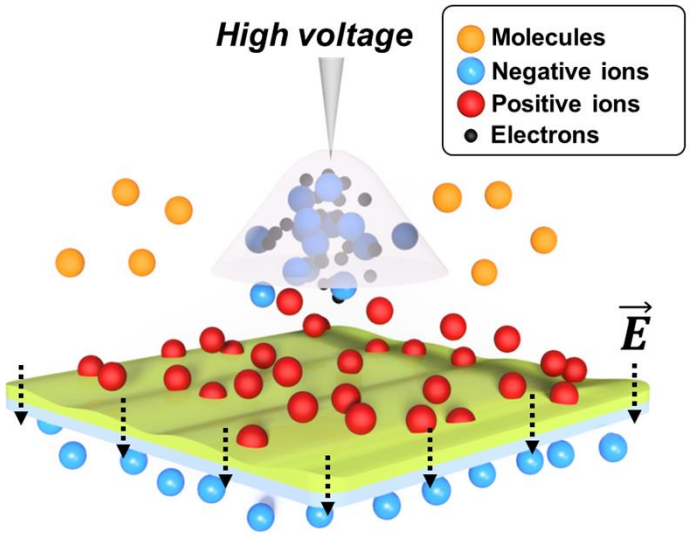
Where did the negative charge come from?

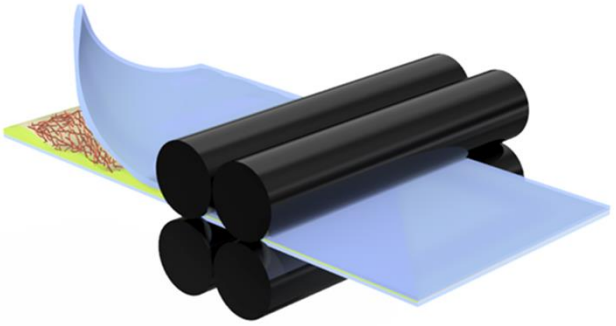
=> **Negative ions in the air or Electrons?**

Fabrication of i-CDT film

Laminating Structure with Ag NWs for TNEG applications



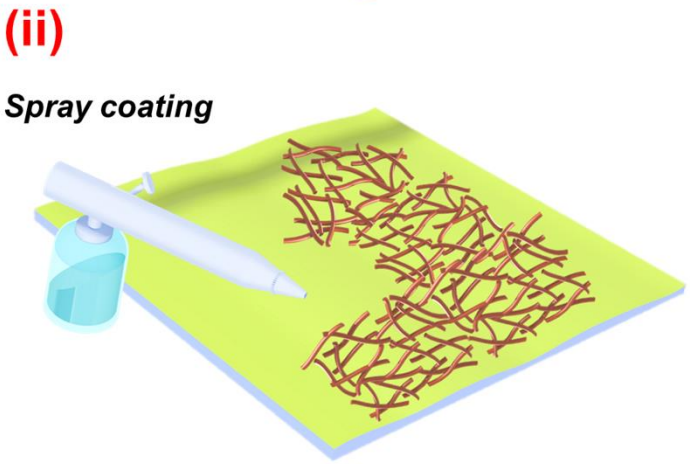




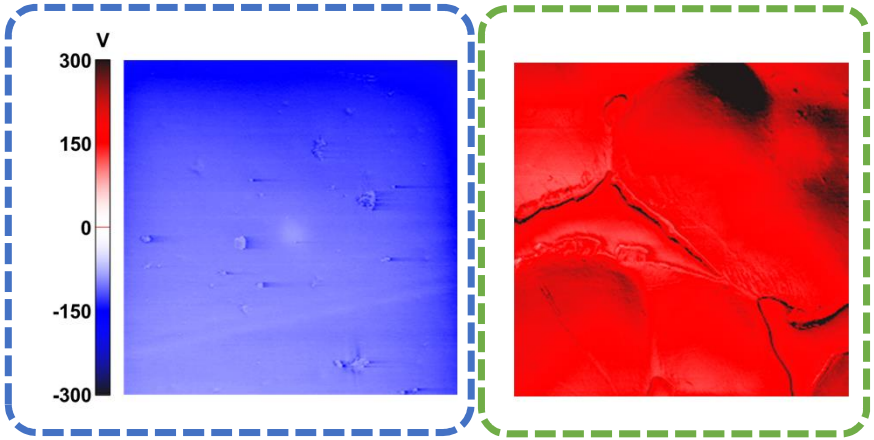
Contact electrification part (Surface part)

PET
PE/EVA

Electrode deposition part (interlayer part)

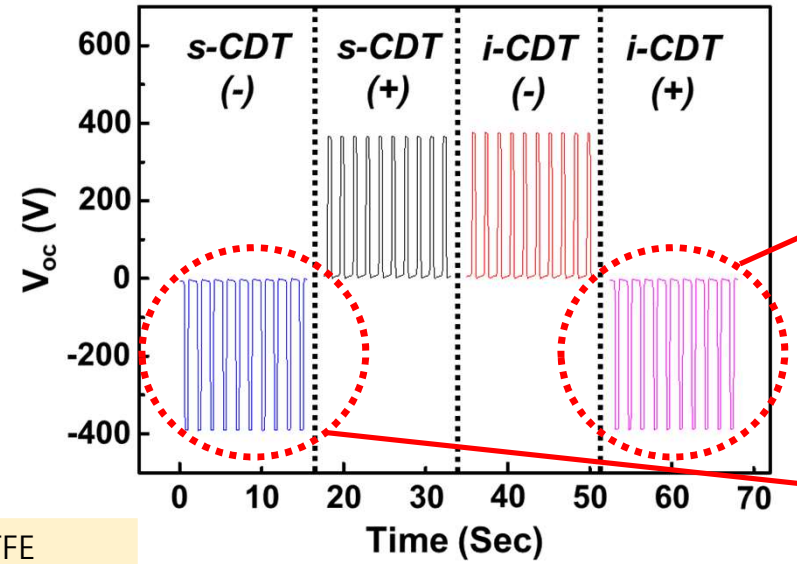


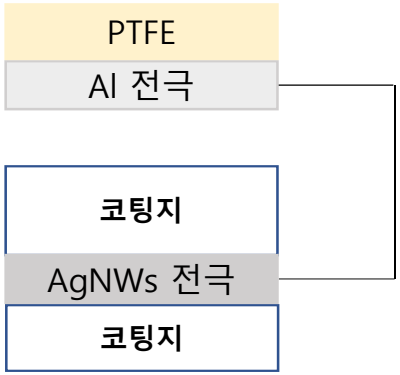
EFM image (after i-CDT)



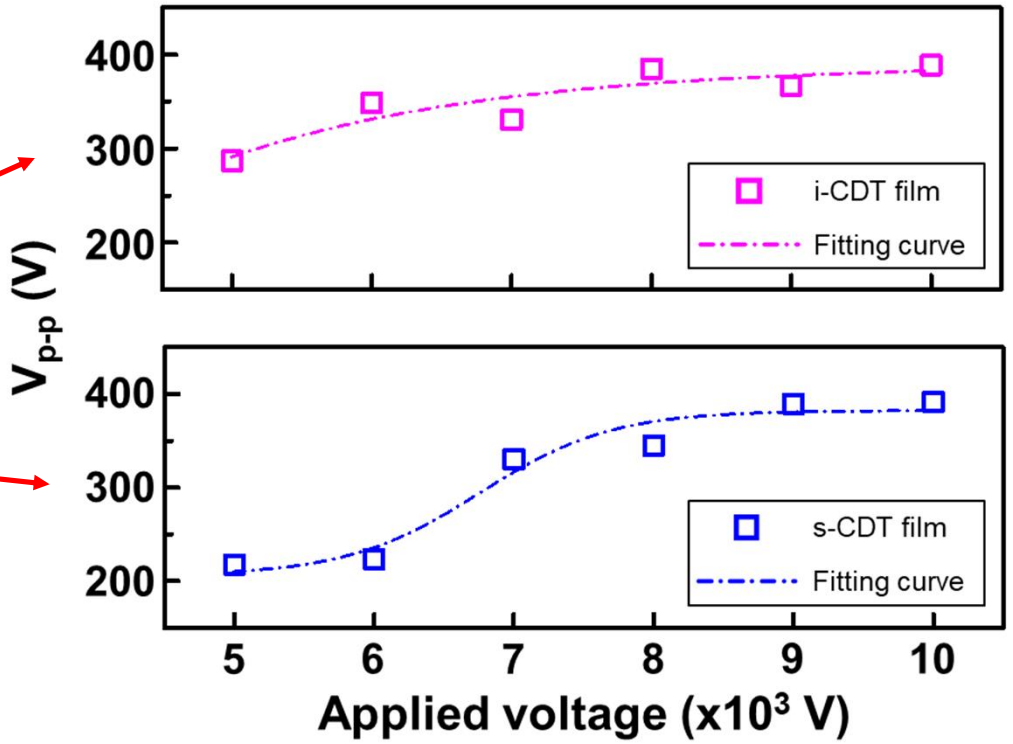
s-CDT vs i-CDT : Triboelectric output (2.5 x 2.5 cm^2)

Triboelectric voltage by the polarity of CDT (10kV)



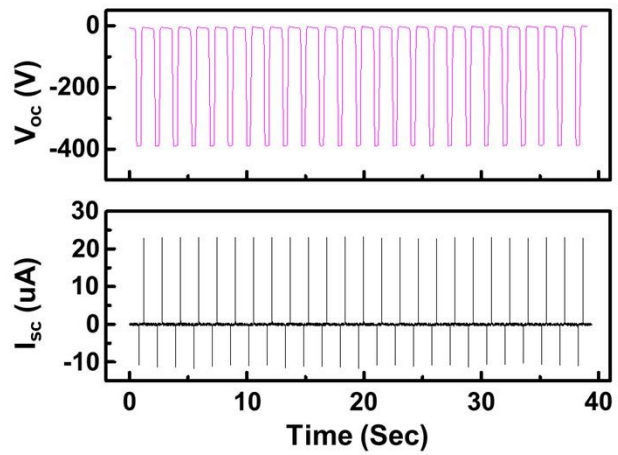


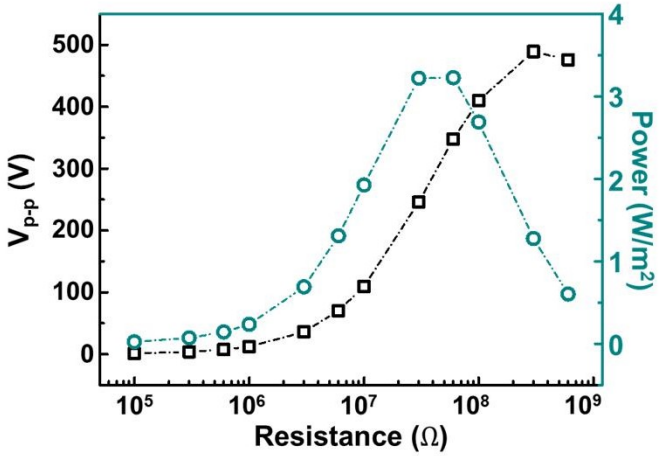
Triboelectric voltage by the applied voltage of CDT

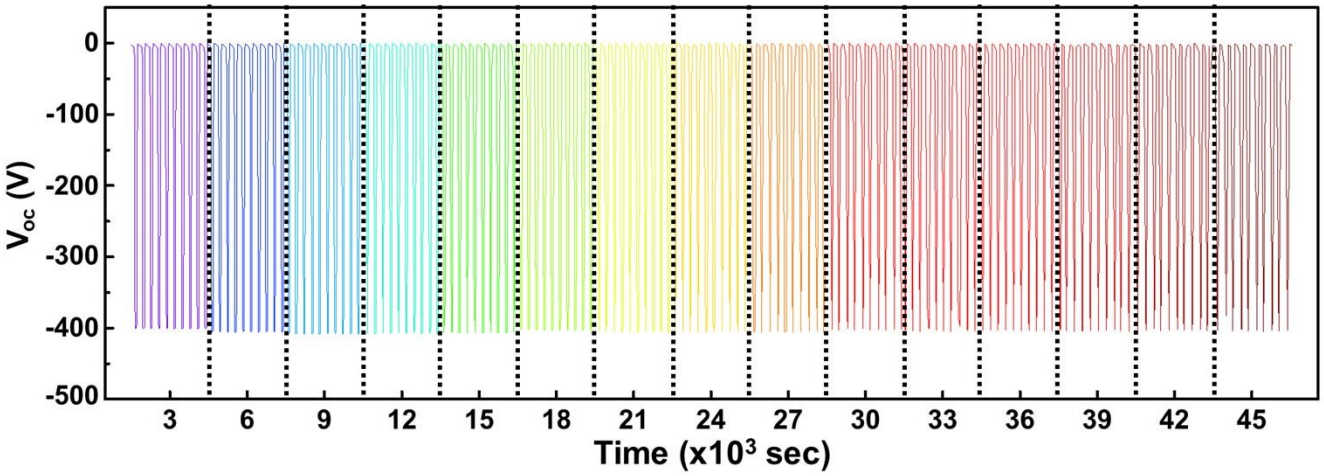


Triboelectric output of i-CDT

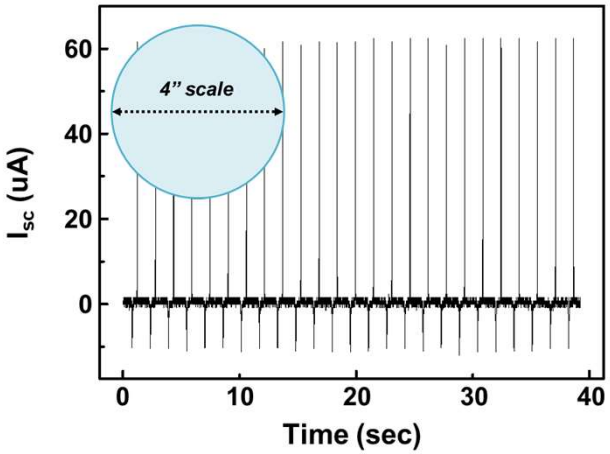
Triboelectric output of i-CDT (2.5x 2.5 cm²)

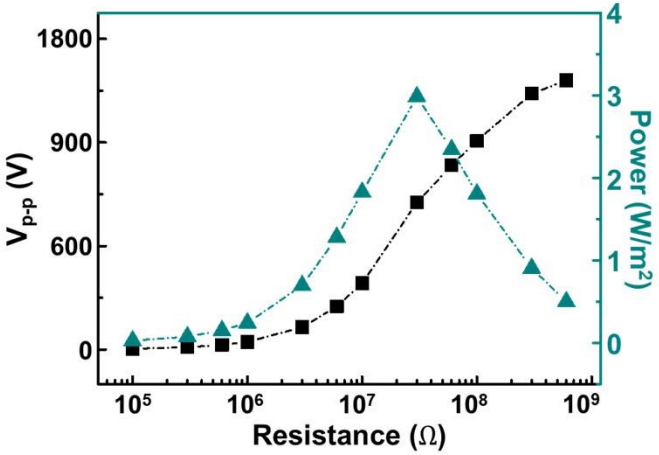






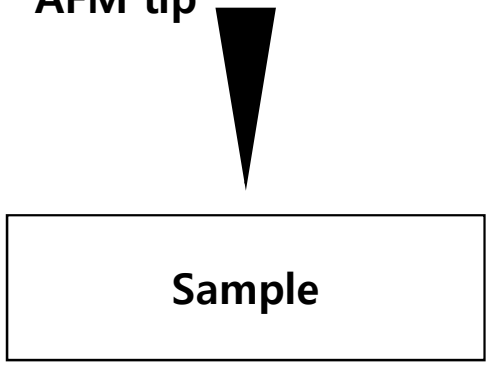
Large area (4”-scale)



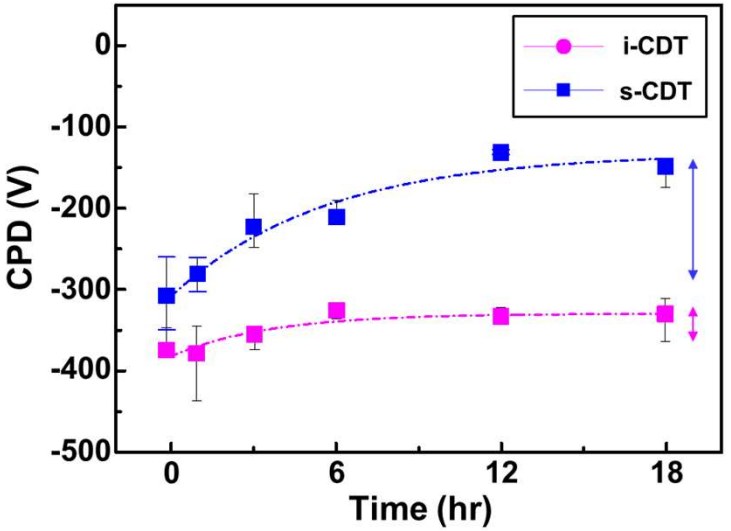


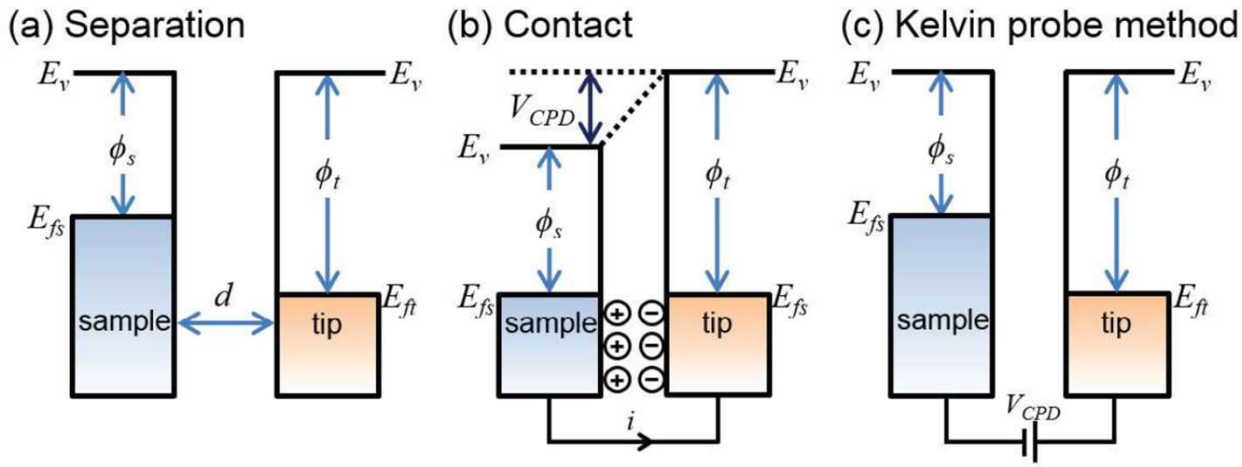
i-CDT: *Where did the negative charge come from?*

CPD (Contact potential difference) by AFM



$$V_{CPD} = \frac{\phi_{tip} - \phi_{sample}}{-e}$$





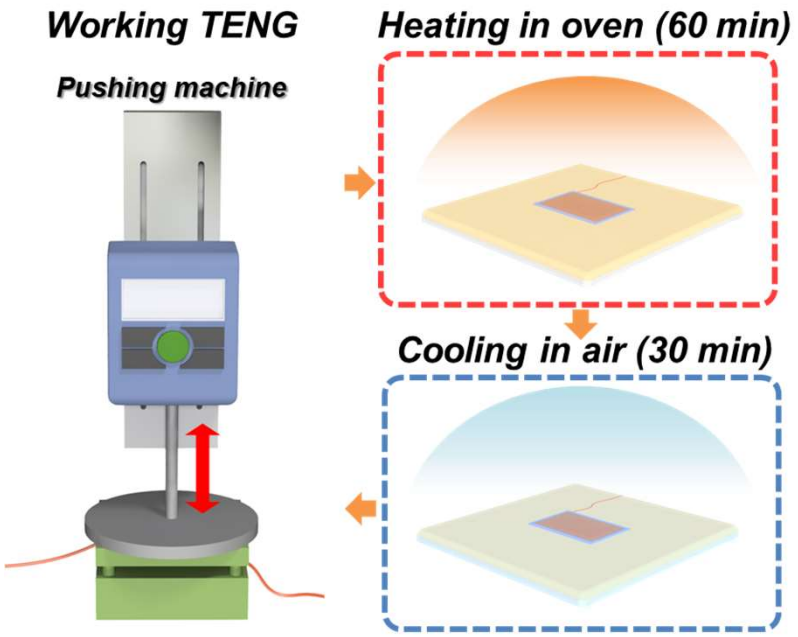
$$\sigma = \sigma_{electron} + \sigma_{ion}$$

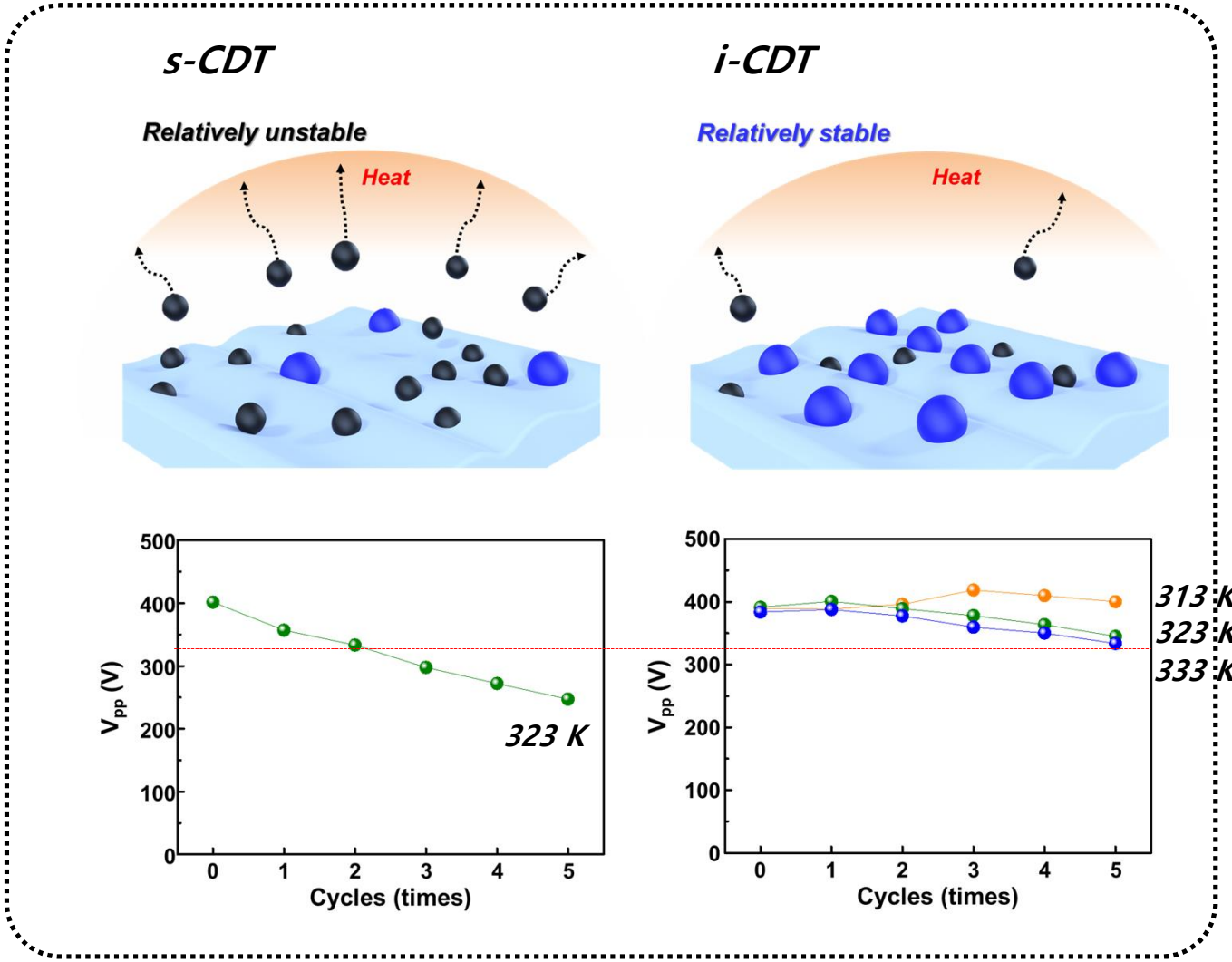
$$\sigma_{electron} = \sigma_0 e^{-\gamma t}$$ *unstable*

$$\sigma_{ion} = \sigma_0'$$ *stable*

i-CDT has more ion contribution than s-CDT.

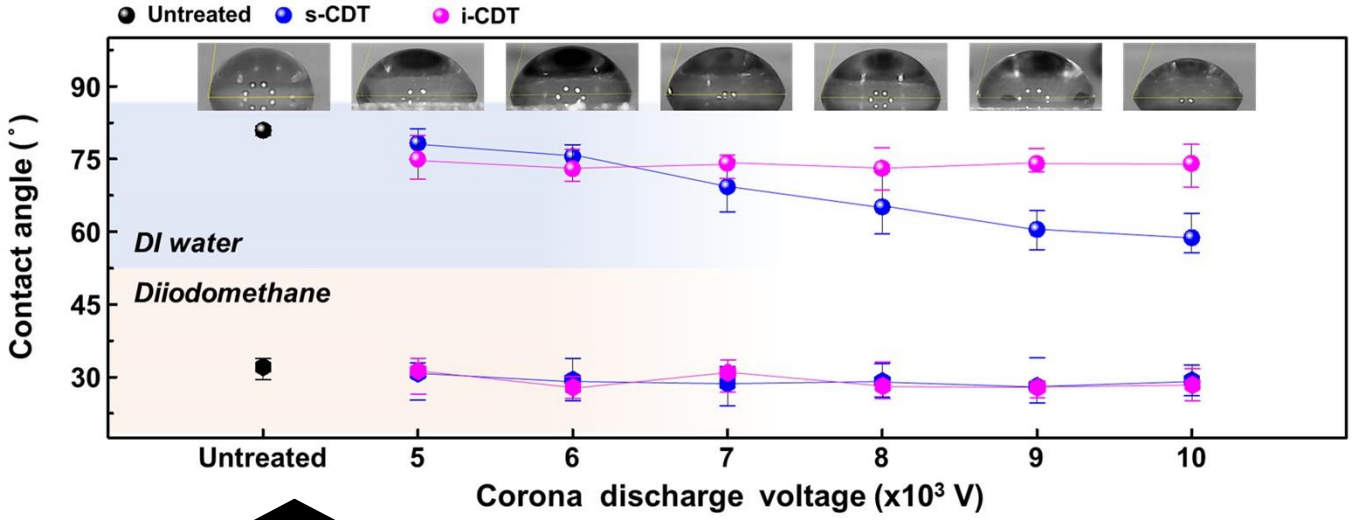
s-CDT < i-CDT : Charge retention in various temperature

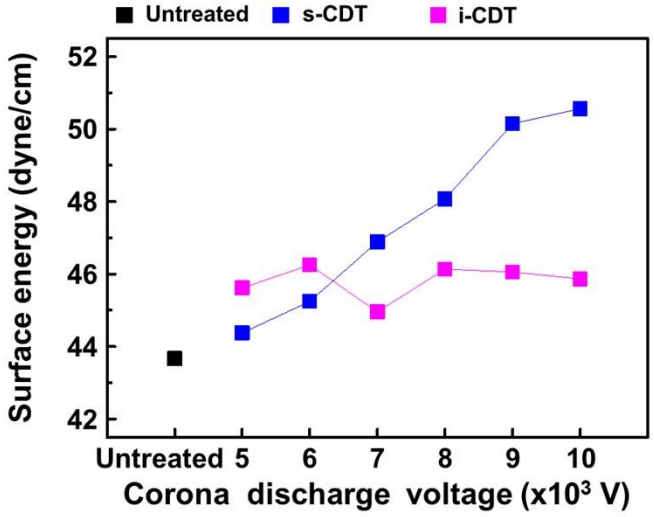


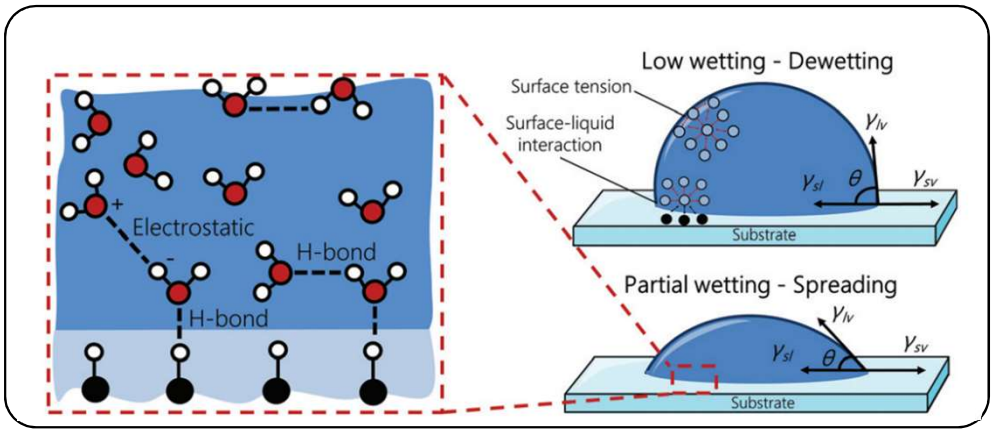


s-CDT < i-CDT : Charge retention in high humidity condition

Contact angle measurement & Surface energy calculation







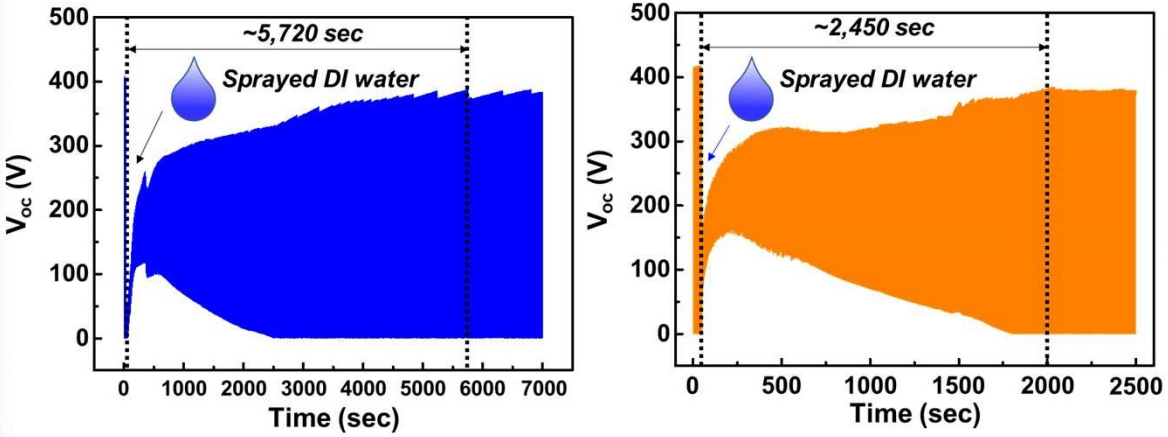
Owen-Wendt equation

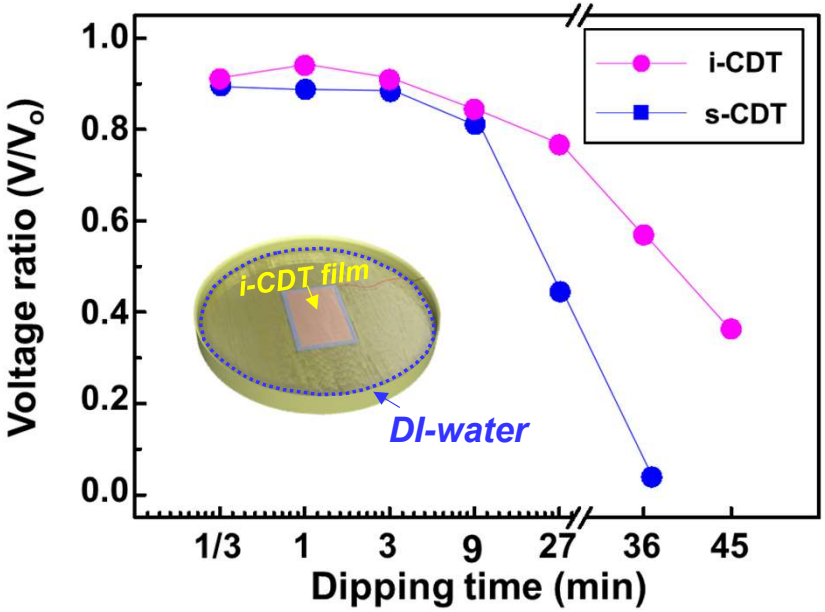
$$(\gamma_s^p)^{0.5} = \frac{\gamma_w(\cos\Theta_w + 1) - 2\sqrt{\gamma_s^d\gamma_w^d}}{2\sqrt{\gamma_w^p}}$$

$$(\gamma_s^d)^{0.5} = \frac{\gamma_d(\cos\Theta_d + 1) - \sqrt{(\gamma_d^p/\gamma_w^p)}\gamma_w(\cos\Theta_w + 1)}{2\left(\sqrt{\gamma_d^d} - \sqrt{\gamma_d^p(\gamma_w^p/\gamma_w^p)}\right)}$$

s-CDT < i-CDT : Charge retention in high humidity condition

The test of resistance and recovery ability about water by spraying DI-water during TENG working

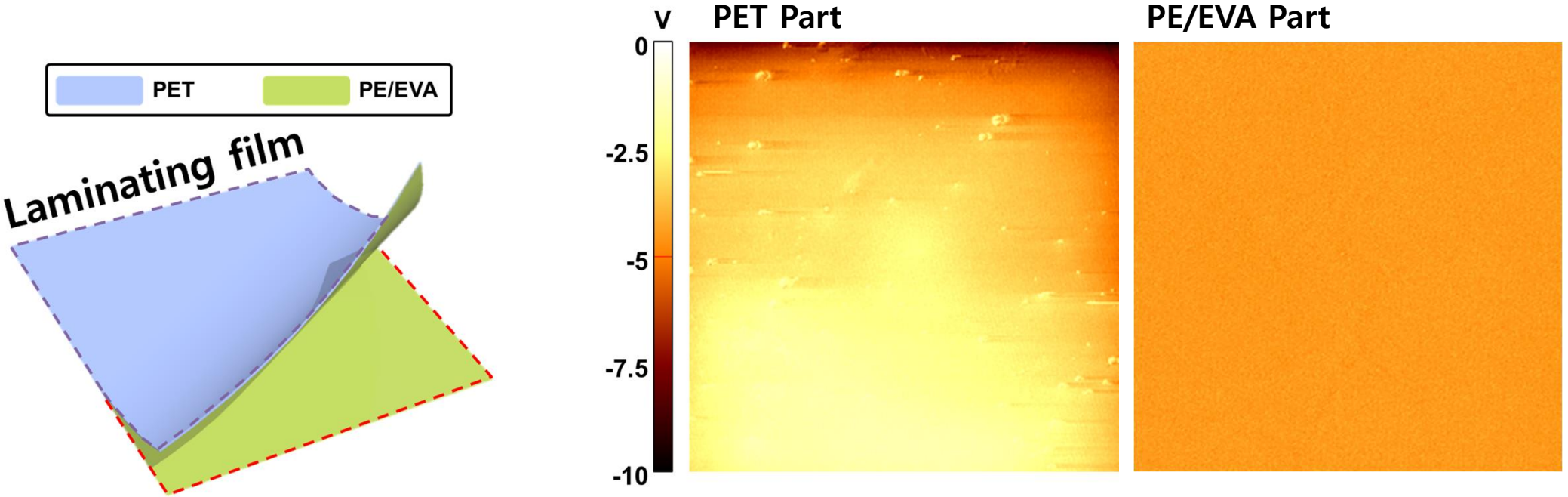




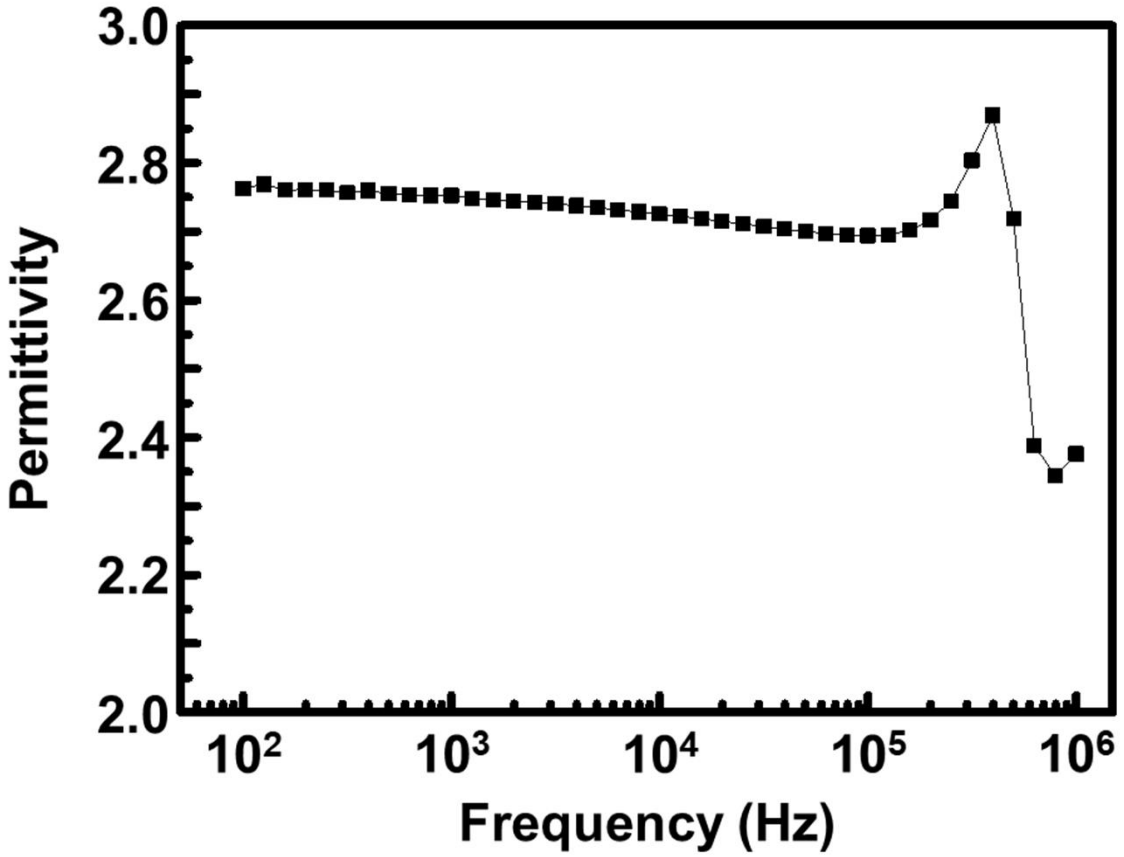
i-CDT is relatively lower surface energy than s-CDT and is better resistant to water.

Q & A

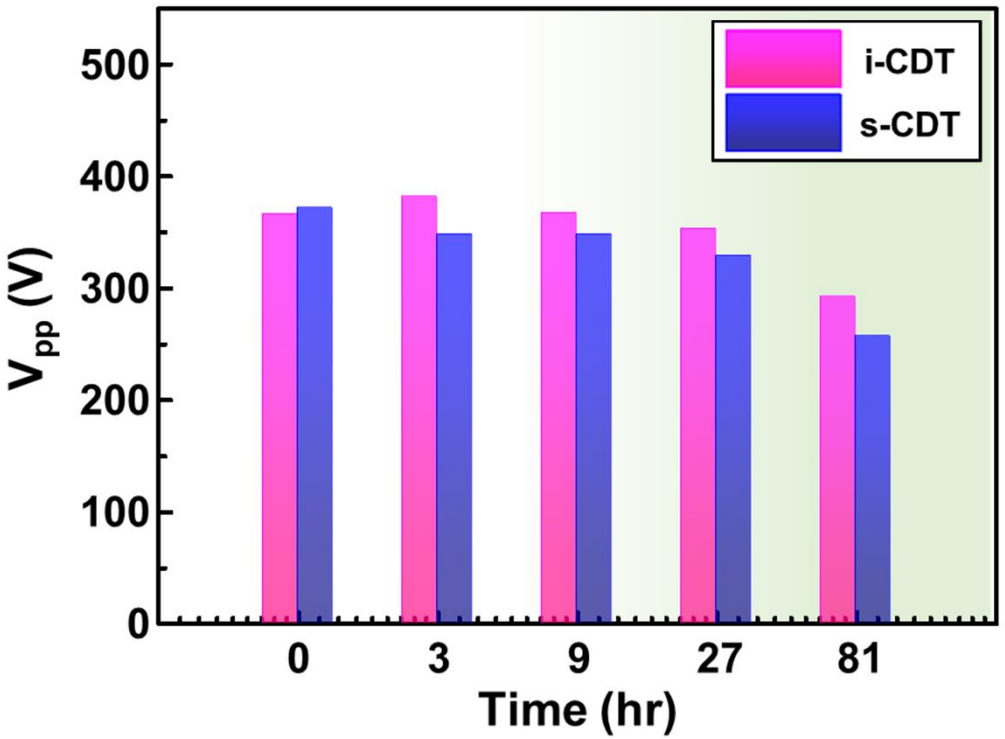
Supporting information 1. EFM image of Non-CDT laminating structure



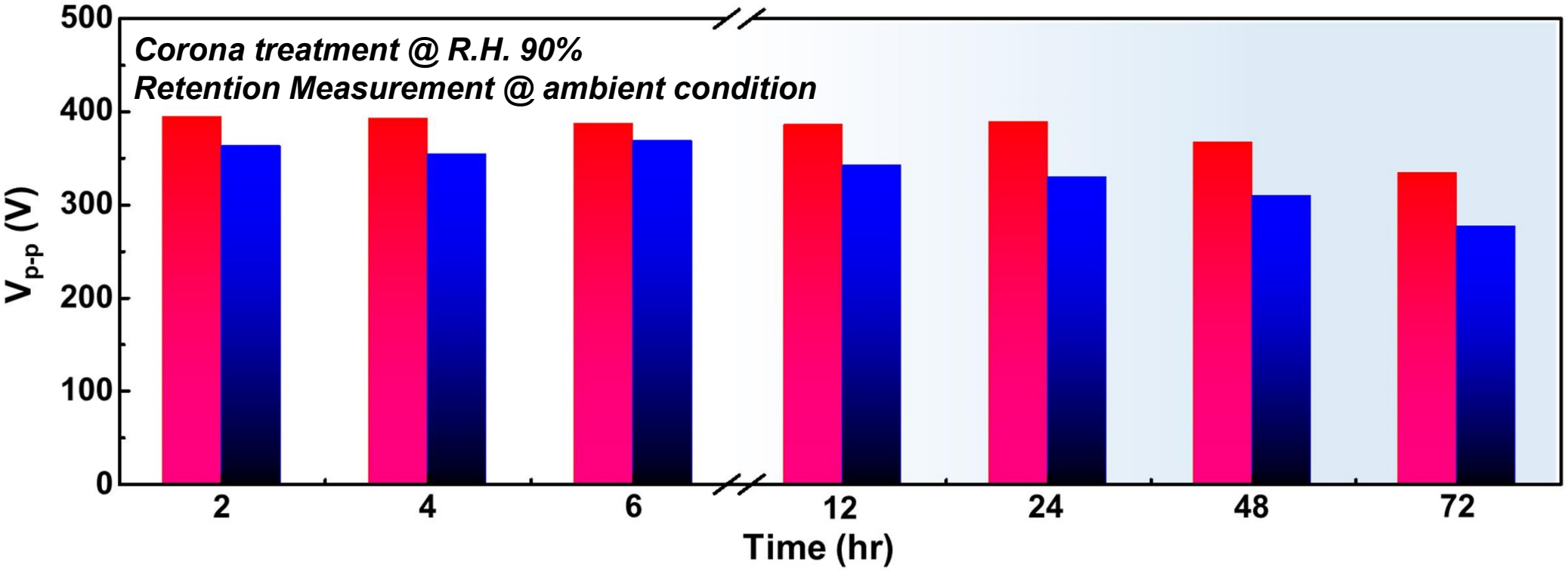
Supporting information 2. permittivity of laminating structure



Supporting information 2. Long-lasting stability test of i-CDT and s-CDT



Supporting information 3. Long-lasting stability test of i-CDT and s-CDT in high humidity condition



Supporting information 4. Surface roughness and images measurement by optical profilometer