2002

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T. Iizuka
Hitachi Home & Life Solutions

A. Ishiyama
Hitachi Home & Life Solutions

R13-4

ESTIMATION METHOD FOR THERMAL STABILITY OF REFRIGERATION OIL AND AUTOMATIC SEALED GLASS TUBE PROCESSING DEVICE

Tadashi IIZUKA and Akihiko ISHIYAMA,Hitachi Home & Life Solutions,Inc.,
800 Tomita, Ohira-machi, Simotsuga-gun, Tochigi, 329-4493, Japan;
E-mail: iizuka-tadashi@hitachi-hl.com, ishiyama-akihiko@hitachi-hl.com

ABSTRACT

Refrigeration oil and other materials used with refrigerant for refrigerators or air conditioners should have thermal and chemical stability to maintain the system reliability. Some kinds of synthetic oil are used for alternative refrigerant, HFC's and hydrolysis, material compatibility, and low-temperature extraction of contaminant or sludge are important subjects. Much more numbers and times of tests are necessary for estimation of thermal stability in comparison with the case of CFC or HCFC systems. We have developed the automatic sealed tube processing device to get sufficient quality and accuracy of sealed glass tubes and we are making it use for many actual cases. We are convinced that this system will help refrigerator or air-conditioner manufacturers, lubricant manufacturers and so on to get higher reliability for their products.

INTRODUCTION

Recently, many kinds of refrigerant and lubricant have been estimated and made use for refrigeration and air conditioning system in consideration with environmental issues. Some kinds of refrigerant have flammability and we should be very careful for estimation. We have developed the automatic sealed glass tube processing device to get sufficient quality and accuracy of sealed glass tubes and also it has been considered to keep safety when handling flammable substances. We are making it use for many actual cases. In this report, we introduce the outline of the device and give several examples of test results.

OUTLINE OF DIVICE

The automatic sealed tube processing device can be automatically operated instead of conventional manual operation following to the contents of JIS (Japanese Industrial Standard) K2211"Refrigeration Oil" and ASHRAE Standard 97-1999 "Sealed Glass Tube Method to Test the Chemical Stability of Materials for Use Within Refrigerant Systems" by making use of sequential control function. Also, it is made with consideration of safety to use for various kinds of refrigerant including flammable substances. Figure 1 shows the main schematic of the device and Figure 2 shows the picture of the outer appearance.

(1) Specification

a. Refrigerants available

HCFC (R22), HFC (R410A, R407C, R404A, R134a) HC (R290, R600a)

Bugloss Tubes

Material: PILEX (registered mark): borosilicate
Dimension (Inner Diameter × Outer Diameter × Length):
$\phi 8 \times \phi 13 \times 370L$, $\phi 6 \times \phi 10 \times 370L$

c. Available conditions

Temperature: 175℃ Maximum, Pressure: 5.0 MPa Maximum

d. Process Time:10 min/sample (50 sample/day)

(2) Processing modes

By setting up the sequential combinations, several processing mode can be chosen.

[Full Automatic Mode]

①Set →Forming Capillary → Vacuum → Cooling → Refrigerant Charge →Sealing
②Set →Forming Capillary → Cooling → Vacuum → Refrigerant Charge →Sealing
③Set →Vacuum → Cooling → Refrigerant Charge → Sealing

[Manual Mode]

①Set →Forming Capillary
②Set →Forming Capillary →Sealing

(3) Operating procedure

Figure 3 shows the procedure of sealed glass tube processing including refrigerant charge and sealing glass tube. The process is automatically carried out by the robot.

PRACTICAL USE OF SEALED GLASS TUBE TEST

Sealed tube test method using sealed glass tube filled with oil and refrigerant is applied for the estimation of several characteristics or performance. For example, the miscibility of oil and refrigerant as the initial characteristics and the deterioration after the thermal and chemical reaction by heating for a certain period of time are estimated. Table 1 shows the items for the estimation.

Table 1 Practical Use of Sealed Tube Test

Refrigerants	HFC's: (R410A, R407C, R404a, R134a)	HC's: (R290, R600a)	CFC's: (R12) HCFC's: (R22)
Oils	POE, PVE	MO, HAB	MO, HAB
Floc point Miscibility	Outer appearance		←
・Thermal Stability Oil Stability/Hydrolysis ・Material Compatibility Motor Materials Sliding Materials Molecular Sieves Plastics ・Contaminant Miscibility Process Materials Manufacturing control	・Outer appearance ・Function and characteristics ・Low temperature extraction ・Gas-chromatography ・GPC ・FT-IR ・Titration neutralization		・Outer appearance ・Titration neutralization

EXAMPLES– EXPERIMENTAL RESULTS

(1) Miscibility of Refrigerant and Oil

Fig.4 shows the experimental result of miscibility test for refrigerant and oil. Dual layer separating characteristic of liquid refrigerant and oil can be seen through glass tube. Critical soluble temperature chart can be drawn from the results of experiment using several numbers of sealed glass tube with different oil rate in each tube. Also floc point can be measured with this method.

(2)Hydrolysis

Fig.5 shows the experimental result of hydrolysis test. In this case, 1000ppm water is added for acceleration of oil deterioration. From this result, it can be seen that some kinds of additive are effective for controlling hydrolysis.

(3) Material Compatibility - Motor Material

(ⅰ) PET Films

Fig.6 shows the experimental result of oligomer extraction test. This chart shows different types of oligomer extracted from PET film. Each number means the size of oligomer. For example, n=3 means trimer, n=4 means tetramer, and so on.

(ⅱ) Enamel Wires

Fig.7 shows the experimental result of compatibility test for enamel wire. This result shows that the extracted substance increases and the breakdown voltage decrease with time passing.

(4)Material Compatibility– Molecular Sieves for Drier

Fig.8 shows the result of dryer material compatibility test. In this case, the compatibility between molecular sieves and POE oil. It can be seen that some kind of additive in POE oil is absorbed by molecular sieves and the effect of additive could be decreased. Also, from this experiment, the decomposition of refrigerant can be estimated by measuring F-ion from the decomposition of refrigerant. Decomposition of refrigerant is accelerated by molecular sieves as catalyst.

(5)Contaminant Miscibility - Process Materials〔Flux for Brazing〕

Fig.9 shows the result of contaminant miscibility test. Flux for brazing has no miscibility with POE oil and it works as catalyst to decompose the oil. This chart shows some kinds of decomposed substance from POE oil. It can be seen that the acid catcher decreased and decomposed substances PE-2-ester and PE-3-ester from POE-PE-4-ester increased.

(6)Thermal Stability

This device is available for flammable refrigerant. Fig.10 shows the experimental result of thermal stability test of HC refrigerant, R600a. This chart shows that CH_4 from R600a (iso-butane) decomposed.

SUMMERY

Automatic sealed tube processing device has been newly developed and it can be effectively used for estimating the thermal and chemical stability of oil to maintain the reliability of refrigeration system from the experimental results for following subjects.

(1) Design Items

- Choice of suitable kind of oil
- Analysis of the miscibility of refrigerant and oil
- Choice of suitable materials for refrigeration system

(2) Process Control Items

- Kind and amount of contaminant (process materials)
- Moisture control – Dry process and limitation of water content
- Vacuum process – limitation of residual air

(3) Analysis of Reliability Trouble

- Substances of capillary clogging
- Cause of insoluble substance
- Traces of process contaminant

(4) Cost Saving by Using the Sealed Tube Processing Device

- Saving cost for preparation of sealed glass tubes
- 50 tubes per day can be prepared
- High quality, High accuracy and safety
- No requirement of high skill

REFERENCES

(1) ASHRAE Standard 97-1999 “Sealed Glass Tube Method to Test the Chemical Stability of Materials for Use Within Refrigerant Systems”

(2) JIS K2211 “Refrigeration Oil”

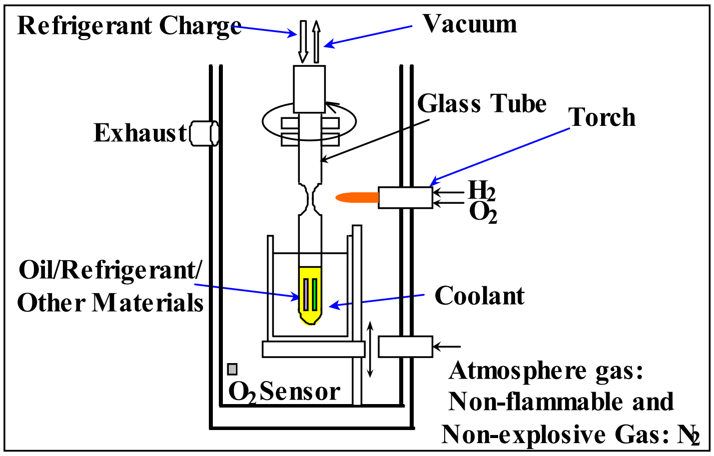

Fig.1 Glass tube sealing scheme

Fig.2 Appearance of the Device

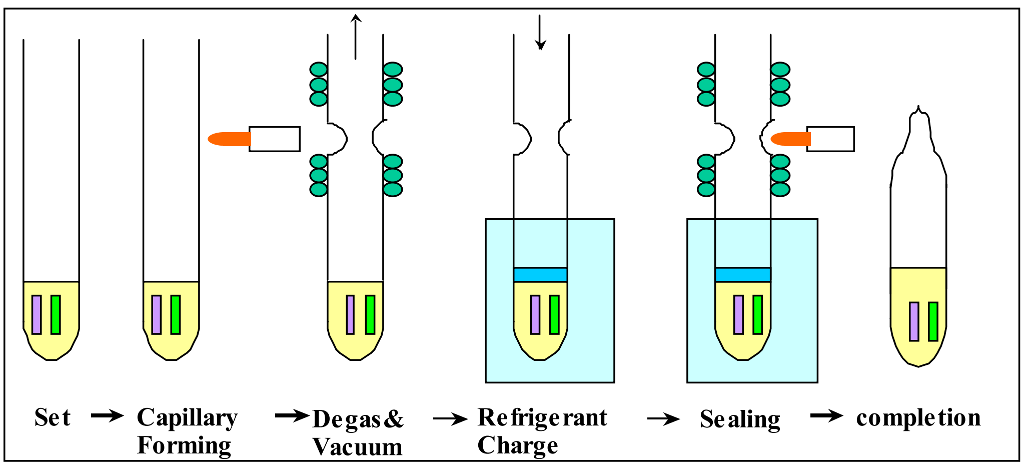

Fig.3 Operating procedure

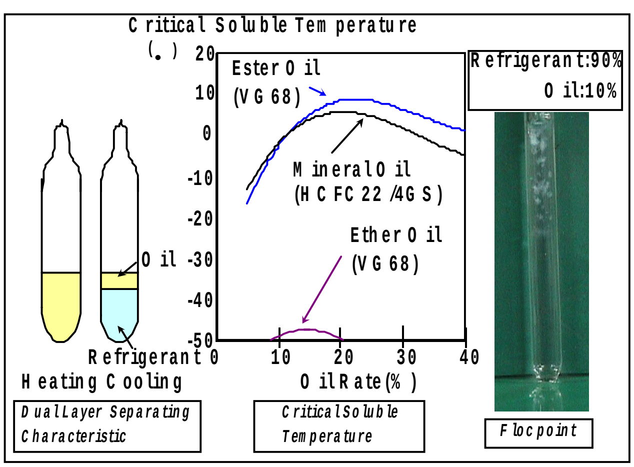

Fig.4 Miscibility of Refrigerant and oil

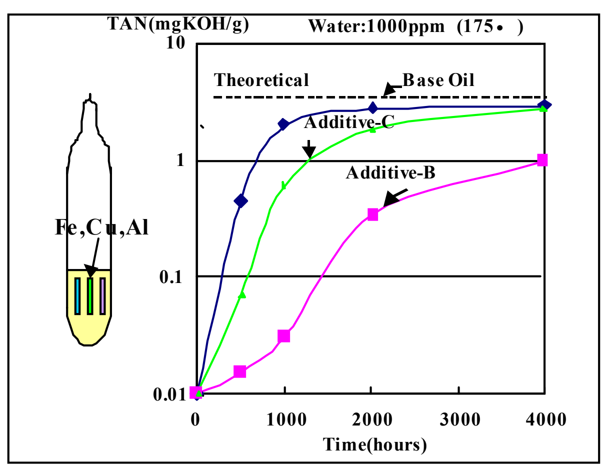

Fig.5 Hydrolysis of Ester oil

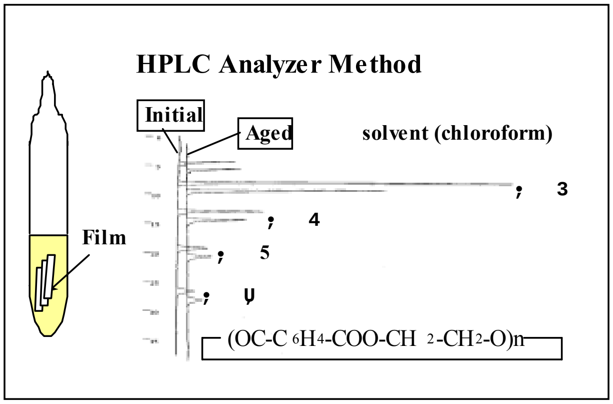

Fig.6 Oligomer extraction of PET film

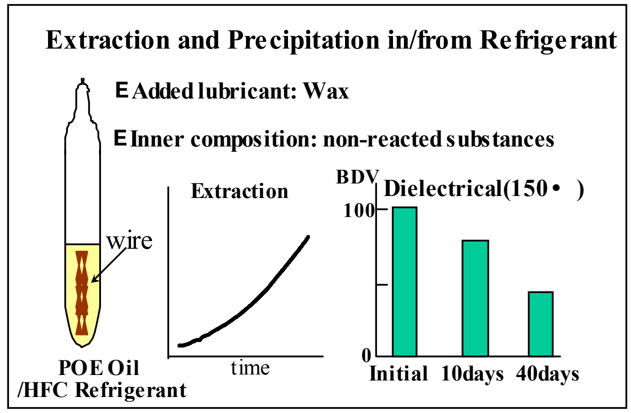

Fig.7 Characteristic change of enamel wire

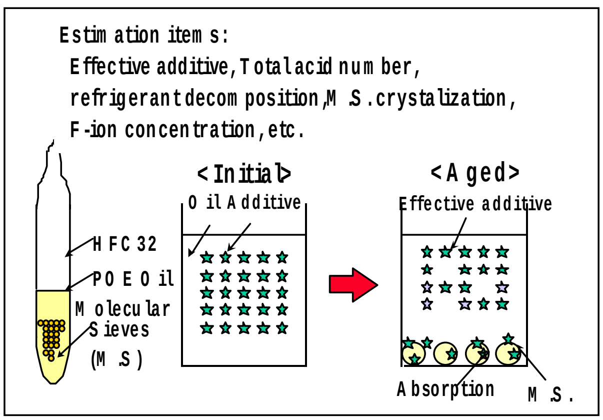

Fig.8 Material Compatibility:Dryer

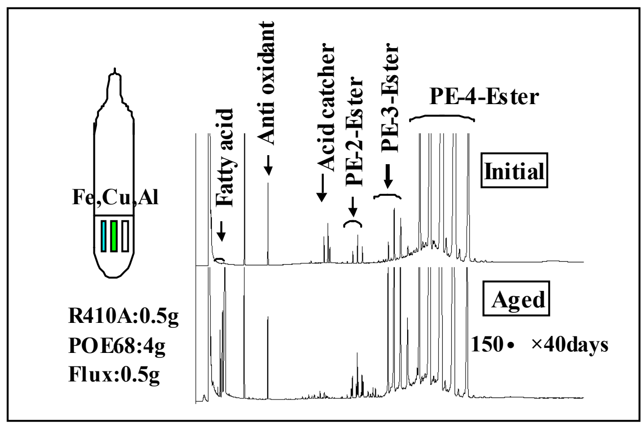

Fig.9 Contaminant miscibility

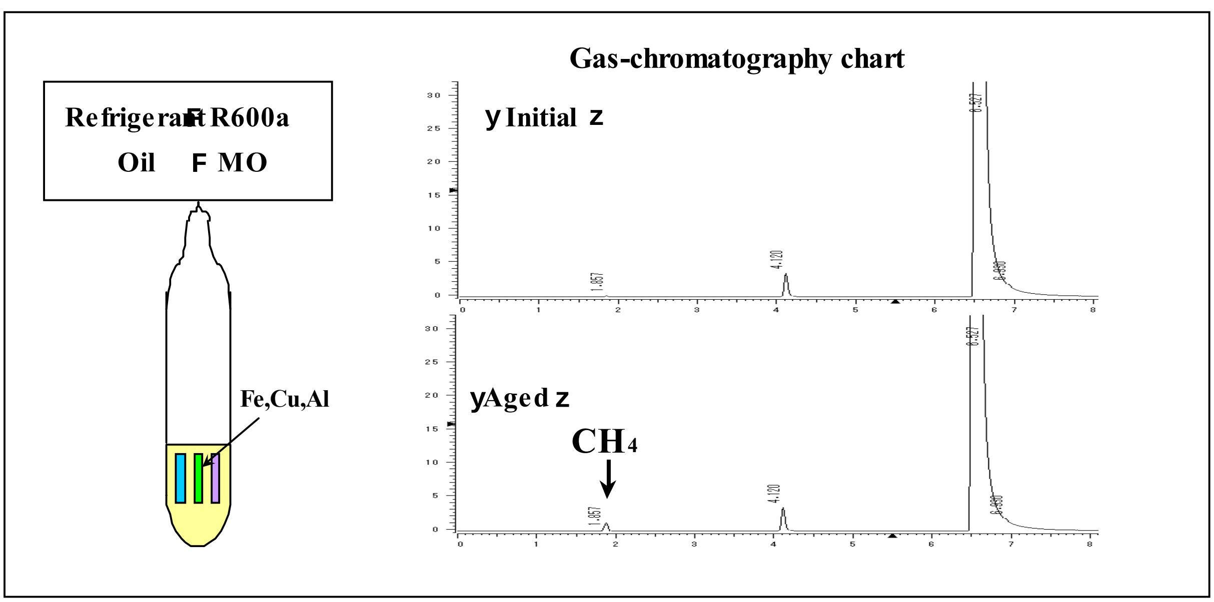

Fig.10 Thermal stability of HC refrigeration