Digitalization versus sustainability

ABSTRACT

Digitalization and sustainability are driving forces in the power transformer industry, but they bring their own set of challenges. In this column, we discuss the complexities of sustainable oils and problems that arise in maintaining consistency in DGA diagnostics in this rapidly evolving field.

KEYWORDS:

DGA, digitalization, sustainability, sustainable oils, standards

DGA procedures require soft skills from sampling to diagnosis, which is not an exact science and cannot be translated into code that adequately expresses all ambiguities

Non-mineral liquids originate from vegetables such as soybeans, canola, and a few types of sunflower, each having its own logistics of pricing, availability, and social environmental impact on the community

In my previous column [1], I discussed the challenges of applying machine learning principles to Dissolved Gas Analysis (DGA).

Artificial Intelligence (AI) is a powerful technology for performing routine tasks and taking interpolated actions. Humans need to properly train sophisticated algorithms and provide continuous feedback in order to achieve a valuable expert system that can correctly diagnose transformer conditions. DGA procedures require soft skills from sampling to diagnosis and are not an exact science. Moreover, DGA is not easily translated into code that adequately expresses all ambiguities.

Power transformer sustainability is achievable today by using more environment-friendly materials, mainly in insulation. Such materials include non-mineral liquids manufactured from vegetable resources, such as ester liquids.

Modern solid insulation materials replace the classic cellulose made from vegetable sources. The former are treated synthetic materials reinforced for higher

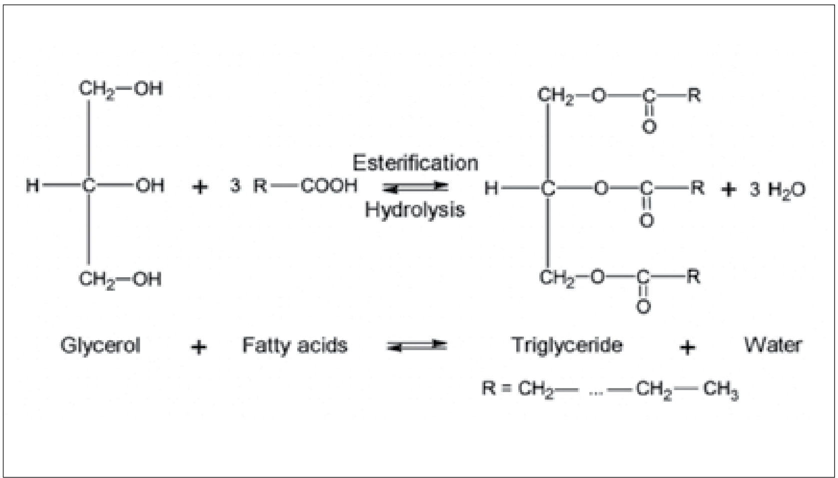

Fig 1. Ester liquid decomposition mechanism

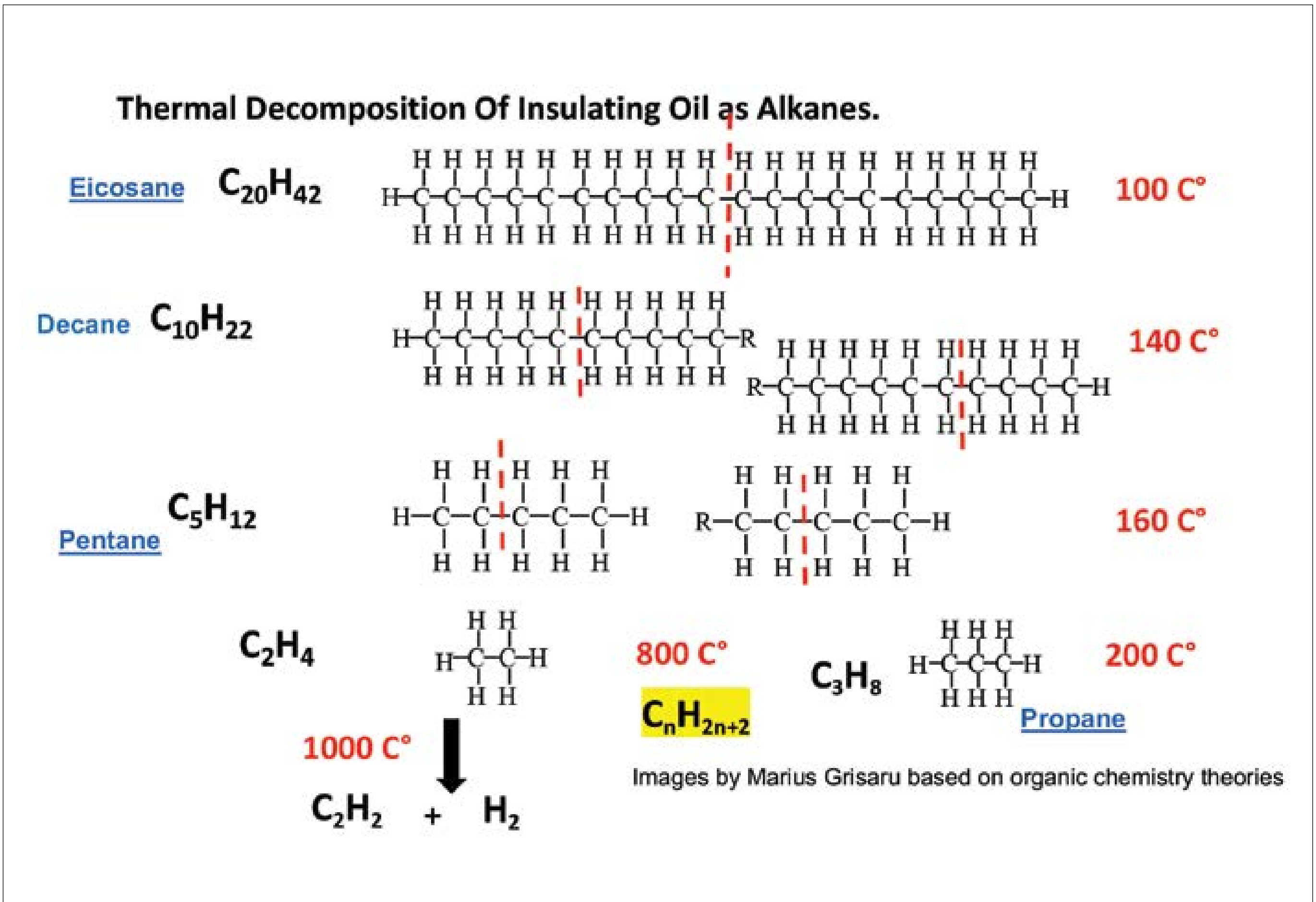

Fig 2. Mineral oil decomposition mechanism

Table 1. Different compositions of ester oils (T. V. Oommen)

Typical Fatty Acid Composition of Some Vegetable Oils				
Vegetable Oil	Saturated Fatty Acids, %	Unsaturated Fatty Acids, %		
		Mono-	**Di-**	**Tri**
Canola oil*	7.9	55.9	22.1	11.1
Corn oil	12.7	24.2	58	0.7
Cottonseed oil	25.8	17.8	51.8	0.2
Peanut oil	13.6	17.8	51.8	0.2
Olive oil	13.2	73.3	7.9	0.6
Safflower oil	8.5	12.1	74.1	0.4
Safflower oil, high oleic	6.1	75.3	14.2	-
Soybean oil	14.2	22.5	51	6.8
Sunflower oil	10.5	19.6	65.7	-
Sunflower oil, high oleic	9.2	80.8	8.4	0
*Low erucic acid variety of rapeseed oil; more recently canola oil containing over 75% monounsaturate content has been developed				

Transformer owners wishing to replace human experts who work from power transformer design to diagnosis should consider classical and well-known materials, such as kraft cellulose and mineral oil

temperatures. Also, synthetic polymers such as Nomex are more durable than all vegetable-based materials.

Non-mineral oils like natural and synthetic esters have different chemical compositions than petroleum-based mineral oils.

As shown in Figures 1 and 2, the chemistries of ester liquid and mineral oil are completely different.

Non-mineral liquids originate from vegetables such as soybeans, canola, and a few types of sunflower, as shown in Table 1, each having its own logistics of pricing, availability, and social environmental impact on the community.

Different liquid chemical structures have different properties. Researchers and manufacturers continuously improve the oil compositions of insulating liquids to meet different transformer design requirements and incorporate continuous feedback from existing installations.

Transformer owners may select non-mineral liquids from at least 10 worldwide manufacturers today, each offering at least two non-mineral alternatives.

Ester liquid products have different pour points, different gas signatures at different temperatures, different water solubilities, and, therefore, different breakdown voltage limits. Dissipation factors are also different than mineral and other liquid types.

All of these differences impose different standardizations for DGA, viz., IEEE C57.55 and the new DGA interpretation standard developed by IEC.

Software for continuous diagnoses of power transformers is designed to incorporate existent data and correlate abnormal measured values to probable fault conditions.

The need for a large, uncensored database for machine learning was discussed in the previous column. The availability of a database for non-mineral measurements is not only restricted to commercial distribution, but one still does not exist. Accordingly, machine learning and artificial intelligence cannot input, calculate, or process relevant data for power transformers filled with non-mineral oils.

Users today should realize that sustainability and power transformer digitalization cannot be achieved concurrently. Present day scholars across the world develop standards and publish numerous new conclusions on oil properties, soft-

ware diagnosis digitalization, and even power transformer design, all of which should be performed prudently and gradually after proper chemical and physical research.

Transformer owners wishing to replace human experts who work from power transformer design to diagnosis should consider classical and well-known materials, such as kraft cellulose and mineral oil.

Bibliography

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Author

Marius Grisaru holds an MSc in Electro-Analytical Chemistry from the Israel Institute of Technology. He has almost 30 years of intense experience in almost all transformer oil test chains, from planning, sampling and diagnosis to recommendations and treatments, mainly in Israel but also in other parts of the world. He is responsible for establishing test strategies and procedures and creating acceptance criteria for insulating liquids and materials based on current standardization and field experience. In addition, he trains and educates electrical staff on insulating matrix issues from a chemical point of view. He is an active member of relevant Working Groups of IEC, CIGRE, and a former member of ASTM. He is also the author and co-author of many papers, CIGRE brochures, and presentations at prestigious international conferences on insulation oil tests, focusing on DGA, analytical chemistry of insulating oil, and advantageous maintenance policy for oil and new transformers.