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(72) Inventeurs/Inventors:

Bird, Frederick John, CA;
DOMINELLI, NICOLA, CA;
Ashby, Gordon R., CA

(73) Propriétaire/Owner:

POWERTECH LABS INC., CA

(74) Agent: OYEN WIGGS GREEN & MUTALA

(54) Titre : METHODE ET REACTIF SERVANT A DETERMINER LE TAUX DE DEGRADATION DU PAPIER DANS DES TRANSFORMATEURS

(54) Title: METHOD AND REAGENT KIT FOR DETERMINING PAPER DEGRADATION IN TRANSFORMERS

(57) **Abrégé/Abstract:**

This invention relates to power transformers. More particularly, this invention pertains to a method and apparatus for detecting the degree of degradation of paper insulation in a transformer by determining the concentration of furaldehyde in the transformer oil. A reagent for detecting the presence of furaldehyde in transformer oil comprising: (a) a primary amine selected from the group consisting of aniline, toluidine, anisidine and aminophenol or an amine; (b) a second component comprising approximately 15 to 33 (weight to volume) percent of acetic acid alone, or in combination with citric acid; from approximately 67 to 85 (volume) percent of a halogenated hydrocarbon selected from the group consisting of dichloromethane, chloroform, carbontetrachloride, dichloroethane, trichloroethane, tetrachloroethane, trichloroethylene and tetrachloroethylene; approximately 4 (weight to volume) percent of salicylic acid; and approximately 1 (weight to volume) percent of an anti-oxidant; and (c) a third component comprising approximately 25 (weight to volume) percent citric acid in distilled water.



ABSTRACT OF THE DISCLOSURE

This invention relates to power transformers. More particularly, this invention pertains to a method and apparatus for detecting the degree of degradation of paper insulation in a transformer by determining the concentration of furaldehyde in the transformer oil. A reagent for detecting the presence of furaldehyde in transformer oil comprising: (a) a primary amine selected from the group consisting of aniline, toluidine, anisidine and aminophenol or an amine; (b) a second component comprising approximately 15 to 33 (weight to volume) percent of acetic acid alone, or in combination with citric acid; from approximately 67 to 85 (volume) percent of a halogenated hydrocarbon selected from the group consisting of dichloromethane, chloroform, carbontetrachloride, dichloroethane, trichloroethane, tetrachloroethane, trichloroethylene and tetrachloroethylene; approximately 4 (weight to volume) percent of salicylic acid; and approximately 1 (weight to volume) percent of an anti-oxidant; and (c) a third component comprising approximately 25 (weight to volume) percent citric acid in distilled water.

METHOD AND REAGENT KIT FOR DETERMINING
PAPER DEGRADATION IN TRANSFORMERS

FIELD OF THE INVENTION

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This invention relates to power transformers. More particularly, this invention pertains to a method and apparatus kit for detecting the degree of degradation of paper insulation in a transformer by determining the
10 concentration of cellulose breakdown products, and particularly furaldehyde, in transformer oil contained in the transformer.

BACKGROUND OF THE INVENTION

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Power transformers, and other large transformers, are a key component of the power transmission system in an electric utility. Several thousand such transformers may be in use at a major facility. A single power transformer
20 may represent an investment of millions of dollars, so a failure can be extremely costly in outage time and investment loss. Transformers are designed to last about 40 years. The residual life of an operating transformer is typically dependent on the residual life of the solid
25 insulation in the transformer.

The solid insulation for the coils in most power transformers and other large transformers is oil impregnated paper. This paper is immersed in a dielectric fluid,
30 such as transformer oil. By monitoring the condition of the paper insulation component it is possible to schedule and minimize maintenance procedures and adjust the power level input in order to extend the useful life of the transformer and reduce maintenance costs.

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As the insulation paper ages by thermal degradation (typically, transformers are rated to operate at temperatures between 55°C and 65°C above ambient), the cellulose in the paper breaks down. Specific degradation

compounds from this breakdown process appear and build up in the transformer oil. The most prominent is a build up of furaldehyde (also known as furfuraldehyde, furfural, fural or 2-furaldehyde) and related furaldehyde such as 5-methyl 2 furaldehyde and 5 hydroxy-2 furaldehyde. By monitoring the amount of furaldehyde build up in the oil, the condition (or proportional degree of degradation) of the paper insulation can be assessed.

10 The presence of furaldehyde build-up in the insulating oil of transformers as an indicator of paper insulation degradation, has been known for some years. Around 0.1 to 0.5 parts per million of furaldehyde in the oil is the range that is now considered as an indication
15 that cellulose in the paper insulation is degrading at a significant rate. The importance of being able to detect furaldehyde at such low levels is now becoming appreciated by maintenance engineers.

20 In some power utilities equipped with laboratories, transformer oil samples are routinely monitored for the presence of furaldehyde as an indicator of paper degradation. The conventional procedure employs high performance liquid chromatography (HPLC), which provides
25 comprehensive information on numerous paper degradation products and is sensitive to very low levels of furaldehyde (as low as 0.01 ppm). But the HPLC procedure is slow and expensive and requires a trained technician operator.

30 The detection of furaldehyde in new, clean petroleum products, which do not have any significant oxidation breakdown products, has been accomplished in the petroleum industry by using an aniline in acetic acid reagent and measuring the colour produced with a photo-
35 meter, or alternatively by visual examination of the colour in the acetic acid layer which separates out underneath the petroleum product layer. A problem with the acetic

acid/aniline test is that the mixture solidifies at about 16°C. Therefore, the test is not useful outdoors in cold climates.

5 Transformer oil, unlike the clear thin petroleum products that are usually tested with the acetic acid/aniline test, for example, gasoline, kerosene and the like, presents a challenge because transformer oil is viscous which retards reaction rates. Also, transformer
10 oil oxidizes and darkens under use. The transformer oil in a typical transformer may be 5 to 40 years old. Since they operate at elevated temperatures, for example, up to 105° or higher at localized spots, the build-up of oxidation breakdown products can be significant. These breakdown
15 products can form emulsions which interfere with the test. In the case of viscous transformer oil, which retards movement of the acetic acid reagent, a diluent solvent can be used to reduce the viscosity of the oil so that the acetic acid reagent can more effectively contact the
20 furaldehyde in the oil.

To increase the sensitivity of the aniline-acetic acid test, the furaldehyde can be pre-concentrated by extracting a large volume of the oil with a small volume of
25 a suitable solvent. This extracted material is then used for conducting the analysis. This additional step increases the complexity of the procedure and requires a trained technician operator.

30 Using the alternative photometric colour measurement procedure described is relatively tedious, time consuming and requires a photometer and a trained technician operator. The test is advantageous, however, because when the procedure is used to detect furaldehyde in oxidized transformer oil, a minimum test sensitivity as low as
35 about 0.05 ppm of furaldehyde can be achieved.

Visual colour measurement, if it could be done reliably, is desirable because it is simple, much less tedious, and does not require any instruments or a trained technician operator. But, because it is optical, it is inherently less sensitive. When used to detect furaldehyde in transformer oils, the sensitivity is further reduced because: (a) the use of a diluent solvent reduces the furaldehyde concentration, making detection more difficult, (b) yellowish or brownish coloured oxidation products from the oil are extracted by the acetic acid and these mask the true intensity of the furaldehyde red/pink compound and reduce the visual detection limit of the test, and (c) the oxidation products form emulsions which obscure the distinction between the upper oil layer and the lower pink/red coloured layer.

To date, the minimum test sensitivity of visual colour detection of furaldehyde in transformer oil, without resorting to an additional pre-concentration step, has only been about 0.5 to 1.0 ppm of furaldehyde depending on the colour condition (oxidation level) of the oil. The visual test is therefore not sufficiently sensitive to enable a meaningful paper degradation assessment to be carried out, particularly under cold field conditions. As mentioned before, a serious problem in using an aniline/acetic acid test is that when aniline and acetic acid are mixed, the mixture freezes at +16°C. This limits the applicability of the test in indoor or outdoor conditions when temperatures are below +16°C.

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As the significance and usefulness of furaldehyde detection, as evidence of cellulose breakdown, to monitor the condition of paper insulation in transformers and other electrical equipment, has become more appreciated, and hence more important, the demand for analysis has increased substantially. This has led to the need for a simple reliable, accurate test that can be conducted visually in

the field by non-chemistry trained personnel to rapidly detect the presence of low levels of furaldehyde in transformer oil that has been in use in transformers for years.

5 There is, to the applicant's knowledge, no quick and reliable visual field test for detecting low levels of furaldehyde in oxidized viscous transformer oil.

 United States Patent No. 4,514,503, issued April
10 30, 1985, R.B. Orelup, discloses a two-component liquid reagent comprising a first component and a second component for detecting the presence of furfural in new, clear light petroleum products of low viscosity, such as gasoline, kerosene, diesel oil, and the like. Orelup uses diethylene
15 glycol in each component to lower the freezing point of the mixture. The freezing points of the two components are stated to be less than -40°C. Each component of the liquid reagent is stored separately from the other component and both components are combined with each other prior to
20 admixture with the petroleum product. The test is intended for use by tax authorities to monitor unauthorized blending of motor fuels with less expensive products such as low octane gas and heating fuels, the latter having a lesser tax rate.

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 The two components of Orelup comprise the following compositions on a weight basis:

 First Component: (a) from about 15 to about 22 volume
30 percent of a primary amine selected from the group consisting of aniline, meta-aminophenol, para-anisidine, meta-toluidine and para-toluidine; (b) from about 35 to 45 volume percent of diethylene glycol; (c) from about 35 to about 45 volume percent of
35 ethanol; and (d) from about 1 to 2 weight to volume percent of an antioxidant.

Second Component: (a) from about 18 to about 25 weight to volume percent of an acid selected from the group consisting of citric acid, lactic acid, formic acid and phosphoric acid; (b) from about 35 to about 5 45 volume percent of diethylene glycol; and (c) from about 35 to 45 volume percent of ethanol.

There is a proviso in Orelup that when the amine in the first component is aniline, then the acid in the 10 second component must be an organic acid selected from the group consisting of citric acid, lactic acid and formic acid. This is probably to avoid the high freezing point (+16°C) of the aniline/acetic acid mixture. The use of diethylene glycol (which is a well known and widely used 15 anti-freeze in sprinkler systems and automotive radiator systems) and ethanol in each component is also taught. It is claimed that this method with no pre-extraction can detect 0.25 ppm of furaldehyde in new clean gasoline, diesel fuel, kerosene, naptha, or heating oil, all of light 20 viscosity.

These light petroleum products are clear in colour and are fresh. They are not old or degraded in any way. They are not heavy hydrocarbons of high viscosity. 25

The test taught by Orelup produces a petroleum product upper layer and a separated lower layer which displays a red colour if there is a furaldehyde primary amine reaction. The lower indicator layer is prone to 30 interference from emulsions formed by degradation products.

Orelup discloses the presence of inhibiting and diluting diethylene glycol in both the first component and the second component. Orelup also discloses large amounts 35 of diluting ethanol in both the first component and the second component. The presence of additional chemicals in

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each component dilutes the concentrations and reduces the sensitivity and the reliability of the procedure.

SUMMARY OF THE INVENTION

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The present invention provides a novel, portable, field usable, user friendly, three-component reagent for reliably detecting paper degradation levels in transformers by detecting low levels of furaldehyde in degraded viscous
10 transformer oils. The pink/red colour indicative of a furaldehyde primary amine reaction appears in an upper layer which is not interfered with by contaminants in the lower layer containing the separated oil product. The combination of reagents works together to minimize the
15 interference from emulsions caused by oil oxidation products.

The invention pertains to a reagent for determining extent of paper degradation in a transformer containing
20 paper and transformer oil by detecting the presence of furaldehyde in the transformer oil comprising: (a) a first component comprising approximately 0.1 mL of a primary amine selected from the group consisting of aniline, toluidine, anisidine and aminophenol or an amine; (b) a
25 second component comprising approximately 3 mL of approximately 15 to 33 (volume) percent of acetic acid alone, or in combination with citric acid; from approximately 67 to 85 (volume) percent of a halogenated hydrocarbon selected from the group consisting of dichloromethane, chloroform,
30 carbontetrachloride, dichloroethane, trichloroethane, tetrachloroethane, trichloroethylene and tetrachloroethylene; approximately 4 (weight to volume) percent of salicylic acid; and approximately 1 (volume) percent of an anti-oxidant; and (c) a third component
35 comprising approximately 1.25 mL of approximately 25 (weight to volume) percent citric acid in distilled water.

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The reagent can consist essentially of aniline as the first component; acetic acid, tetrachloroethylene, salicylic acid and t-butyl hydroquinone as anti-oxidant, as the second component; and citric acid in distilled water as the third component.

The invention is also directed to a reagent kit for deterring extent of paper degradation in a transformer by detecting the presence of furaldehyde in approximately 3 mL of transformer oil, said reagent kit comprising: (a) a first sealed pipette containing approximately 0.1 mL of aniline; (b) a vessel with removable cap comprising approximately 3 mL of approximately 15 (volume) percent of acetic acid, approximately 85 (volume) percent of tetrachloroethylene, approximately 4 (weight to volume) percent salicylic acid and approximately 1 (volume) percent antioxidant; and (c) a second sealed pipette containing approximately 1.25 mL of approximately 25 (volume) percent citric acid in distilled water.

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The aniline in the first sealed pipette (a) can be absorbed in a substrate and the vessel (b) can be a test tube with a Teflon lined plastic cap. The substrate can be a nylon fabric and the first and second sealed pipettes (a) and (c) can be disposable.

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The invention is also directed to a process for determining extent of paper degradation in a transformer containing paper and transformer oil by detecting the presence of furaldehyde in transformer oil containing said furaldehyde comprising: (a) withdrawing approximately 3 mL of the transformer oil with a pipette containing approximately 0.1 mL of aniline; (b) adding the 3 mL of transformer oil and the 0.1 mL of aniline contents of the pipette to a transparent vessel containing 3 mL of approximately 15 weight to volume percent of acetic acid and approximately 85 volume percent of tetrachloroethylene; (c)

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adding to the vessel and its contents the contents of a pipette containing 1.25 mL of approximately 25 weight to volume percent citric acid in distilled water; (d) capping the vessel and shaking the contents of the vessel for a
5 time sufficient to permit the contents to chemically react with one another; (e) observing the intensity of a pink/red colour characteristic of a furaldehyde complex in an upper layer formed on top of the transformer oil mixture; and (f) comparing the intensity of the pink/red colour with the
10 intensity of colour on a calibrated colour standards medium. The pipettes and vessel can be sealed air tight prior to opening.

15 DETAILED DESCRIPTION OF SPECIFIC
EMBODIMENTS OF THE INVENTION

We have invented a portable, reliable, outdoor friendly, easy to use, highly sensitive, three-component chemical reagent kit for the determination of paper break-
20 down in a transformer by detection of low levels of furaldehyde in degraded transformer oil. The reagents possess the following advantageous characteristics:

1. The three reagents are stored separately to improve
25 stability and shelf life. The colour that is developed in an upper layer when the reagents are used in detecting furaldehyde is stable, does not fade or change, and is less susceptible to contamination from a layer containing petroleum products, than is a lower
30 indicator layer.
2. The test sensitivity is sufficiently great that detection of furaldehyde even in diluted and aged mineral oil can be made by visual means, without pre-
35 concentration steps, in concentrations as low as about 0.1 parts per million of furaldehyde. A comparison of detection limit in viscous transformer oil, which must

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5 be diluted, is the most relevant comparison because in diesel and heating oil, a lower furaldehyde detection level is easier to achieve because a diluent solvent is not required, and the diesel or heating oil is not viscous and is a new clean product.

10 3. Interference from coloured oil oxidation products in the degraded oil and formed emulsions is substantially reduced because the colour indicator appears in an upper layer.

15 4. The analytical procedure for low level semi-quantitative measurement of furaldehyde in mineral oil is simplified and is much more rapid than prior art tests.

20 5. The kit and analytical procedure can be used in both indoor and outdoor conditions, even at extremely low temperatures (for example, -40°C).

6. The reagent components are held in sealed airtight containers which ensure reagent stability, ease of use and operator safety.

25 7. The volume of transformer oil and reagents required for the test is minimal and therefore a compact, portable multiple sample test kit package is possible.

30 The subject invention is not anticipated or taught by Orelup because Orelup does not disclose or suggest a small, compact, portable, easy to use three-component sealed liquid reagent kit for use in reliably detecting and determining very low levels of furaldehyde in heavy viscous transformer oil, which may be degraded and
35 extensively darkened due to oxidization. Orelup does not disclose detecting furaldehyde by viewing an upper indicator layer which is less prone to contamination from oxi-

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dants. Orelup does not disclose the use of acetic acid, or a chlorinated hydrocarbon such as tetrachloroethylene in a second component.

5 The three components comprise the following compositions on a weight/volume basis:

(a) First Component

10 0.1 mL of a primary amine selected from the group consisting of aniline, toluidine, anisidine, aminophenol or an amine;

(b) Second Component

15 3 mL of (a) approximately 15 to 33 weight to volume percent of acetic acid alone, or in combination with citric acid; (b) approximately 67 to 85 volume percent of a halogenated hydrocarbon selected from the group consisting of dichloromethane, chloroform, carbontetrachloride, dichloroethane, trichloroethane, 20 tetrachloroethane, trichloroethylene, tetrachloroethylene; (c) approximately 4 weight to volume percent of salicylic acid, and (d) approximately 1 percent of an anti-oxidant, t-butyl hydroquinone.

25

(c) Third Component

1.25 mL of approximately 25 weight percent citric acid in distilled water.

30 In practice, a small amount (typically about 3 ml) of transformer oil containing furaldehyde is withdrawn using a pipette which contains the first component (a) as described above. The withdrawn oil and first component (a) are then dispensed into a suitable container containing 35 component (b) as discussed above. The third component (c) as described above is then added on top of the oil/first and second components mixture. The container is then

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capped and shaken. After about 60 seconds, the characteristic pink/red colour of the primary amine-furaldehyde reaction appears in the separated upper layer, above the oil/first and second component mixture.

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The present invention provides a process for making the liquid containing the pink/red colour of the primary amine-furaldehyde reaction easily accessible for further use, by using a non-miscible petroleum product
10 philic solvent in the second component with a sufficiently high specific gravity so that after the test is performed, the layer containing the said red/pink colour separates out on top of the oil/solvent layer, rather than below it where there is more interference. It is advantageous to have the
15 pink/red colour layer separate on top where it is more clearly visible and less contaminated by oil and oxidation products than if the pink/red layer separates below, as in Orelup.

20 To estimate the 2-furaldehyde content, the intensity of the developed colour in the top layer is compared with colour standards that simulate the hue and intensity of colours from a 0.1 ppm to 1.5 ppm range of 2-furaldehyde concentration. The colour standards are
25 supplied in association with the kit, or separately.

Reagent Packaging Kit

The first component (a) is placed on an absorbent
30 substrate such as nylon fabric and is contained in a dispensing device such as a polyethylene disposable pipette.

The second component (b) is contained in a glass
35 vessel such as a test tube fitted with a TeflonTM lined phenolic cap.

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The third component (c) is contained in a dispensing device such as a polyethylene disposable pipette.

For a more complete understanding of the present invention, and to confirm the efficacy of the reagent and the method, reference is now made to the following specific examples illustrating the present novel three-component reagent for detecting furaldehyde in mineral oils.

10 Example 1

About 3 mL of viscous oxidized transformer oil was withdrawn using the pipette that contains the first reagent component (a). The first component (a) and the transformer oil were then dispensed into the test tube containing the second component (b). The third reagent component (c) was then introduced on top of the oil/reagent components mixture and the tube was then capped and shaken. After 60 seconds, it was observed that the developed pink/red colour was removed by the third reagent and this layer, which was clear and bright, separated out on top of the lower dark oil and other reagents layer.

This described process was repeated five more times using the same transformer oil containing: 0.2, 0.3, 0.5, 0.8 and 1.0 ppm of furaldehyde respectively.

The same general results were obtained. However, it was noticed that the intensity of the pink/red colour in the top layer increased proportionately in accordance with the relative increase in furaldehyde content of the oil. The increased intensity of pink/red colour could be readily compared with a corresponding colour chart to thereby determine the concentration of furaldehyde.

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The results of Example 1 demonstrate that the reagent of the invention is very sensitive and is more

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effective than conventional tests and can be used for semi-quantitative measurement. Furthermore, since the number of chemicals in each component is minimal, there is no dilution factor which decreases the sensitivity of the test.

5

Comparative Example

Prior to development of the test and formulation according to the invention with the diagnostic pink/red colour in the upper layer, numerous tests were conducted using acetic acid/aniline reagents, diluents such as ethanol and ethylene glycol, and water, for detecting furaldehyde in dark oxidized transformer oil. In such tests, the pink/red colour separated out into the lower layer, which was water, since the other fractions were lower specific gravity. We found, however, that the water layer at the bottom was not satisfactory because some of the yellowish and brownish oxidant products also separated into the lower water layer, thereby obscuring the correct pink/red colour in the lower water layer. Also, emulsion products formed by the oxidants tended to interfere with the indicator layer.

As will be apparent to those skilled in the art in the light of the foregoing disclosure, many alterations and modifications are possible in the practice of this invention without departing from the spirit or scope thereof. Accordingly, the scope of the invention is to be construed in accordance with the substance defined by the following claims.

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WHAT IS CLAIMED IS:

1. A reagent combination for determining extent of paper degradation in a transformer containing paper and transformer oil by detecting the presence of furaldehyde in the transformer oil comprising:
 - (a) a first component comprising approximately 0.1 mL of a primary amine selected from the group consisting of aniline, toluidine, anisidine and aminophenol or an amine;
 - (b) a second component comprising approximately 3 mL of approximately 15 to 33 volume percent of acetic acid alone, or in combination with citric acid; from approximately 67 to 85 volume percent of a halogenated hydrocarbon selected from the group consisting of dichloromethane, chloroform, carbontetrachloride, dichloroethane, trichloroethane, tetrachloroethane, trichloroethylene and tetrachloroethylene; approximately 4 weight to volume percent of salicylic acid; and approximately 1 volume percent of an anti-oxidant; and
 - (c) a third component comprising approximately 1.25 mL of approximately 25 weight volume percent citric acid in distilled water.
2. A reagent as claimed in claim 1 consisting essentially of aniline as the first component; acetic acid, tetrachloroethylene, salicylic acid and t-butyl hydroquinone as anti-oxidant, as the second component; and citric acid in distilled water as the third component.
3. A reagent kit for determining extent of paper degradation in a transformer by detecting the presence of furaldehyde in approximately 3 mL of transformer oil, said reagent kit comprising:
 - (a) a first sealed pipette containing approximately 0.1 ml of aniline;

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(b) a vessel with removable cap comprising approximately 3 mL of approximately 15 (volume) percent of acetic acid, approximately 85 (volume) percent of tetrachloroethylene, approximately 4 (weight to volume) percent salicylic acid and approximately 1 (volume) percent antioxidant; and

(c) a second sealed pipette containing approximately 1.25 mL of approximately 25 (weight to volume) percent citric acid in distilled water.

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4. A reagent kit as claimed in claim 3 wherein the aniline in the first sealed pipette (a) is absorbed in a substrate and the vessel (b) is a test tube with a Teflon lined plastic cap.

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5. A reagent kit as claimed in claim 4 wherein the substrate is a nylon fabric and the first and second sealed pipettes (a) and (c) are disposable.

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6. A reagent kit as claimed in claim 3 including a calibrated colour standards medium illustrating colour intensity in proportion to concentration of furaldehyde.

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7. A process for determining extent of paper degradation in a transformer containing paper and transformer oil by detecting the presence of furaldehyde in the transformer oil comprising:

(a) withdrawing approximately 3 mL of the transformer oil with a pipette containing approximately 0.1 mL of aniline;

(b) adding the 3 mL of transformer oil and the 0.1 mL of aniline contents of the pipette to a transparent vessel containing 3 mL of approximately 15 weight to volume percent of acetic acid and approximately 85 volume percent of tetrachloroethylene;

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(c) adding to the vessel and its contents the contents of a pipette containing 1.25 mL of approximately 25 weight to volume percent citric acid in distilled water;

(d) capping the vessel and shaking the contents of the vessel for a time sufficient to permit the contents to chemically react with one another;

(e) observing the intensity of a pink/red colour characteristic of a furaldehyde complex in a layer formed on top of the transformer oil reagent mixture; and

(f) comparing the intensity of the pink/red colour with the intensity of colour on a calibrated colour standards medium.

8. A process as claimed in claim 7 wherein the pipettes of steps (a) and (c) and the vessel of step (b) are sealed airtight.

9. A reagent combination for determining extent of paper degradation in a transformer containing paper and transformer oil by detecting the presence of furaldehyde in the transformer oil comprising:

(a) a first component comprising a primary amine selected from the group consisting of aniline, toluidine, anisidine and aminophenol or an amine;

(b) a second component comprising approximately 15 to 33 volume percent of acetic acid alone, or in combination with citric acid; from approximately 67 to 85 volume percent of a halogenated hydrocarbon selected from the group consisting of dichloromethane, chloroform, carbontetrachloride, dichloroethane, trichloroethane, tetrachloroethane, trichloroethylene and tetrachloroethylene; approximately 4 weight to volume percent of salicylic acid; and approximately 1 volume percent of an anti-oxidant; and

(c) a third component comprising approximately 25 weight volume percent citric acid in distilled water,

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wherein a volumetric ratio of the first to second to third components is approximately 1 to 30 to 12½.

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OYEN WIGGS GREEN & MUTALA
Patent Agents
for the Applicant