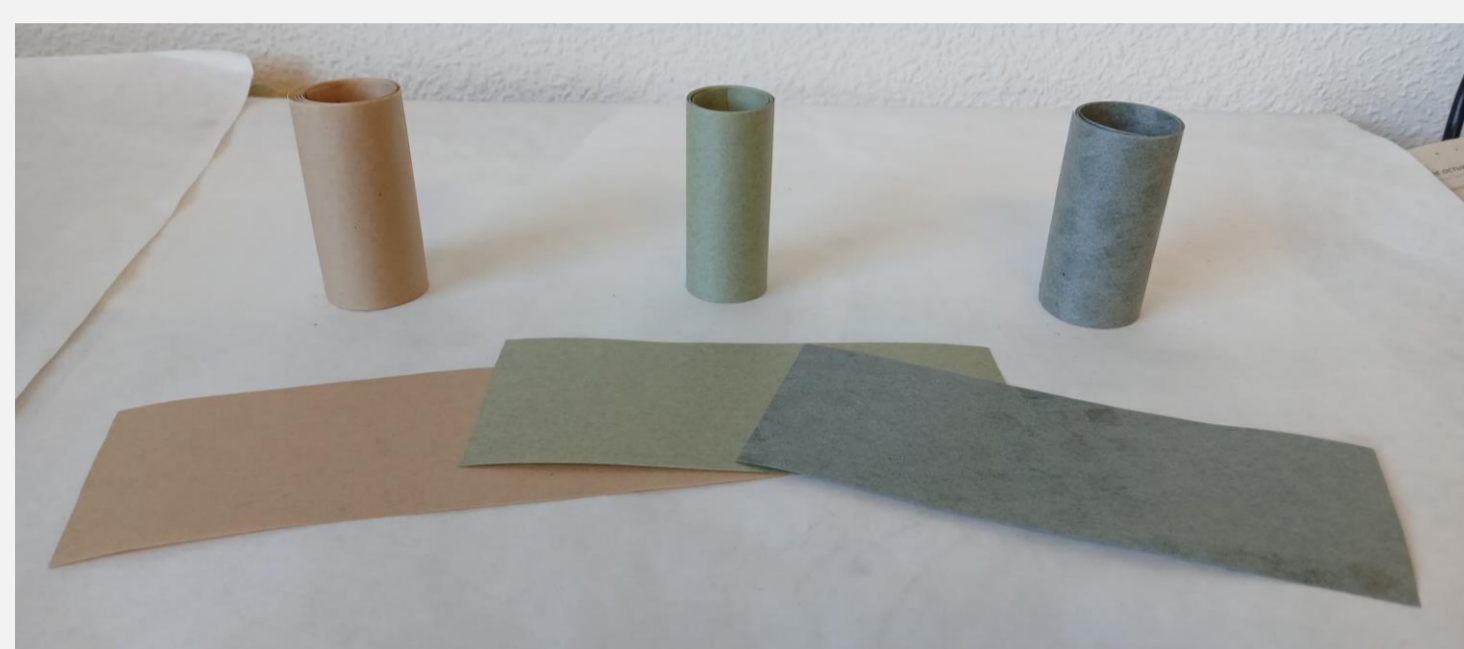


Abstract

The electrical insulation system, usually composed of cellulosic materials and mineral oil, is essential for the reliable operation of the power transformers. The dielectric system must be kept in prime condition to increase the lifetime of the machine. Moisture in these materials reduces the dielectric strength and enhances the rate of insulation ageing. Frequency Domain Spectroscopy (FDS) is a promising method to analyze the effect of moisture in oil-paper insulation system. This study compares the influence of moisture on the dielectric capacity of 3 insulating papers impregnated with mineral oil using FDS.

Experimental Procedure

A. Materials

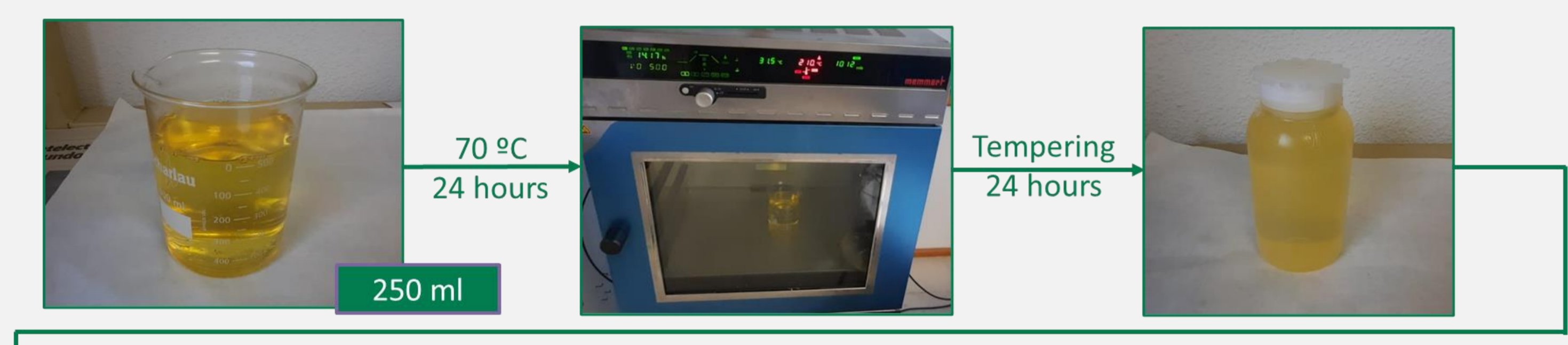
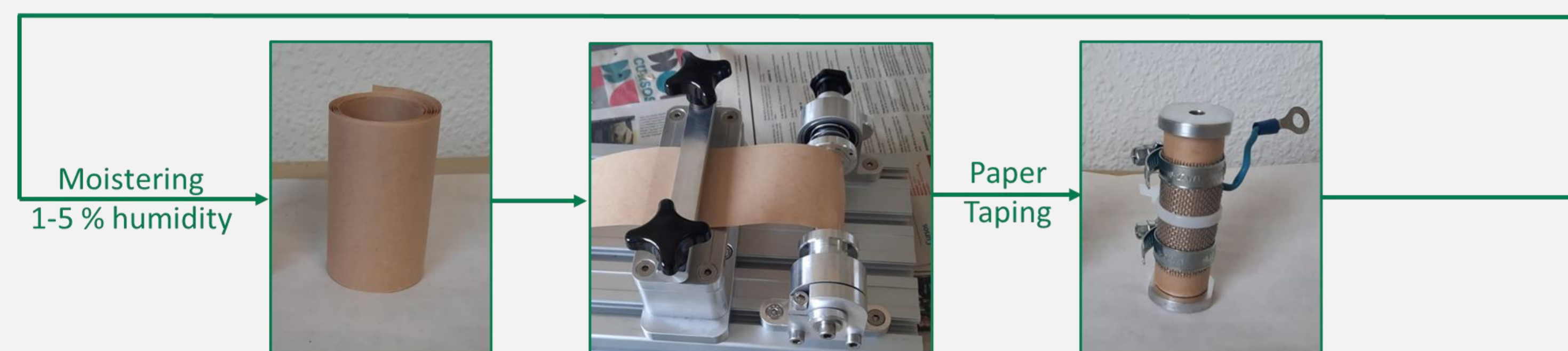


Kraft, TUK and DPE papers



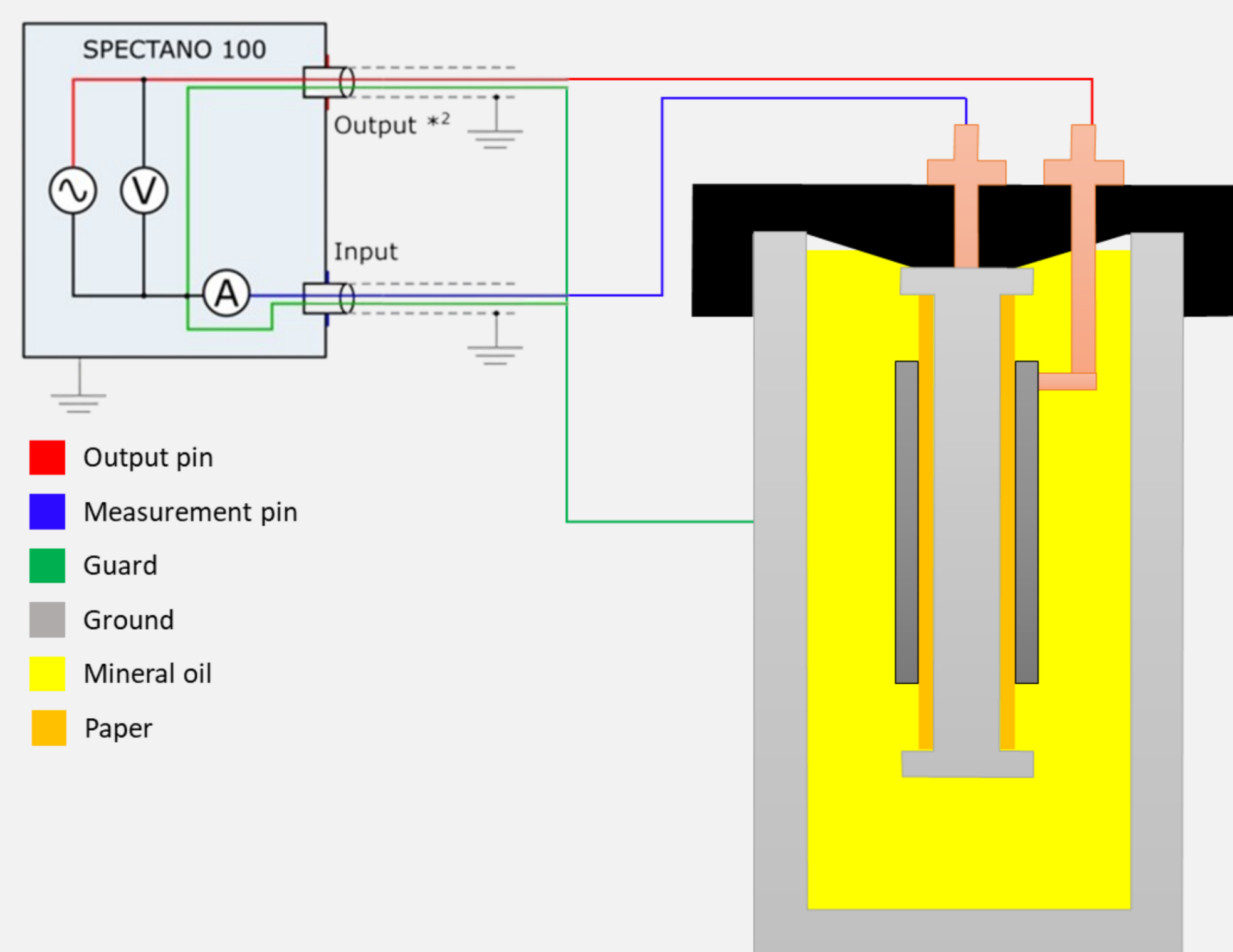
Mineral Oil

B. Samples Preparation



C. Measurement Setup

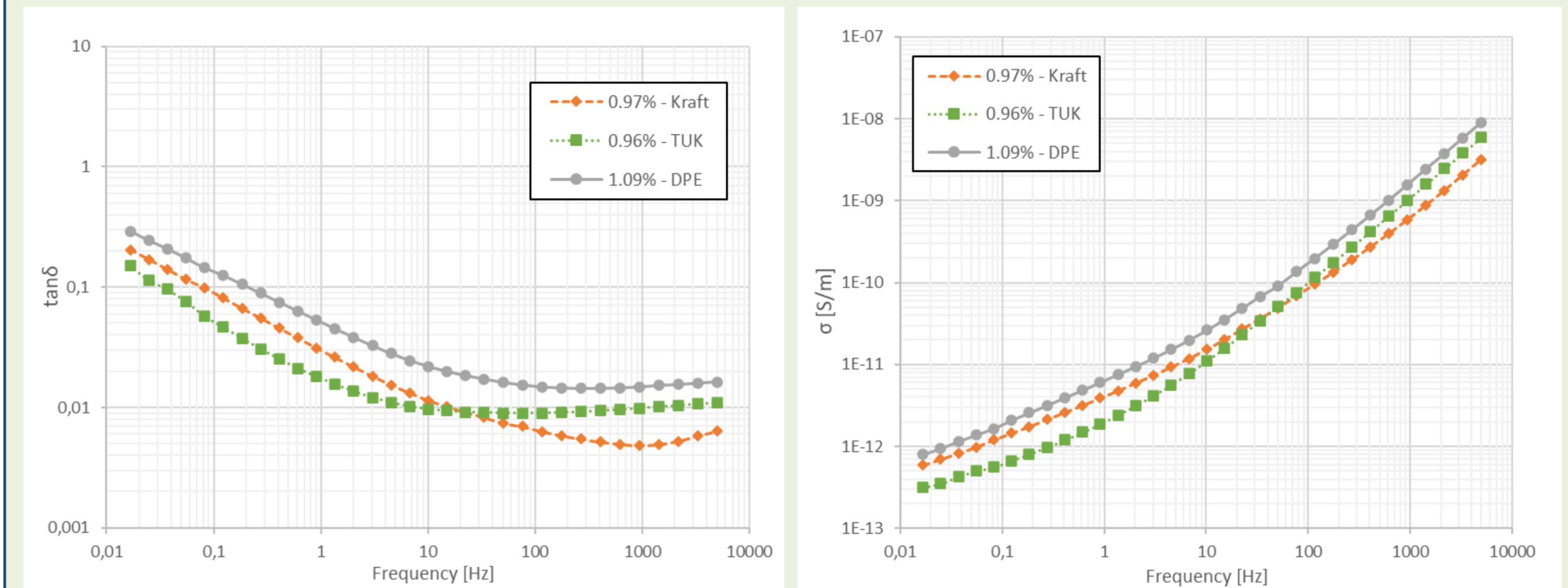
Measurements were performed over a frequency range from 16.62 mHz to 5 kHz.



Results and discussion

A. Low moisture level

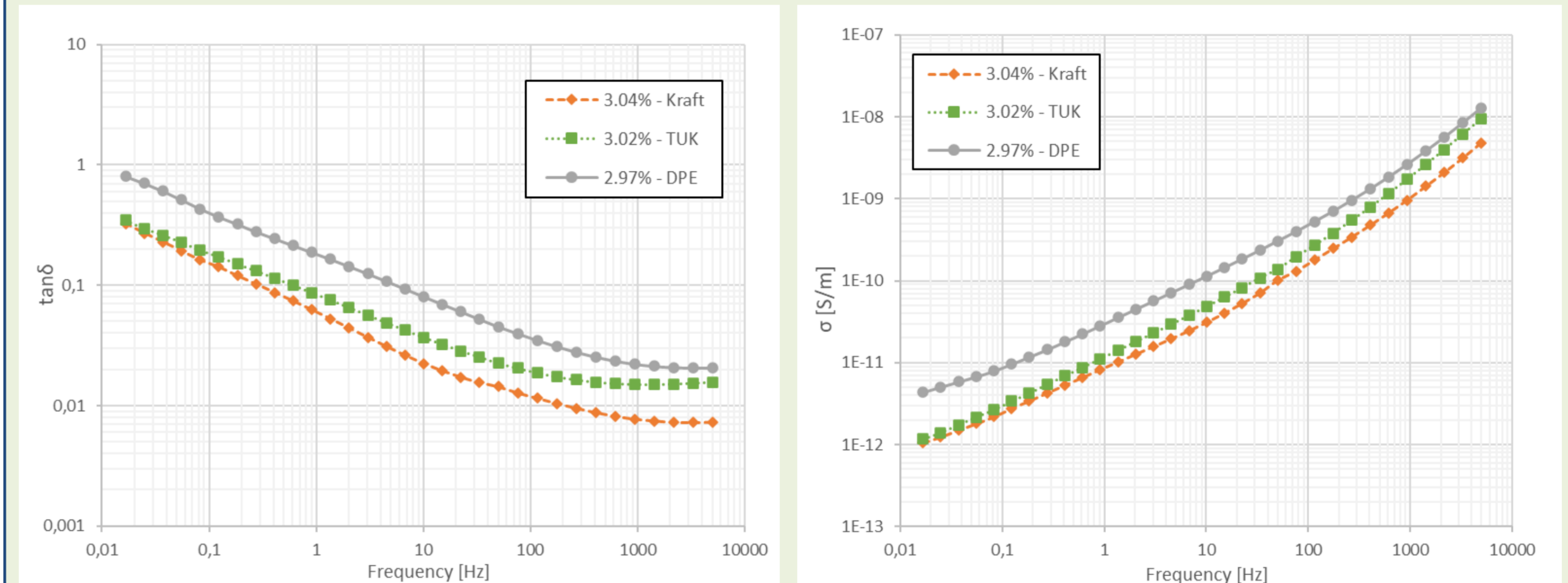
The general shape of $\tan \delta$ and σ remains nearly the same for each paper. The $\tan \delta$ decreases with increasing frequency while σ increases with it



At 50 Hz, the $\tan \delta$ of DPE paper is 218% higher than that of Kraft paper, while for TUK paper, it is 121% higher.

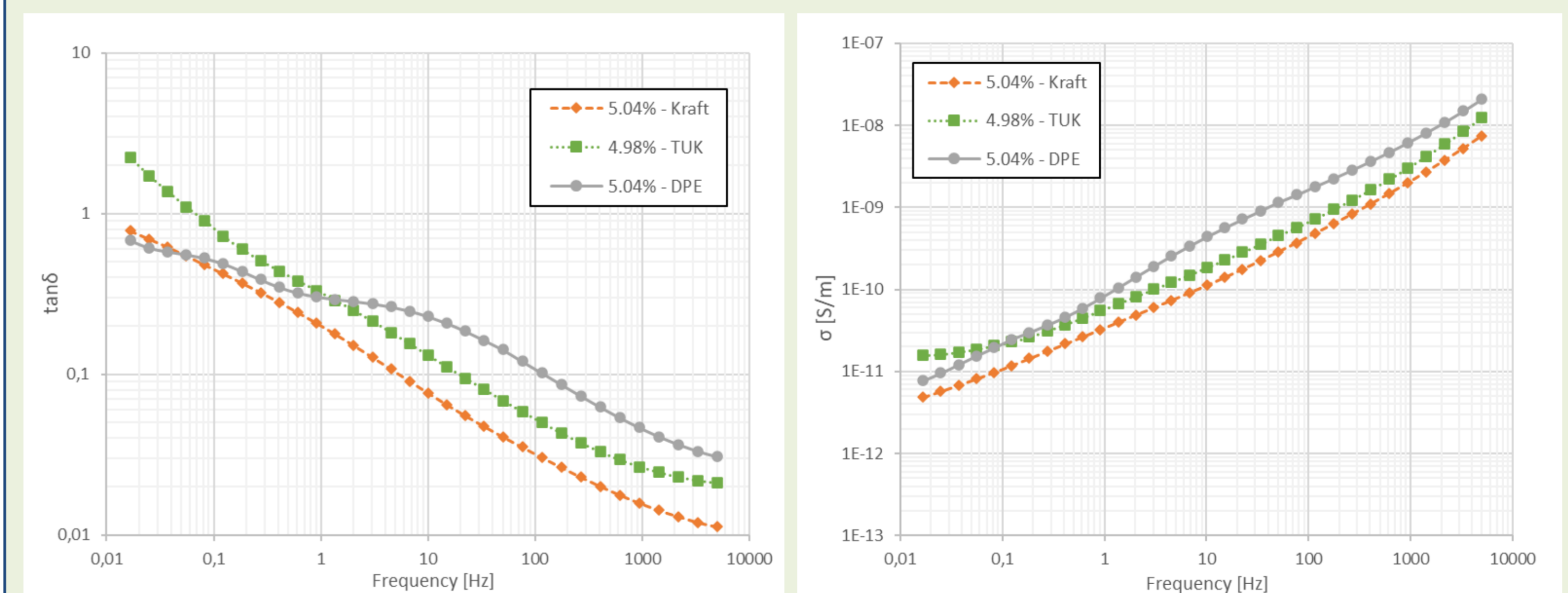
B. Medium Moisture Level

At 50 Hz, the $\tan \delta$ of DPE paper is 316% higher than Kraft paper. However, in this case, TUK paper has a higher $\tan \delta$ than Kraft paper across the entire frequency range, being 157% higher.



C. High Moisture Level

At 50 Hz, the $\tan \delta$ of DPE paper is 348% higher than that of Kraft paper, while for TUK paper, it is 168% higher.



All papers impregnated with mineral oil exhibit a similar behavior when moisture increases: there is a deterioration of the dielectric properties and a rise of the $\tan \delta$ and σ .

Conclusions

- The dielectric capacity decreases with the increase of the paper's moisture content, which is reflected in a higher values of $\tan \delta$ and σ .
- DPE paper samples exhibit the highest values of $\tan \delta$, ϵ' , and σ compared to TUK and Kraft samples, for the entire range of moisture values analysed.
- Moisture data of the paper samples covers a wide range, enabling the assessment of dielectric response from the initial dry conditions of the transformer to necessary insulation re-drying due to high moisture.