Feasibility Study on the use of Magnesium Silicate for Reclaiming Synthetic Ester Insulating Liquid

T. Jayasree[1], M. Rodriguez Celis[2], U. Mohan Rao[1], I. Fofana[1], P. Picher[2], S. Brettschneider[1]

[1]Research Chair on the Aging of Power Network Infrastructure (ViAHT)
Université du Québec à Chicoutimi, Chicoutimi, QC, Canada
[2]Institut de recherche d'Hydro-Québec (IREQ), Varennes, QC, Canada

Contents

- ✓ **Background and Significance**
- ✓ **State of the Art**
- ✓ **Experimental**
- ✓ **Results and Analysis**
- ✓ **Closing Remarks and Future Work**

BACKGROUND AND SIGNIFICANCE

Alternatives to mineral insulating liquids for high voltage electrical Insulation applications is an interesting topic of research in the context of the energy transition

- ***Ester liquids for transformers, challenges!!***
  - ✓ *Transformers in cold regions, like here in Canada*
  - ✓ *Reclamation of Ester Liquids*

- ***Transformer oil reclamation***
  - ✓ *To restore properties of the oil close to pristine conditions*
  - ✓ *To enhance the workability and service life of the transformer*

✓ *To investigate and understand the reclamation avenues of ester fluids*

Reclamation of transformer liquids

- Purpose: To improve the properties and workability of the aged liquids
- Approach for mineral oils: Fullers earth treatment
- Standards: IEEE C57.637-2015 and IEC 60422-2013

When to reclaim (for mineral oils)

- Acidity
- Interfacial tension

Methods:

- Standard: Percolation (Gravity/Pressure) and Contact (Stirring)

STATE OF THE ART

- ✓ Reclamation of natural esters is not possible due to their high viscosity and poor oxidation stability (*H. M. Wilhelm, G. B. Stocco, and S. G. Batista, "Reclaiming of in-service natural ester based insulating fluids," IEEE Trans. Dielectrics Electr. Insul., vol. 20, no. 1, pp. 128-134, Feb. 2013*).

- ✓ Reclamation of synthetic esters using fullers earth has been reported questionable and not satisfactory (*U. Mohan Rao, I. Fofana, P. Picher, "Decay Particles and Regeneration of Ester Dielectric Liquids: A Challenge, "Transformer technology Mag., Issue 17, pp. 65-69, 2022*)

- ✓ The reclamation avenues and possibilities of the reclamation of synthetic esters are least emphasised and stands as a challenge that needs to be explored

Significant influencing factors

- Pre-treatment
- Temperature
- Oil-adsorbent Ratios
- Passes/cycles

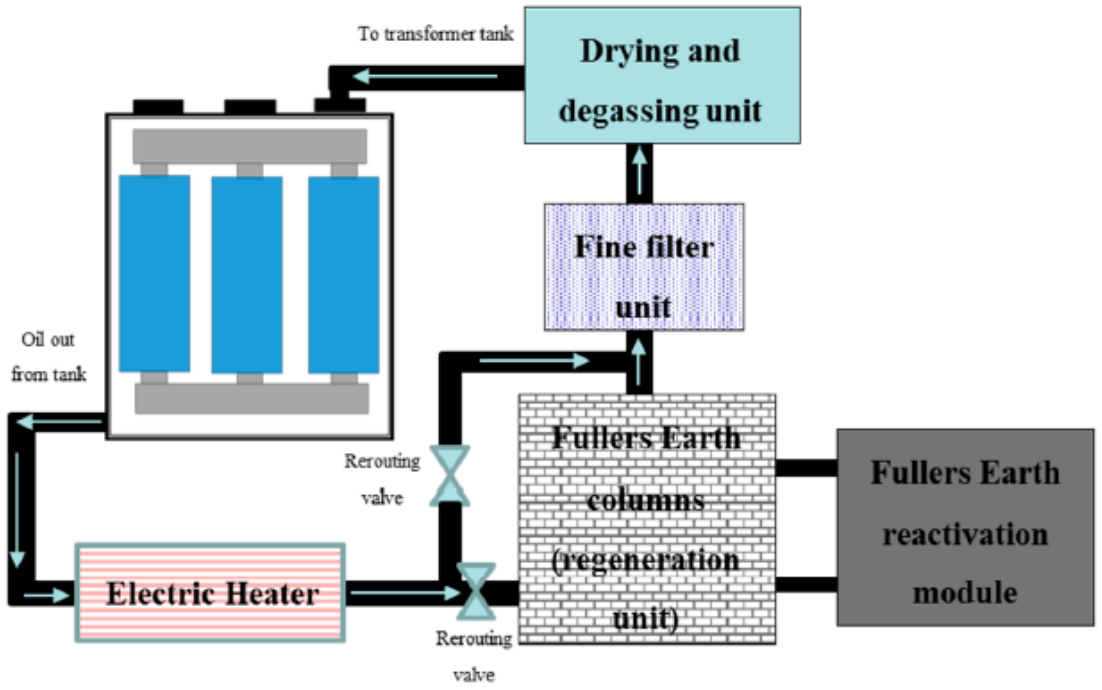
Critical parameters

- Acidity
- Interfacial Tension
- Breakdown Voltage

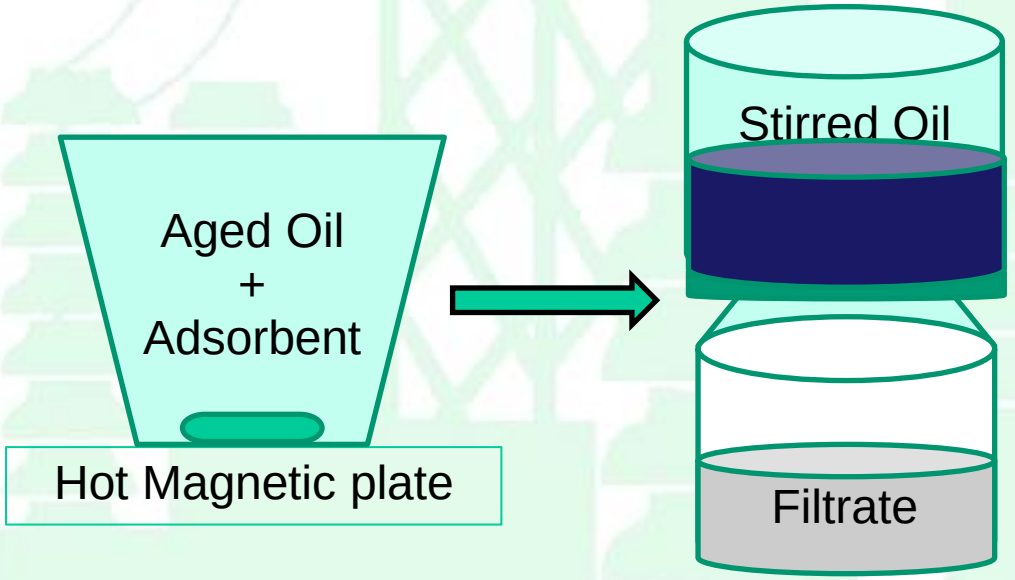
Major considerations

- Temperature (< 80 deg. C)
- Viscosity
- Reclamation or Reconditioning

SCHEMATIC OF TYPICAL METHODS



Percolation method (+ reconditioning)



Contact Method

MATERIALS

Liquid Samples

S.No	Liquid Sample	Pourpoint
1	Mineral oil (MO)	-51 °C
2	Synthetic ester (SE)	-56 °C

Solid Sample

Cellulose kraft paper is adopted for this work with a ratio of 1:20.

Adsorbents

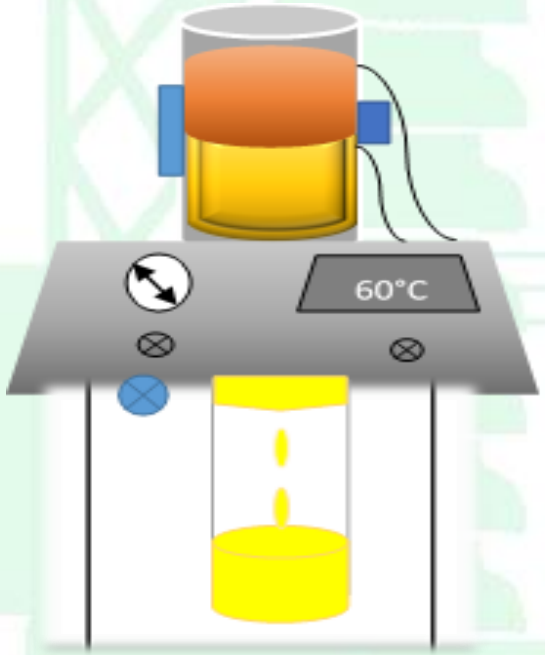
Magnesium silicate based adsorbents (AD1 and AD2)

Thermal aging

✓ An open beaker aging method as per modified ASTM D1934-2020* at **150°C for 8 weeks**

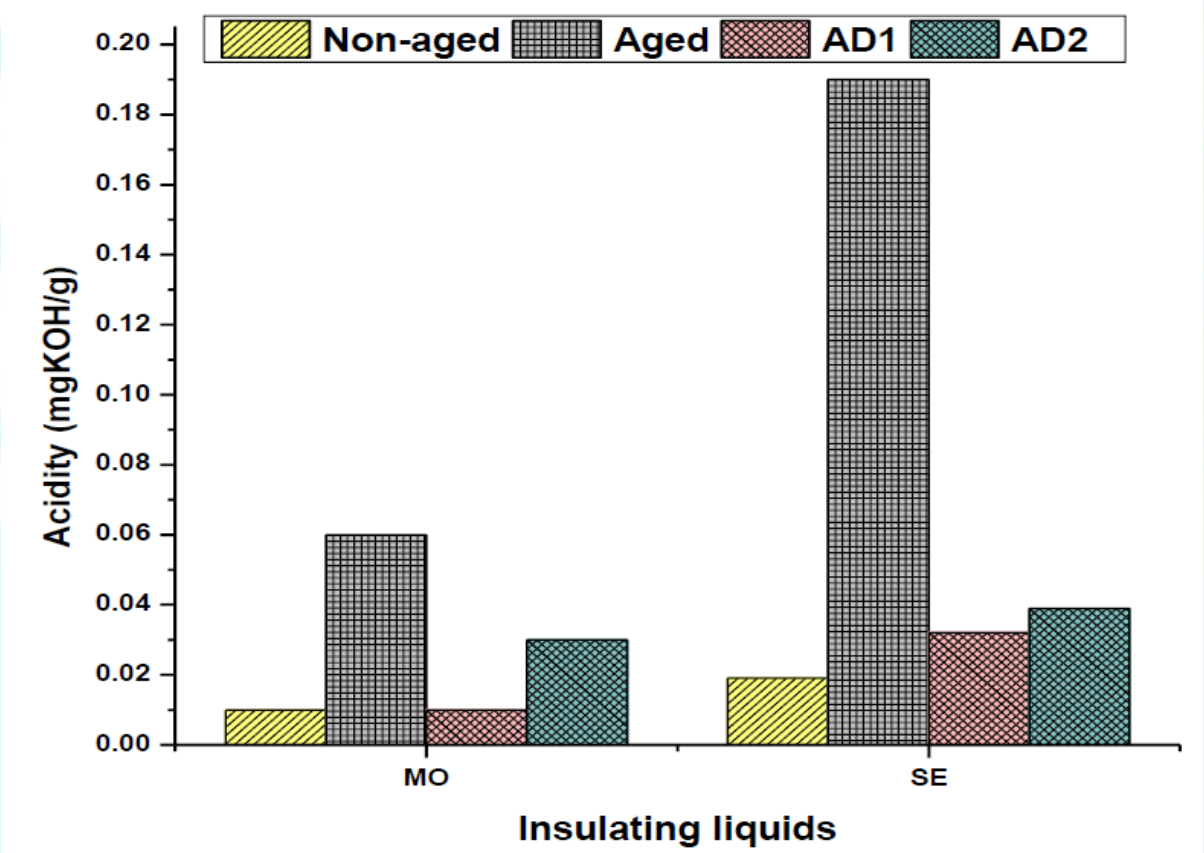
Reclamation method

✓ Pressure Percolation (50g for 100 ml, @ 60 °C)



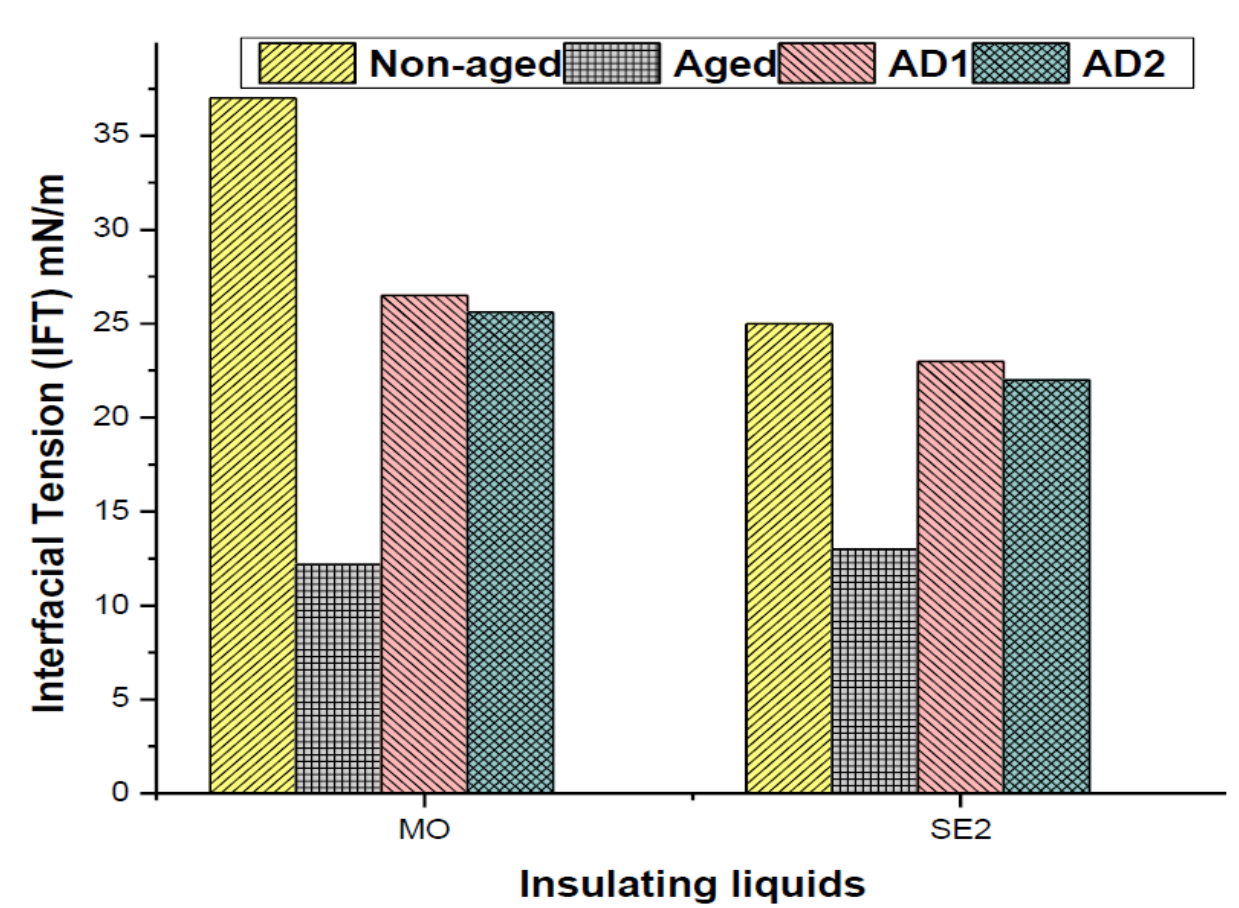
* ASTM-D1934-2020 Standard Test Method for Oxidative Aging of Electrical Insulating Liquids by Open-Beaker Method

Total acid number (TAN) (mgKOH/g)



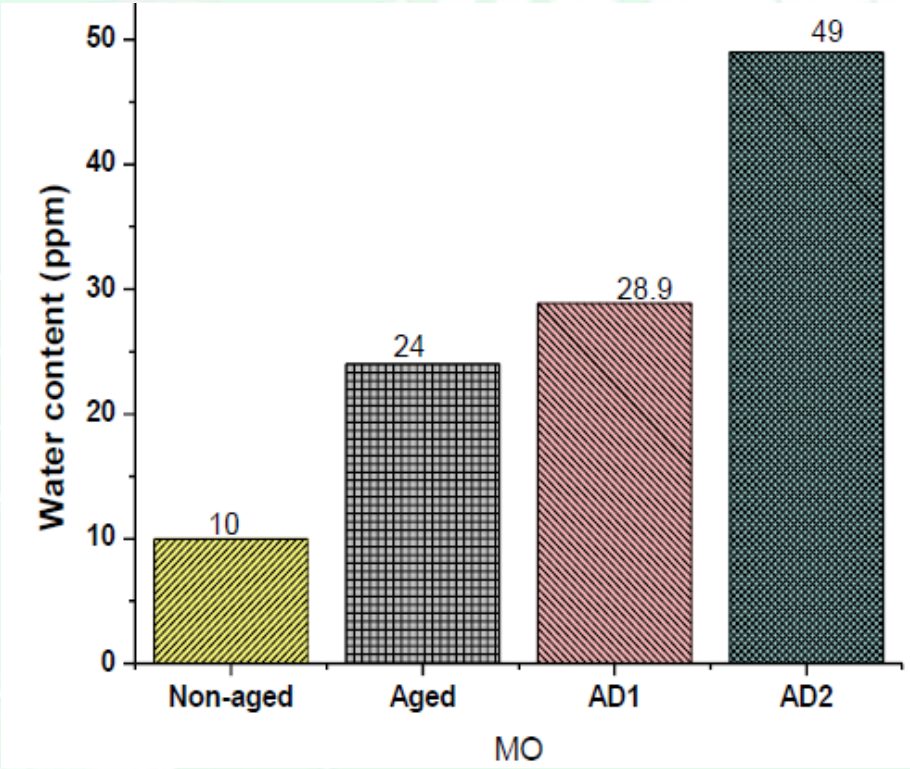
Acidity of MO and SE before and after reclamation.

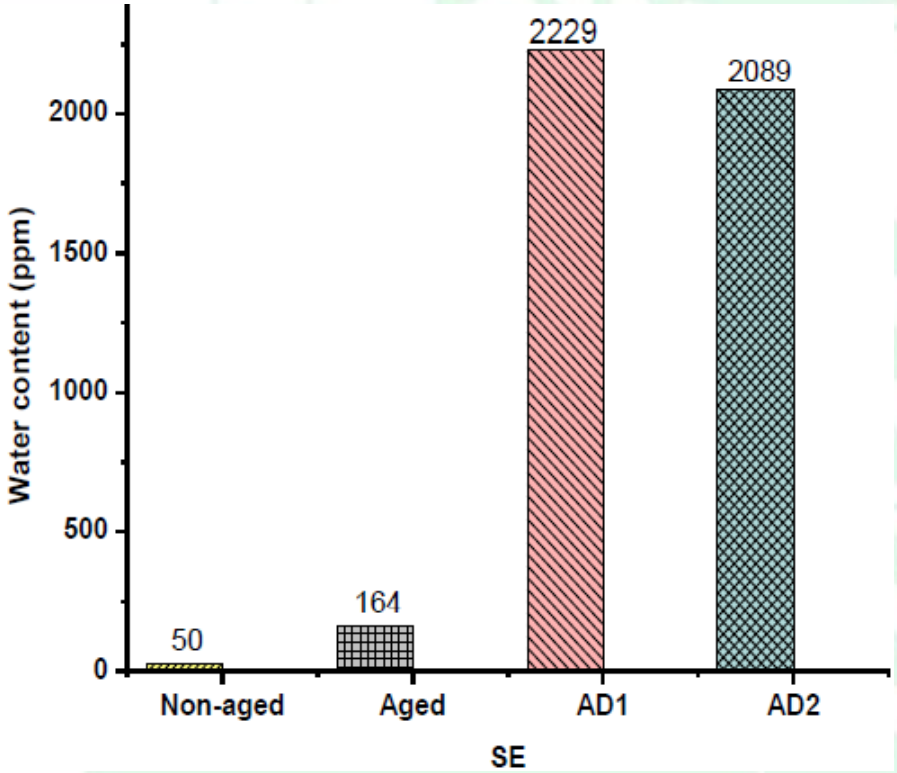
Interfacial tension (IFT) (mN/m)



IFT of MO and SE before and after reclamation.

Water content (ppm)





Water content in MO and SE before and after reclamation.

AC breakdown strength (kV)

Breakdown voltage values of MO and SE before and after reclamation.

AC breakdown voltage (kV)	MO	SE1
Non-aged	62	65
Aged (8 weeks at 150°C)	48	45
Reclamation with AD1	13	12
Reclamation with AD2	11	15

CLOSING REMARKS AND FUTURE WORK

- It is understood that the adsorbents AD1 and AD2 are effective in improving the acid number and IFT while removing the oxidation products and contaminants from MO and SE.
- The dielectric strength for both MO and SE decreases significantly after reclamation. However, water content also increased after reclamation.
- Recommendations for future work include the study of other percolation methods, including finding magnesium silicate-based adsorbents in a suitable particle size to be used in reclamation by pressure percolation.
- The reclamation should be followed by moisture removal.
- Other parameters to explore consist of the study of other adsorbents, adsorbent-liquid ratios, and the number of passes to be performed to achieve acceptable operational conditions for esters.

Thank You For Your Attention

This work was co-sponsored by the Natural Sciences and Engineering Research Council of Canada (NSERC), Hydro-Québec (Grant No. RDCPJ513264-17) and InnovÉÉ (R11-1707).