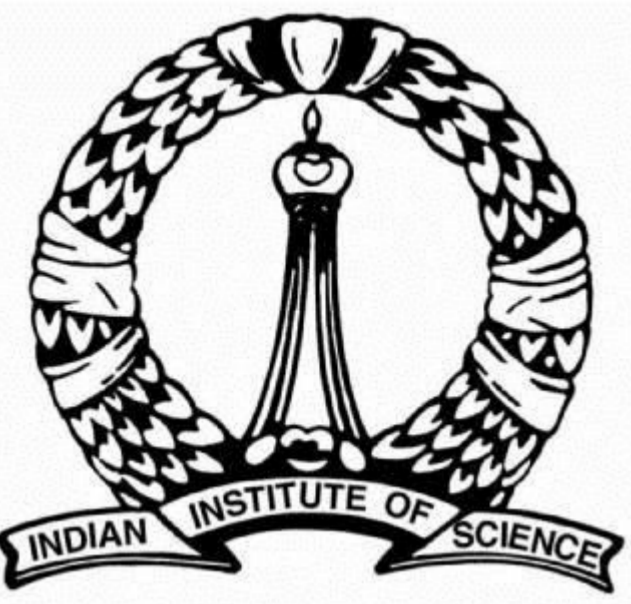


Thermal Aging Studies on High Temperature Vulcanized Silicone Rubber Insulators

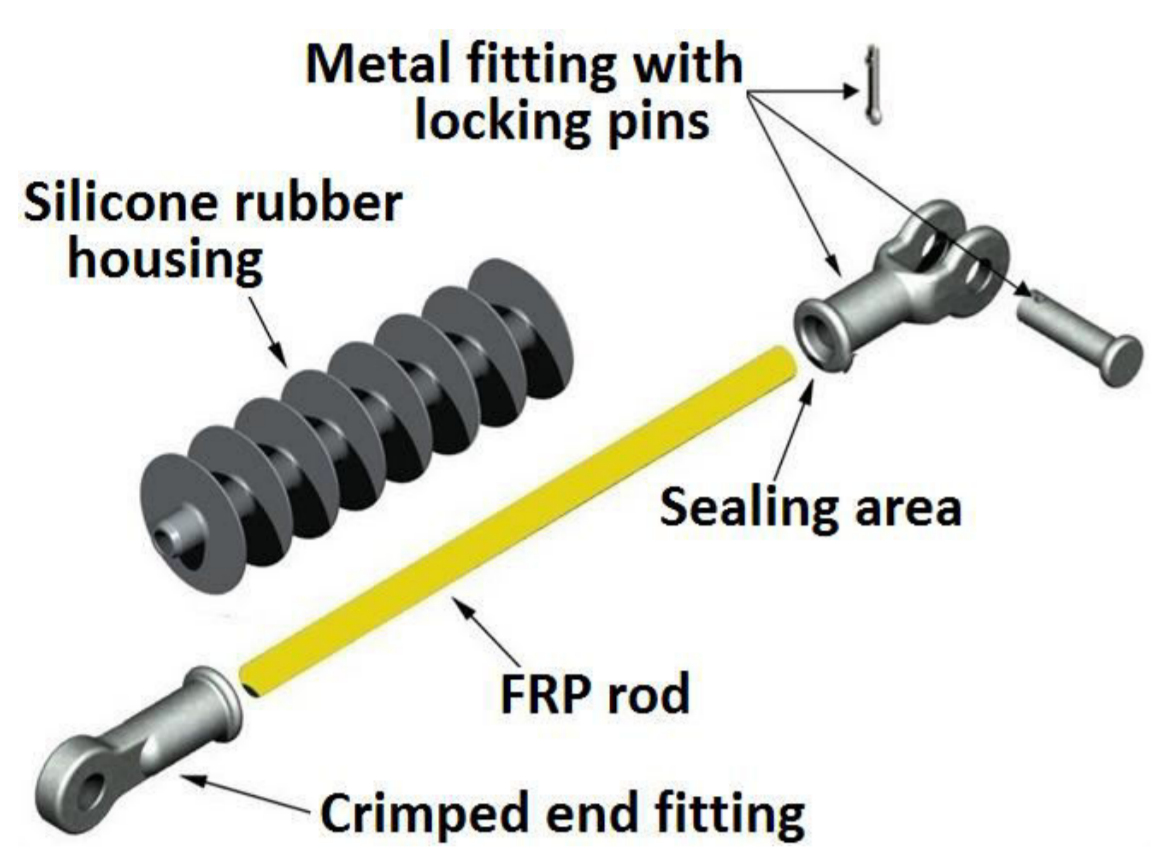
Rahul Chakraborty and Subba Reddy B

Department of Electrical Engineering, Indian Institute of Science, Bangalore

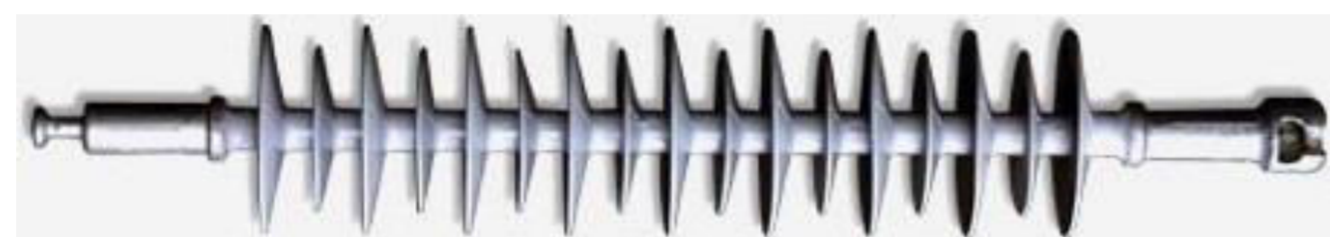
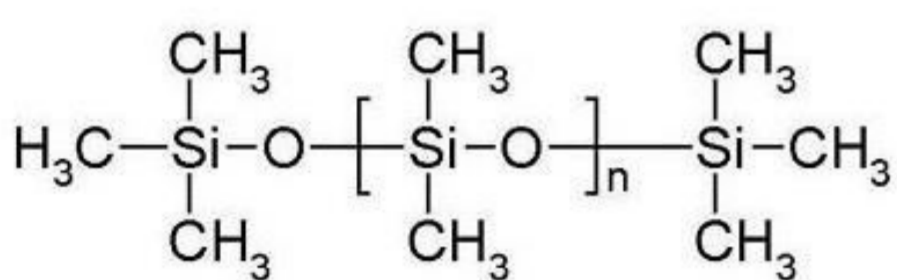
Email ID: rahul06ch@gmail.com



Introduction



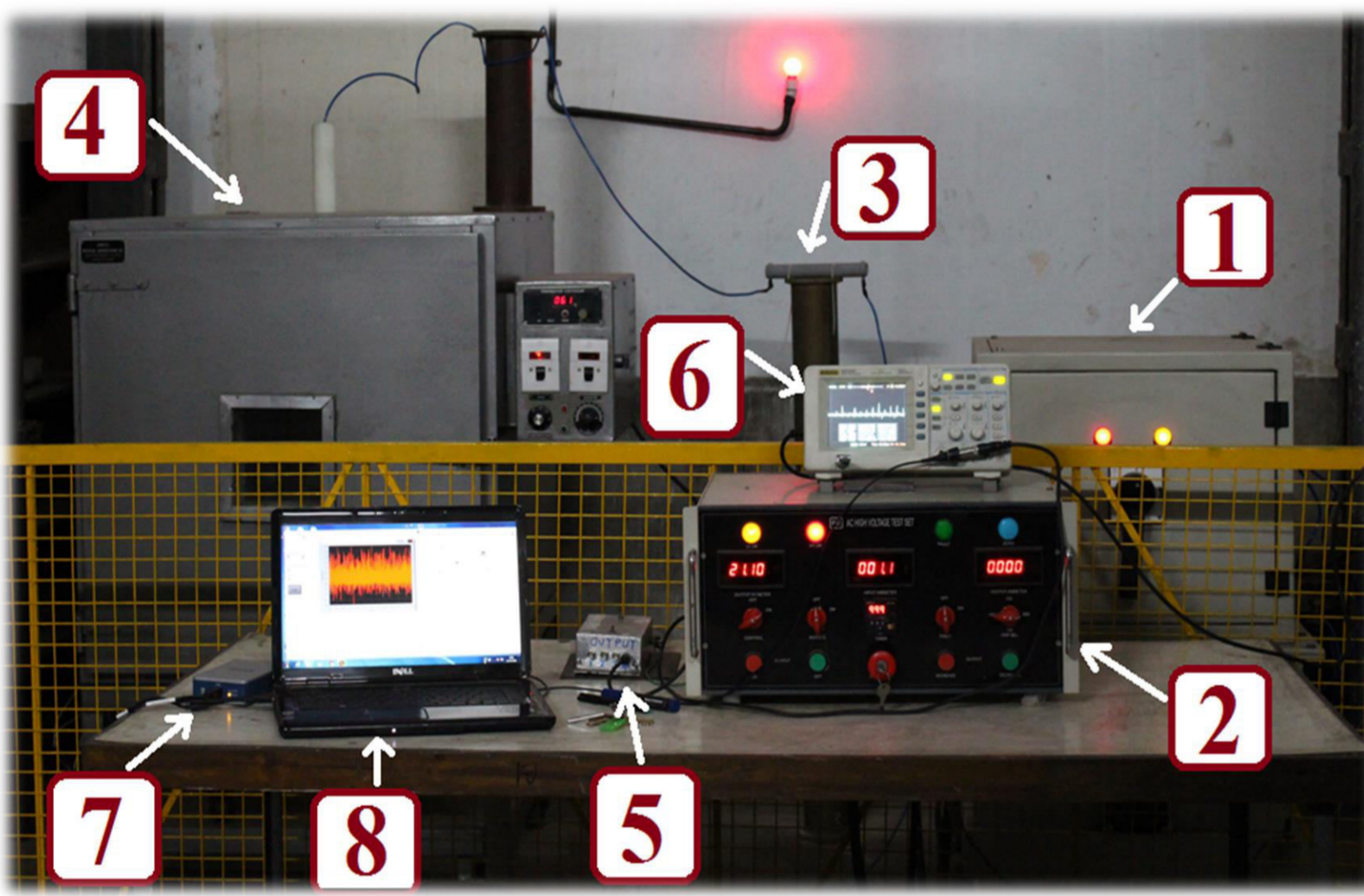
- Polymeric insulators are widely used in EHV and UHV transmission.
- Advantages: light weight, hydrophobicity recovery, better pollution performance.
- **Environmental stresses** (temperature, humidity, UV, fog, rain etc.) degrades its performance.
- **Standard pollution testing procedure** for polymeric insulators is yet to be established.



Objective of the Work

- Long term thermal aging studies conducted on polymer insulators with different degrees of pollution.
- A novel and simple pollution methodology is proposed for inherently hydrophobic insulator surface to achieve uniform contamination layer.

Experimental Details



1: HVAC source, 2: Control panel, 3: Current limiting resistor, 4: Furnace, 5: Shunt box, 6: Digital Oscilloscope, 7: NI cDAQ for LC measurement, 8: NI cDAQ data acquisition in LabVIEW environment

Sample Details

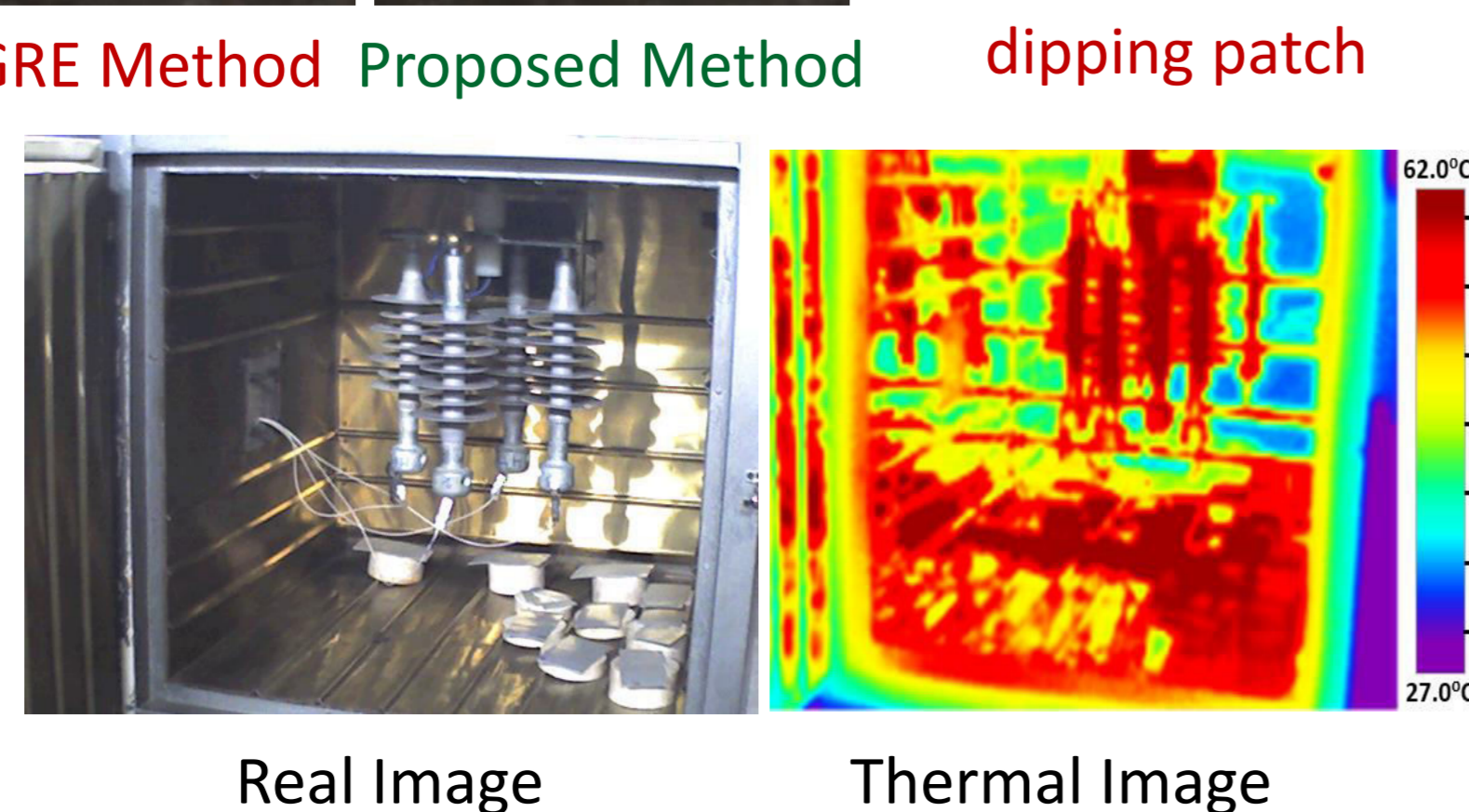
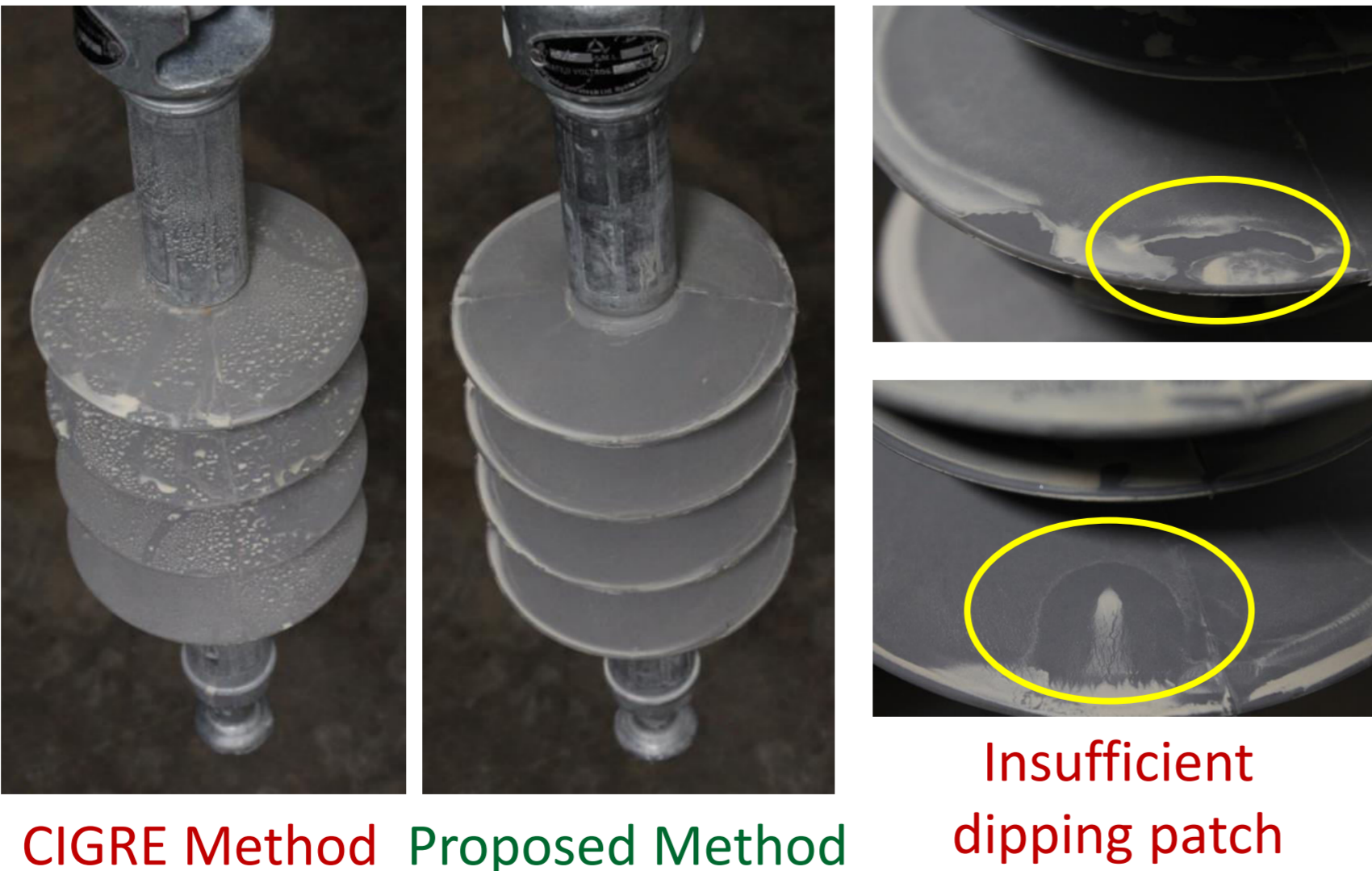
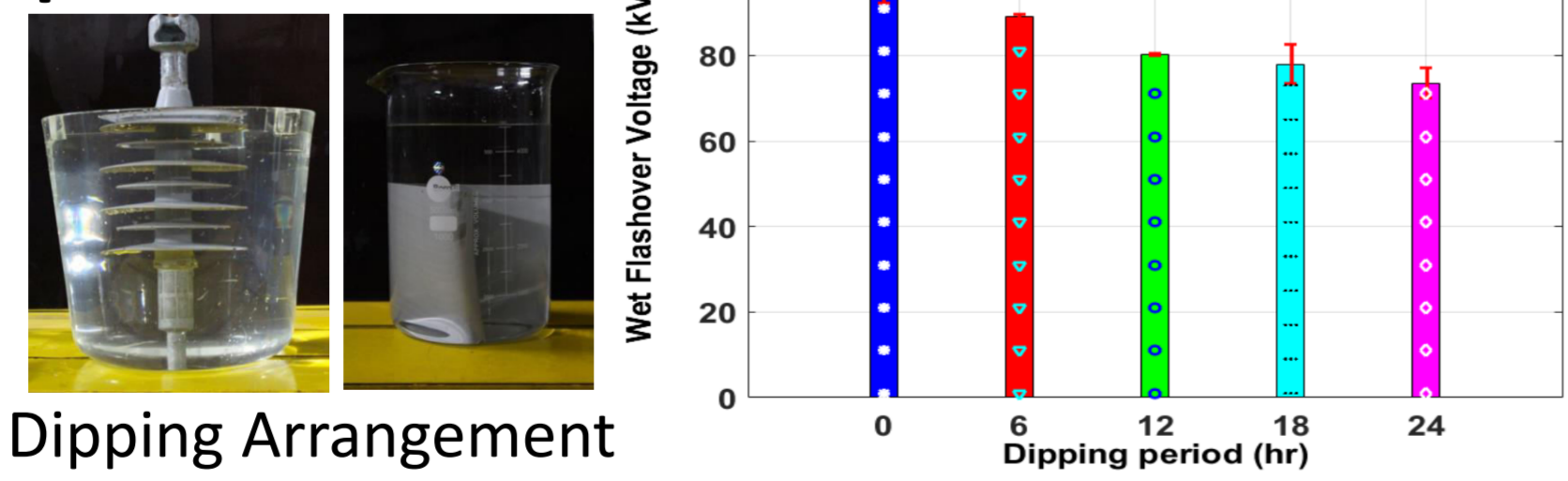
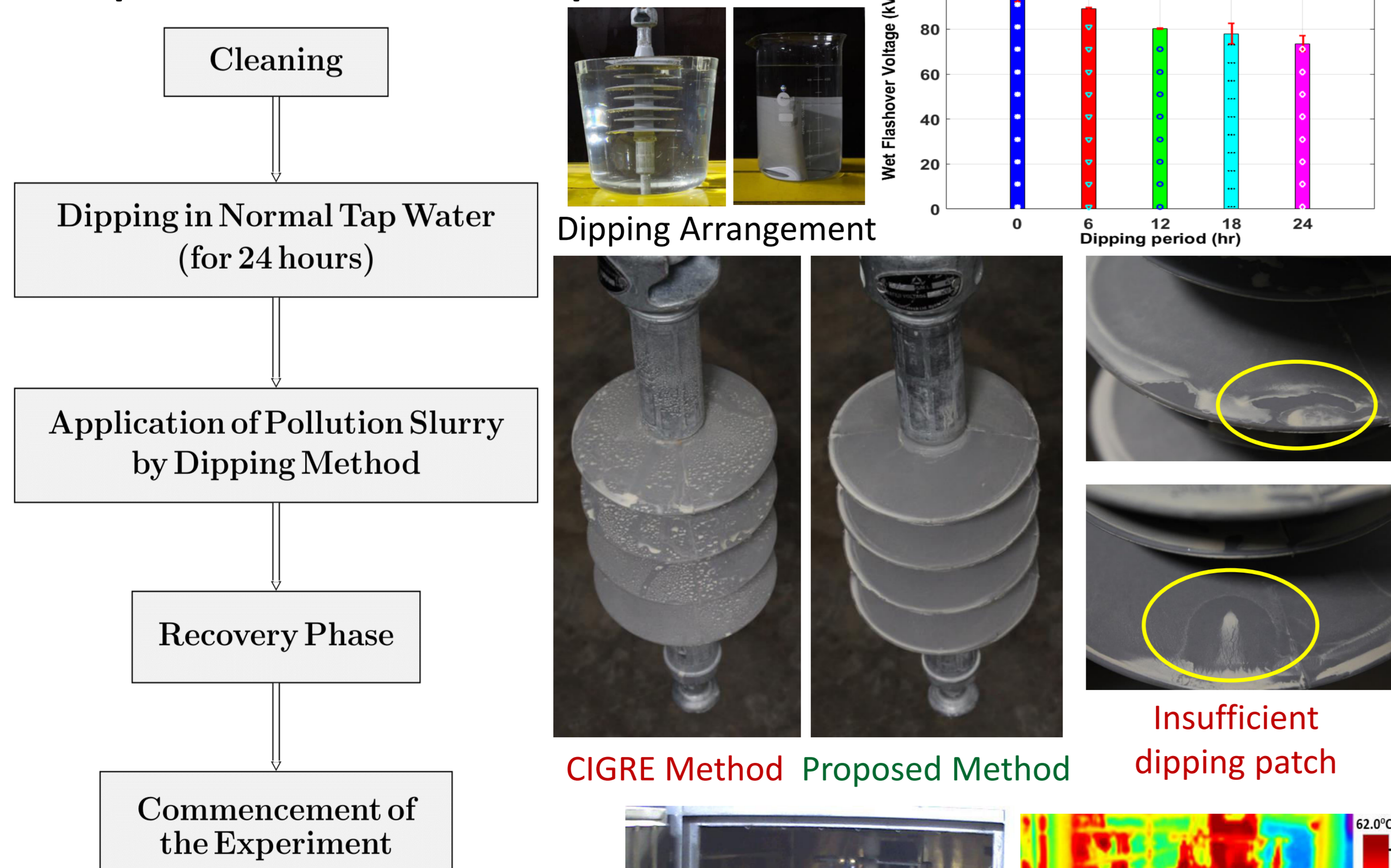
Category	Identity
Type – A (Full Scale)	A1 _F [†] , A2 _F ^ψ , A3 _F ^θ , A4 _F [□]
Type – A (Slab)	A1 _S [†] , A2 _S ^ψ , A3 _S ^θ , A4 _S [□] , A5 _S [†] , A6 _S [□]
Type – B (Slab)	B1 _S [†] , B2 _S ^ψ , B3 _S ^θ , B4 _S [†] , B5 _S ^ψ , B6 _S ^θ

- Samples with 24 hr recovery phase, † Fresh without pollution, ψ Medium Polluted, θ Heavily Polluted, □ No stress is applied, † Thermal stress is applied, ψ Electro-thermal stress is applied

Wettability Class (WC) Measurement Set-Up



Proposed Pollution Technique

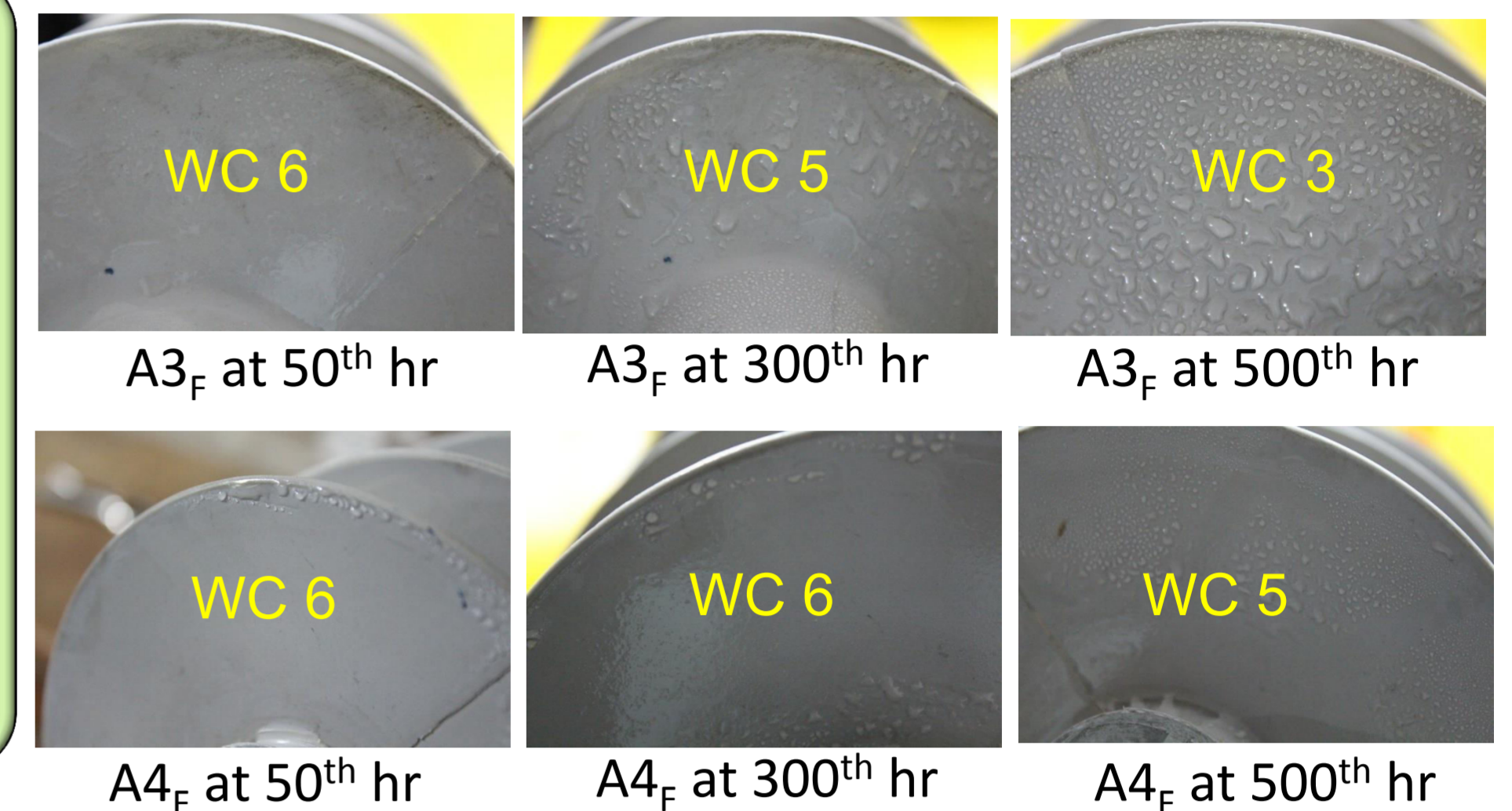


- Solid layer method is used as per IEC 60507.
- HVAC is applied to polymeric insulator units at 60°C - 600 hr.

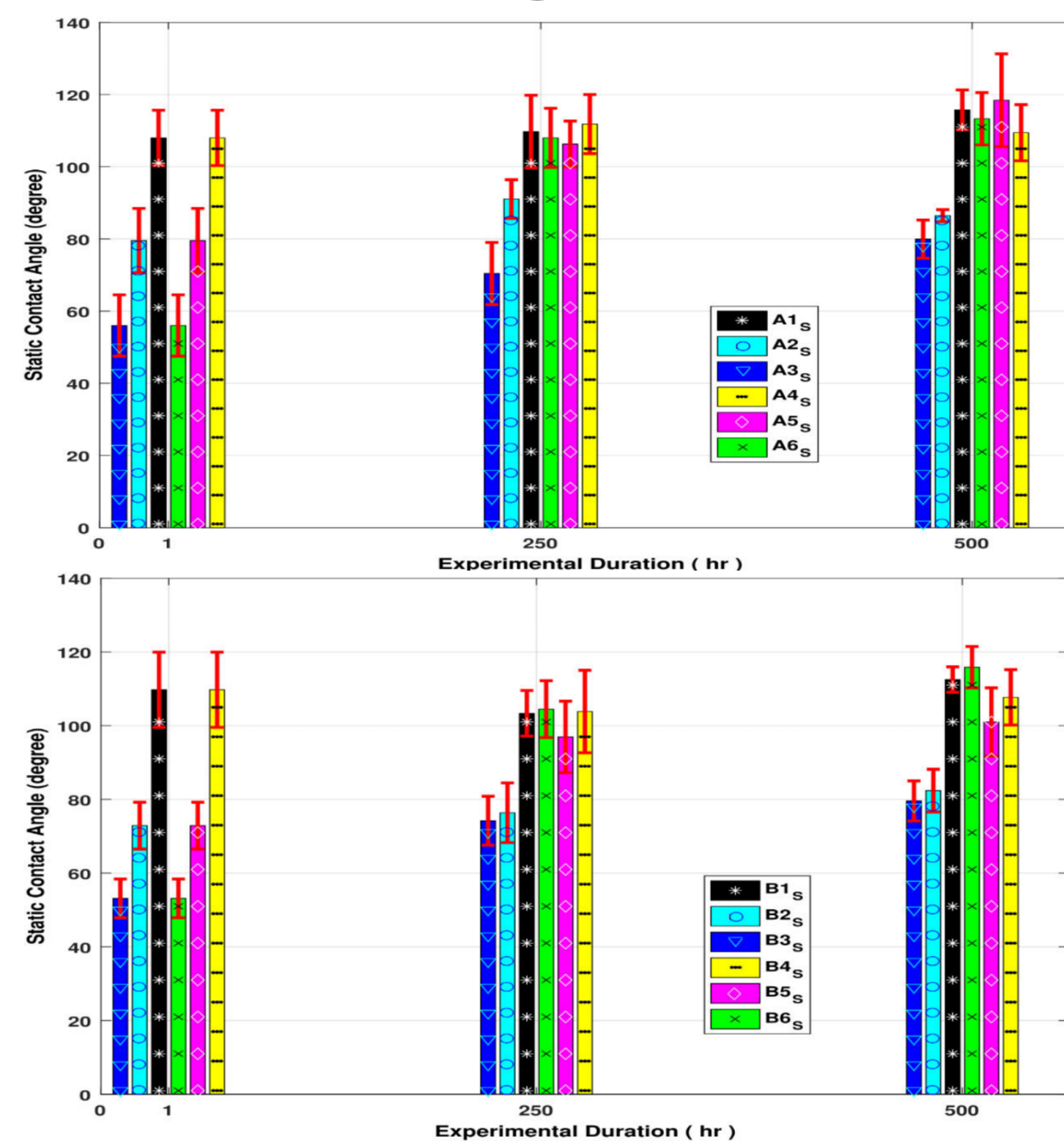
Results discussions

- 1) Wettability Class
- 2) Static Contact Angle
- 3) Fourier Transform Infrared Spectroscopy
- 4) X-Ray Photoelectron Spectroscopy
- 5) Scanning Electron Microscopy
- 6) Thermo-Gravimetric Analysis
- 7) Tensile Strength
- 8) Leakage Current Acquisition

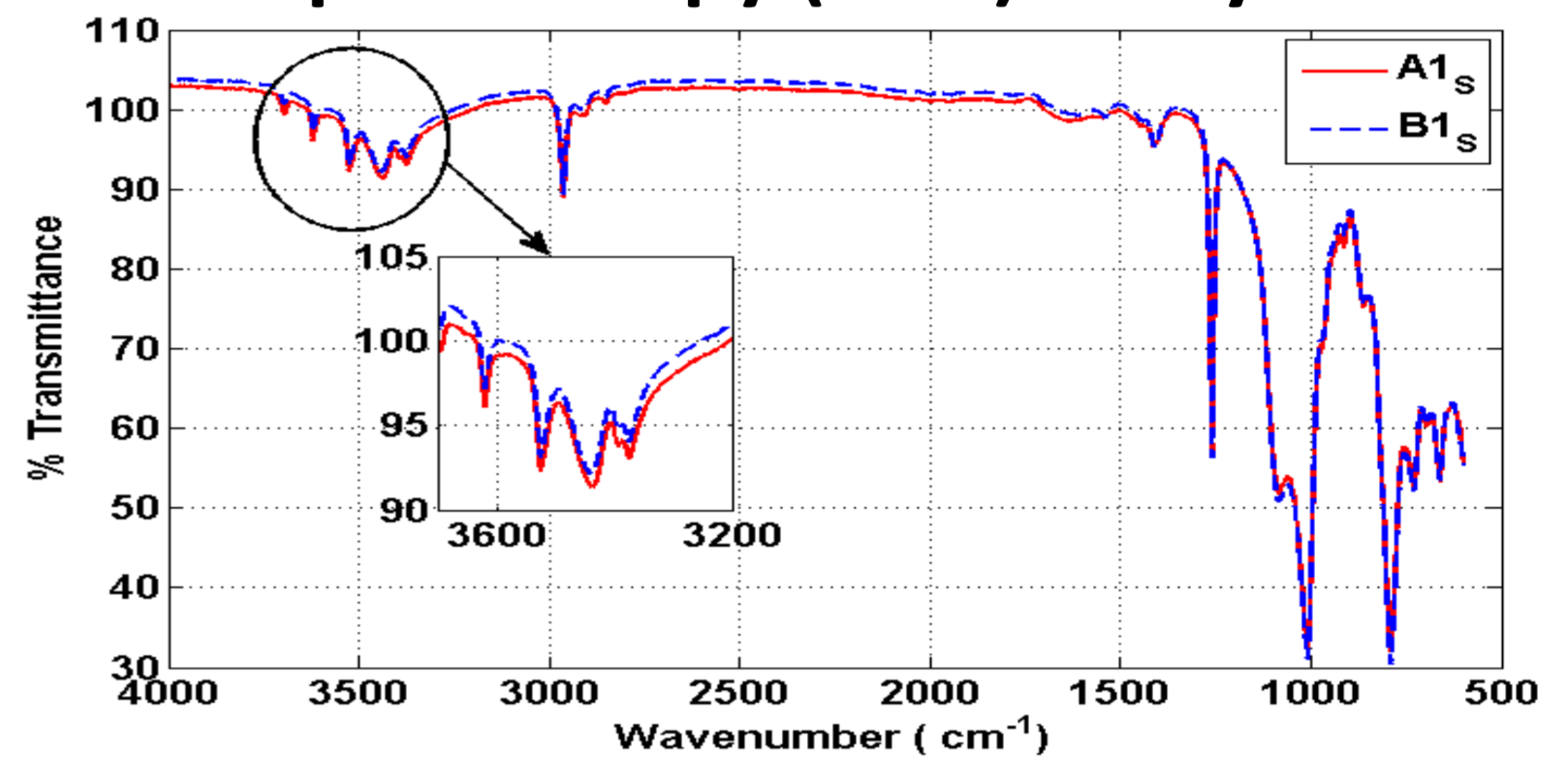
Wettability Class Measurement



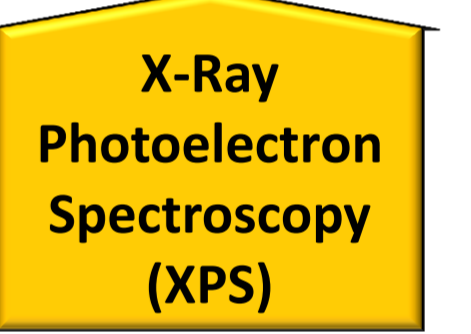
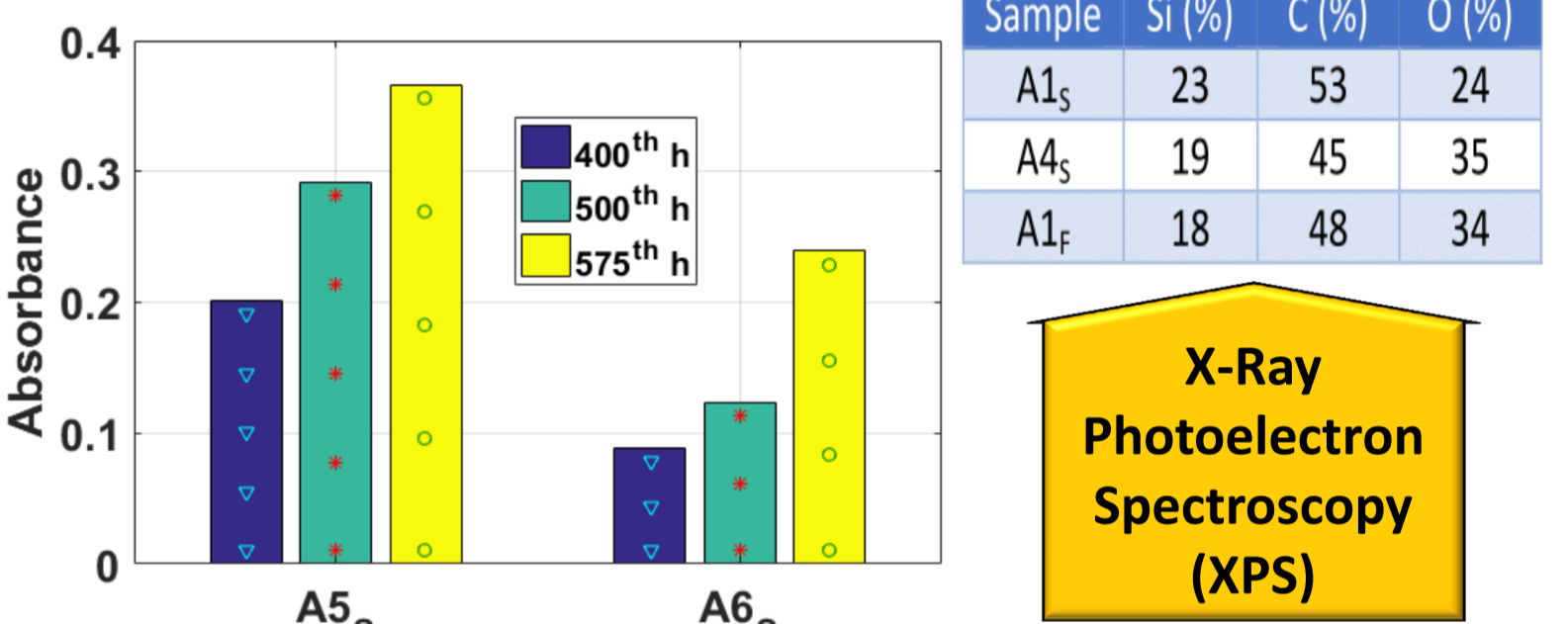
Static Contact Angle Measurement



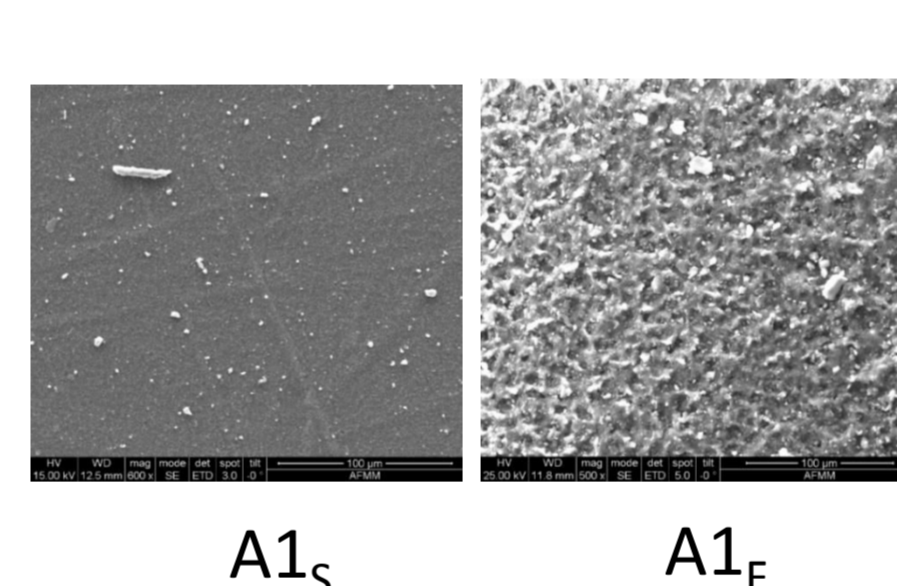
Fourier Transform Infrared Spectroscopy (FTIR) Analysis



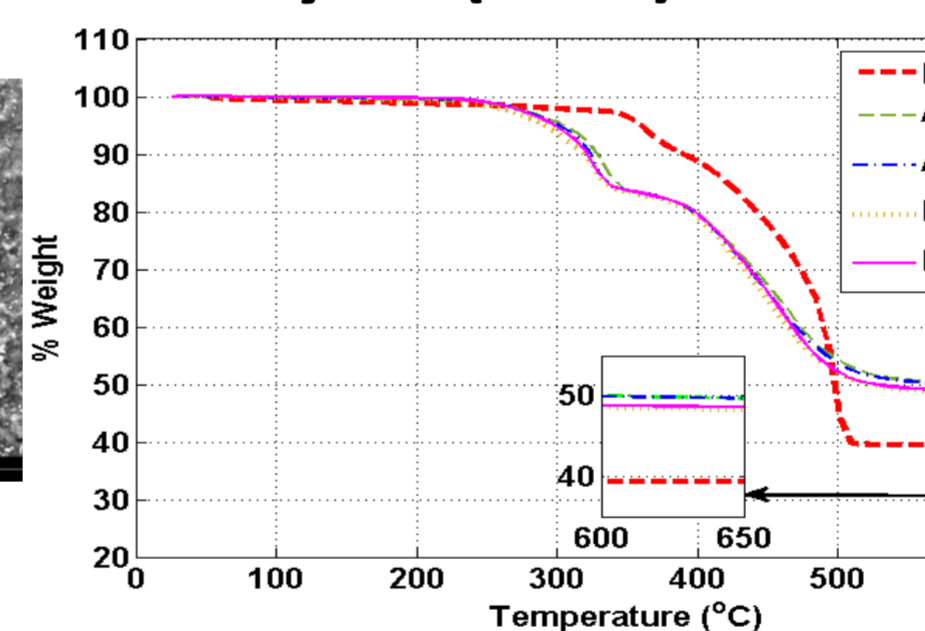
$$A = 2 - \log_{10}(T)$$



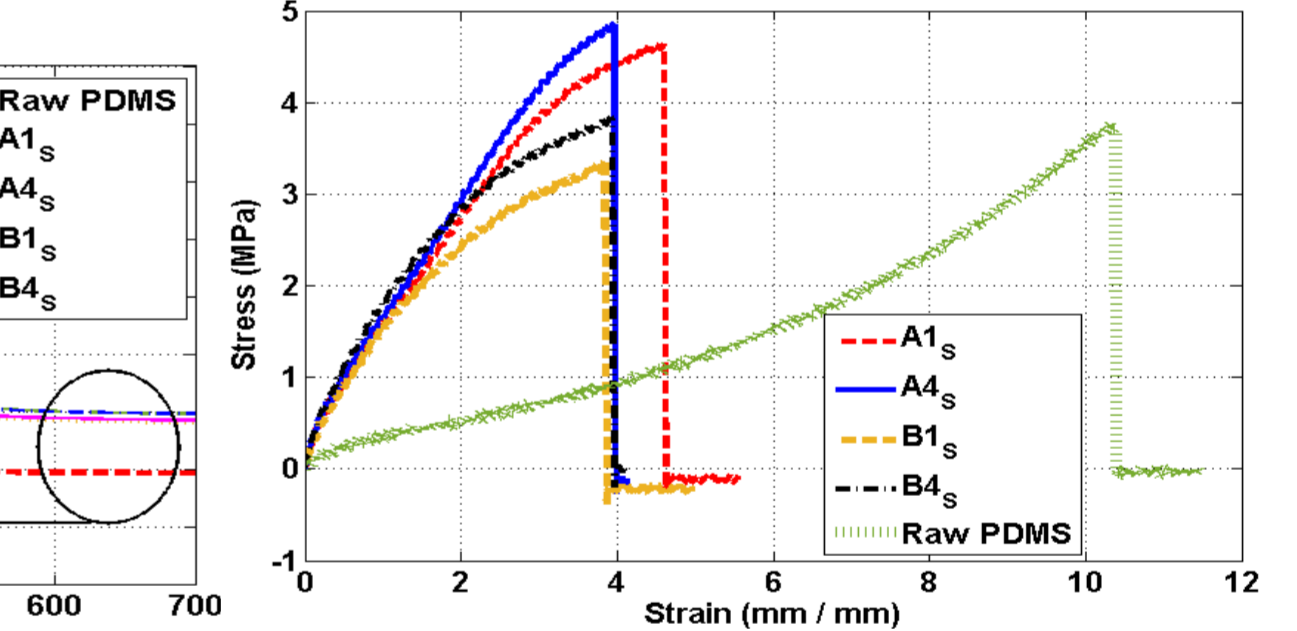
Scanning Electron Microscopy (SEM)



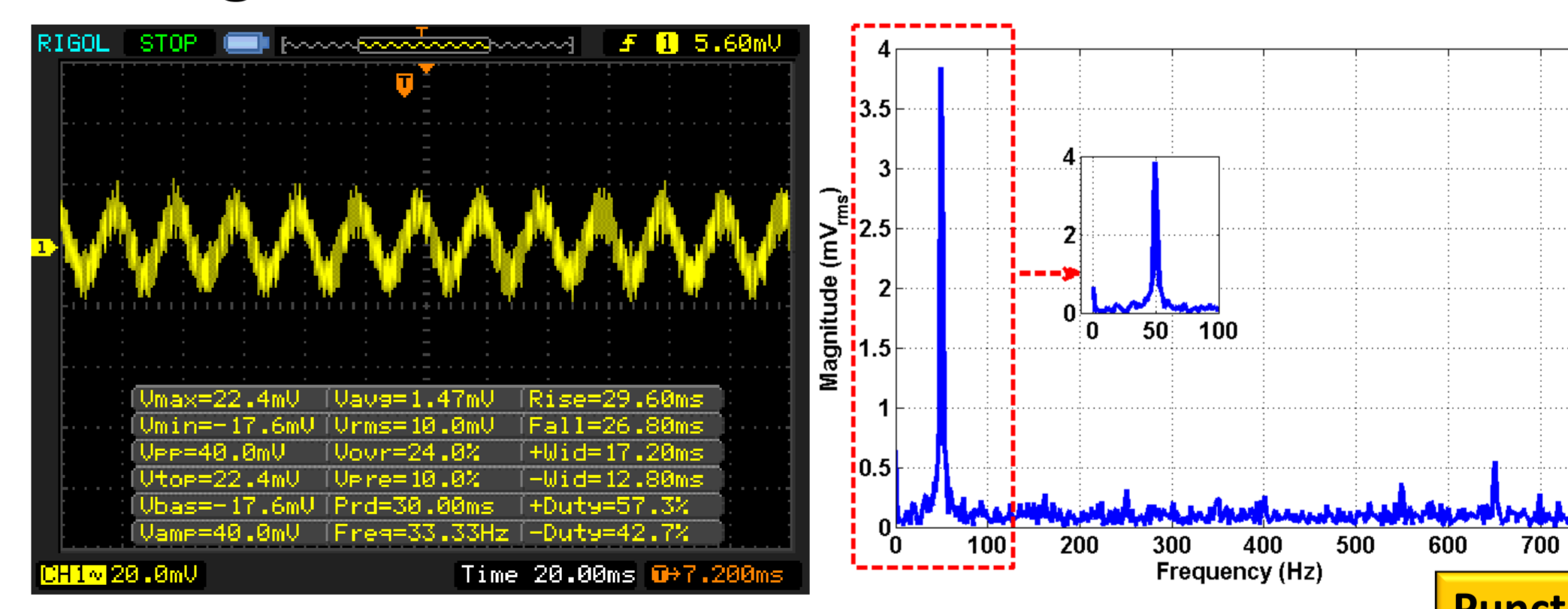
Thermo-Gravimetric Analysis (TGA)



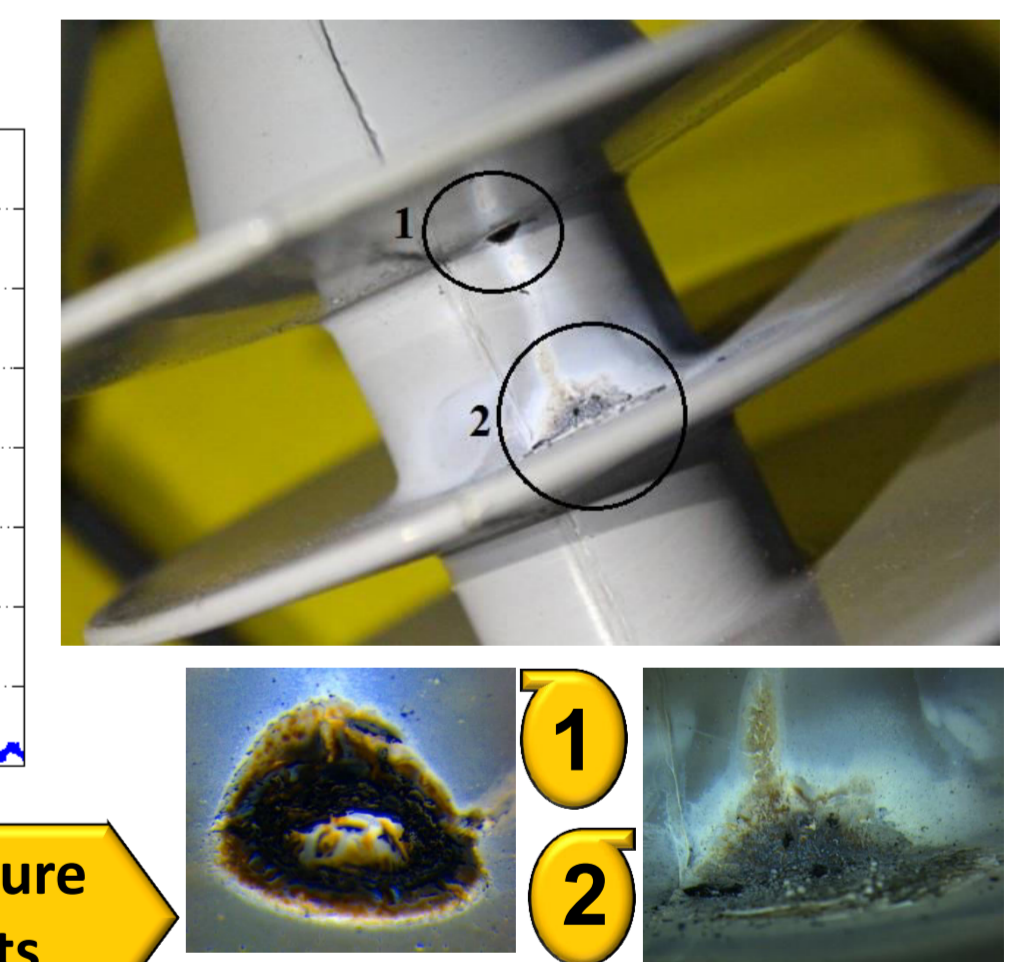
Tensile Strength Assessment



Leakage Current Measurement



Leakage Current Waveform and FFT of A1_F at 430th hr



Conclusions

- A simple pollution methodology is proposed to achieve uniformity in contamination layer on insulator surface.
- Long term thermal aging experimentation is conducted and thermally accelerated hydrophobicity recovery phenomenon is reported.
- Surface morphological studies like FTIR, XPS, SEM & TGA and tensile strength assessment are conducted.
- Thermal aging of polymeric insulators leads to increased surface oxidation, surface roughness and mechanical stress.

Publications [Forming part of the research work]

1. Rahul Chakraborty, Subba Reddy B, "Performance of Silicone Rubber Insulators under Thermal and Electrical Stress", *IEEE Transactions on Industry Applications*. [DOI: 10.1109/TIA.2017.2672667] (accepted)
2. Rahul Chakraborty, Subba Reddy B, "Studies on High Temperature Vulcanized Silicone Rubber Insulators under Arid Climatic Aging", *IEEE Transactions on Dielectrics and Electrical Insulation*. (accepted)
3. Rahul Chakraborty, Subba Reddy B, "Performance of Silicone Rubber Insulators under Thermal and Electrical Stress", paper presented at *IEEE IAS & Electrostatics Society of America (ESA) Joint Conference*, Purdue University, USA, June, 2016.
4. Rahul Chakraborty, Subba Reddy B, "Investigation on the Pollution Performance of Silicone Rubber Insulator Samples", 10th Conference of the French Society of Electrostatics (SFE), University of Poitiers, France, August, 2016.