

# Unveiling the Future of Insulator Coatings: Unmatched Corrosion Resistance and Self-Healing Properties of PFPE Lubricating Oil-Infused Hydrophobized CeO<sub>2</sub> Surfaces

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The prepared composite was sprayed three to five times on insulator samples and dried at room temperature for 3 h. Finally, the PFPE lubricating oil was coated/sprayed on insulator specimens with a brush/spray.

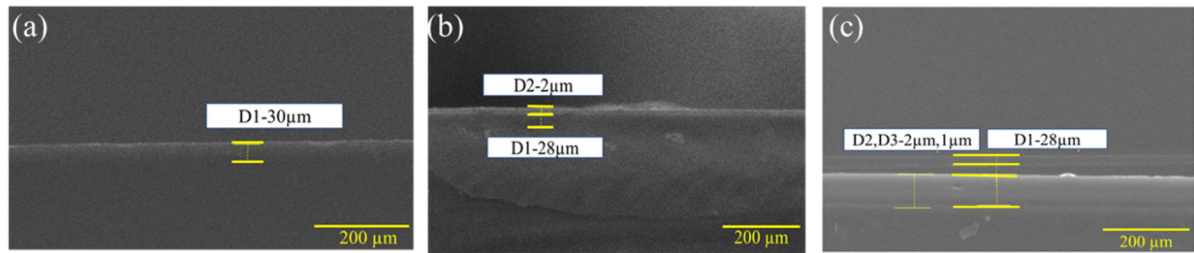


Figure S1. The cross-sectional SEM micrographs of coatings. (a) CeO<sub>2</sub> conversion coating, T0; (b) hydrophobized CeO<sub>2</sub> composite coating, T1; and (c) PFPE infused hydrophobised CeO<sub>2</sub> composite, T2.

The contact angle measurements states that the transition from Cassie to Wenzel occurs via a nucleation mechanism starting from the drop center, due to the surface degradation of specimen T1. The change converts the specimen T1 from a fully non-wettable to a partially wettable surface. Specimen T2 maintains non-wettability due to the healing properties of the PFPE-infused hydrophobized CeO<sub>2</sub> composite. The contact angle hysteresis measurements also align with the specimens' contact angle measurement results. Specimen T2 shows lower contact angle hysteresis at 2.3°, thus maintaining super-hydrophobicity, as shown in Figure 3 and Figure S2, S3.

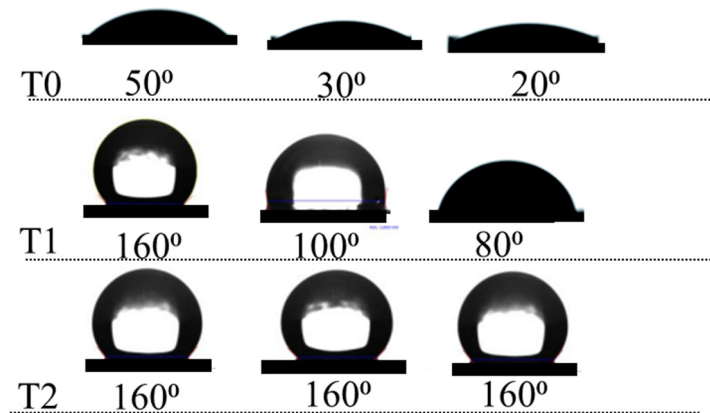


Figure S2. Contact angle measurements after thermo-mechanical aging of insulator specimens.



Figure S3. The micrographs justifying the water repelling capability of samples (a) T0, (b) T1, and (c) T2.

The T0 specimen showed the highest corrosion current density ( $2.89 \times 10^{-6}$  A/cm<sup>2</sup>) and corrosion rate ( $4.41 \times 10^{-2}$  mm/year). The T2 specimen exhibited the lowest corrosion rate ( $0.3 \times 10^{-3}$  mm/year) and corrosion current density ( $1.2 \times 10^{-7}$  A/cm<sup>2</sup>) as depicted in Table S1. The chemical structure of per-fluoro poly ether can be seen in Figure S5. The contact angle measurements reveal that the transition from the Cassie to Wenzel state occurs through a nucleation mechanism originating from the center of the droplet. This transition is caused by the degradation of the T1 specimen's surface [23-24]. Consequently, specimen T1 transforms from being completely non-wettable to partially wettable. On the other hand, specimen T2 maintains its non-wettability due to the healing properties of the PFPE-infused hydrophobized CeO<sub>2</sub> composite. The contact angle hysteresis measurements support the findings of the contact angle measurements. Specifically, the hysteresis measurements of specimen T2 demonstrated a lower value of 2.3°, indicating the maintenance of superhydrophobicity, as shown in Table S2. This information is illustrated in Figure 3 and Figures S2 and S3.

Table S1. The corrosion resistance performance of prepared samples

| Samples | Composition   | Thickness (μm) | I <sub>corr</sub> (A/cm <sup>2</sup> ) | Corrosion rate (mm/Y) |
|---------|---|----------------|--|-----------------------|
| T0      | CeO <sub>2</sub>                                    | 30             | $2.89 \times 10^{-6}$                  | $4.41 \times 10^{-2}$ |
| T1      | EPDM-CeO <sub>2</sub><br>composite                  | 30             | $0.82 \times 10^{-6}$                  | $1.26 \times 10^{-6}$ |
| T2      | PFPE-infused<br>EPDM- CeO <sub>2</sub><br>composite | 31             | $1.20 \times 10^{-7}$                  | $0.30 \times 10^{-3}$ |

Table S2. The wettability performance of prepared samples after 500h of aging

| Samples | Composition                                   | Thickness ( $\mu\text{m}$ ) | Contact angle ( $^{\circ}$ ) | Contact angle hysteresis ( $^{\circ}$ ) |
|---------|---|-----------------------------|------------------------------|---|
| T0      | CeO <sub>2</sub>                              | 30                          | 20                           | 150                                     |
| T1      | EPDM-CeO <sub>2</sub> composite               | 30                          | 80                           | 15                                      |
| T2      | PFPE-infused EPDM- CeO <sub>2</sub> composite | 31                          | 160                          | 2.3                                     |

Table S3. Specifications of Krytox 157 FSL Oil (PFPE)

| Properties         | Values       |
|--------------------|--------------|
| Viscosity at 104°F | 99.4-149 cSt |
| Density at 15°F    | 1.91g/ml     |
| Molecular weight   | 2500         |