Advanced Polymer Nanocomposites for Medium and High Voltage Electrical Insulation

Dr. Nitin Shingne and Dr. Uday Puntambekar

Electrical Research and Development Association (ERDA), Vadodara, Gujarat

Introduction

Polymer insulation is an integral part of electrical equipment. The complex interplay between electrical, mechanical and thermal properties determine life cycle of polymer insulation. In this context, challenges faced by different polymeric materials used in medium and high voltage insulation applications such as transformers and bushings (epoxy composites), and composite insulators (silicone rubber) are shown. It has been found that failures in the insulations can be traced back to combination of electrical, thermal, mechanical and environmental stresses. To overcome these challenges, nanocomposites are prepared for medium and high voltage applications.

Problems in High Voltage Insulation

1. Epoxy Insulation: Partial Discharge

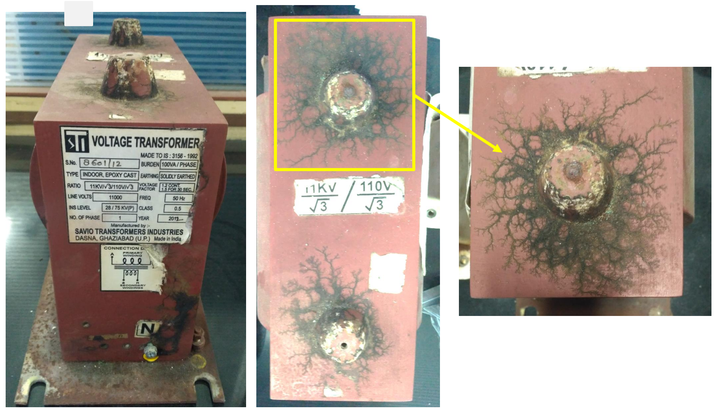
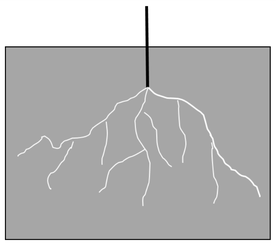


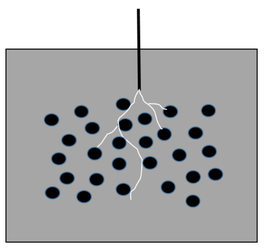
Figure: Electrical trees can be seen around electrical terminal of potential transformer. Electrical tree start with localized discharges and branch out degrading the polymer composites resulting in failures

- High partial discharge resistance can restrict the electrical tree growth

Role of Nanofillers for Enhanced Dielectric Properties



Electrical tree growth in Epoxy



Restricted Electrical tree growth in Nanocomposite

Epoxy Micro-Nano Composite

Epoxy Resin + Silica Nano-particles + Silica flour

- Silane modified Fumed Silica nanoparticles dimension – 7 nm
- Silica flour dimensions - > 10 µm

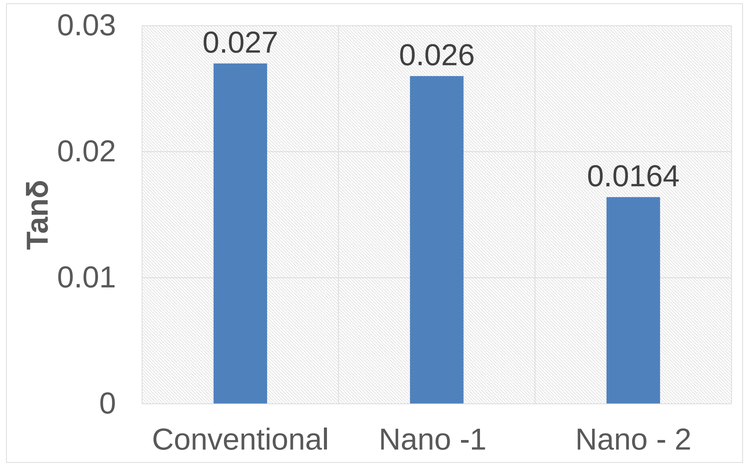
Epoxy Composite Samples:

I. Conventional Epoxy: Epoxy resin and 200 wt% silica flour

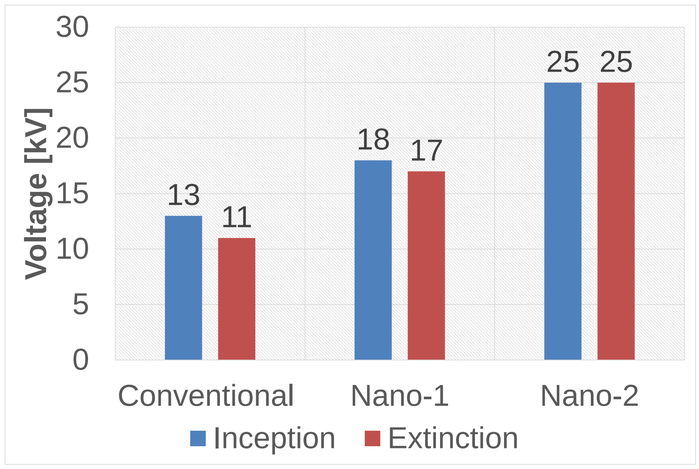
II. Nano - 1: Epoxy resin + 1.25 wt% silica nano-filler + 200 wt% silica flour

III. Nano – 2: : Epoxy resin + 2.5 wt% silica nano-filler + 150 wt% silica flour

Results for Laboratory Samples



- Dielectric dissipation (tanδ) is reduced in nanocomposite samples



- Partial discharge voltage inception and extinction voltages are enhanced in nanocomposites

Epoxy Nanocomposite Insulation for Potential Transformer

Figure: Epoxy nanocomposite insulation used for fabrication of 11 kV potential transformer

Results for 11 kV Potential Transformer Insulation

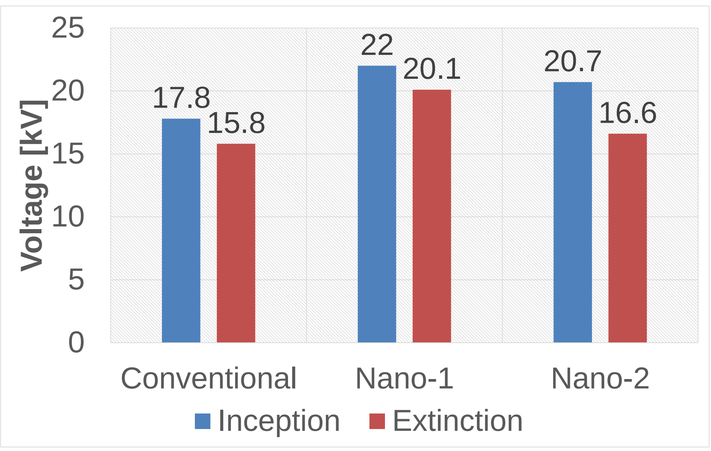


Figure: Partial Discharge Inception and Extinction voltages for 11 kV PTs

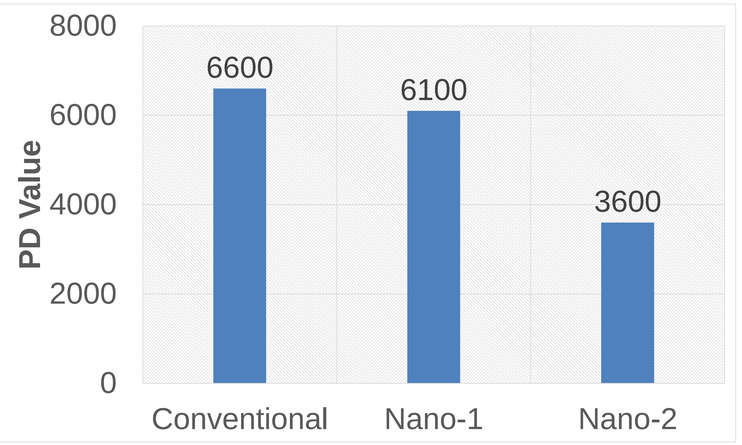


Figure: Partial Discharge values at 28 kV

Conclusions

- Potential transformer fabricated using epoxy nanocomposite insulation
- Nanocomposites showed increased partial discharge resistance and lower PD values
- Currently PTs are undergoing long term ageing test under thermal and electrical stress