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Similarity Analysis of Cable Insulations by Chemical Test

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1. Introduction

In old nuclear power plant, it is easy to find black cable which has no marking of cable information such as manufacturer, material name and voltage. If a type test is required for qualification of these cables, how could I select representative cable? How could I determine the similarity of these cables?

If manufacturer has qualified a cable for nuclear power plant more than a decade ago and composition of cable material is changed with similar one, is it acceptable to use the old EQ report for recently manufactured cable?

It is well known to use FT-IR method to determine the similarity of cable materials[1]. Infrared ray is easy tool to compare compositions of each material. But, it is not proper to compare aging trend of these materials.

Study for similarity analysis of cable insulation by chemical test is described herein.

2. Methods and Results

2.1 Introduction of test equipments

2.1.1 FT-IR

FT-IR analyzes infrared ray spectrum radiated from liquid, solid or powder for comparing infrared ray(hereafter IR) spectrum of each material. Since this machine uses small piece for test, it is relatively easy to get a test specimen from operating plant. Test specimen can be obtained by cutting out the cable end in a junction box. Fig. 1 shows portable FT-IR analysis equipment.

2.1.2 TGA

TGA is very convenient tool for calculating activation energy of non-metal material since it takes a short time for test. Small test specimen of 3mg is a strong benefit of this test. It calculates activation energy of material by measuring weight of test specimen during heating from 100 to 800℃ at the increasing rate of 1, 2, 5, 10 ℃/min. It is general to follow the procedure of ASTM E-1641[2] for calculation of activation energy. Fig. 2 shows TGA machine.

2.1.3 OIT

Oxygen induction time(hereafter OIT) is test method which measure remaining amount of anti-oxidation ingredient after thermal aging. Cable material contains anti-oxidation ingredient during manufacturing to protect cable from aging degradation. When thermal aging proceeds, anti-oxidation ingredient in the material decreases. If we measure the remaining amount of anti-oxidation ingredient, we can estimate the status of aging degradation. Differential scanning calorimeter (hereafter DSC) machine is used for OIT measuring. OIT is a time from oxygen intrusion to starting of oxidation reaction at 180~220℃. Since increasing of environment temperature is proportional to decreasing of anti-oxidation ingredient in the material, activation energy can be calculated by using Arrhenius equation. Fig. 3 shows DSC machine.

Fig.1 FT-IR

Fig. 2 TGA

Fig. 3 DSC

2.2 Similarity analysis method

2.2.1 FT-IR

Fig. 4 show FT-IR test result for two similar cable insulations(old & new) manufactured by same company. Since it show 99% similarity, we can estimate them as similar with regard to major material composition. These materials are mainly composed of EPR but have small difference in amount of affixation material. This difference shows 1% deviation. With this analysis, we can assume the similarity of material composition. But, character of aging degradation can't be evaluated.

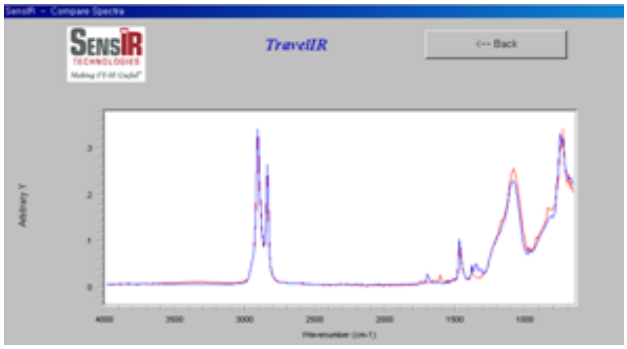

Fig. 4 FT-IR result for two similar cable insulation

2.2.2 TGA

Fig. 5, 6 show calculation results of activation energies for two cable insulations by using TGA. The new material showed high activation energy compared with that of old one. If we repeat TGA test and use statistics method, it may show more similar trend.

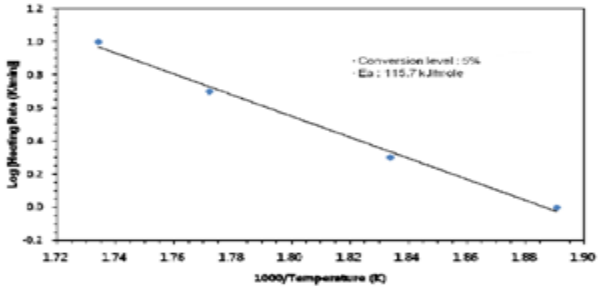

Fig. 5 activation energy of old insulation by TGA

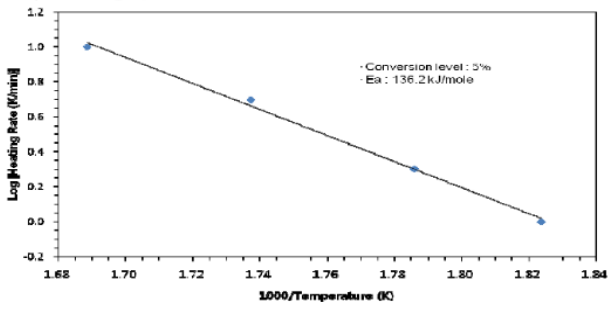

Fig. 6 activation energy of new insulation by TGA

2.2.3 OIT

Fig. 6, 7 show calculation results of activation energies for two cable insulation materials by using OIT method. New insulation had slightly higher activation energy compared with that of old one.

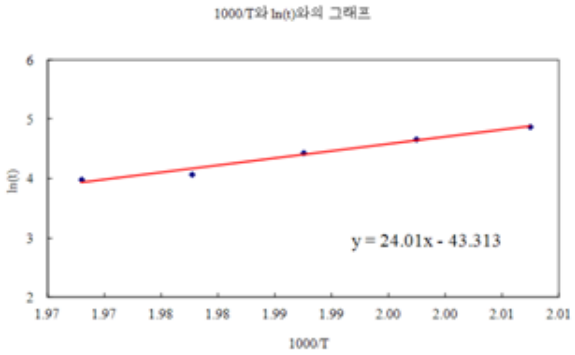

Fig. 7 activation energy of old insulation by OIT

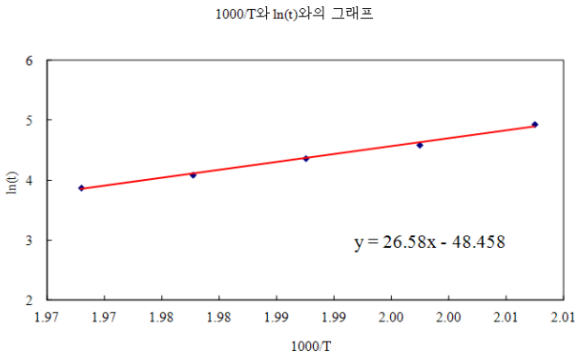

Fig. 8 activation energy of new insulation by OIT

3. Conclusions

To study a similarity evaluation method for polymer materials, FT-IR, TGA and OIT tests were performed for two cable insulation(old and new) which were supplied from same manufacturer.

FT-IR shows good result to compare material compositions while TGA and OIT show good result to compare aging character of materials.

As result of this experiment, it was found that FT-IR test for material composition, TGA test for aging trend are applicable for similarity analysis of cable materials. OIT is recommended as option if TGA doesn't show good trend. Qualification of new insulation by EQ report of old insulation should be based on higher activation energy of new insulation than that of old one in the consideration of conservatism.

REFERENCES

[1] J.S Kim, 'Evaluation of nuclear plant cable aging through condition monitoring', Journal of KNS vol. 36, number5, pp 475-484', 2004

[2] ASTM E1641, 'Standard test method for decomposition kinetics by thermo-gravimetry', 1999