Applications of odour measurements in Korea

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Abstract

In spite of the fact that it is known to be difficult to measure odours, increasing odour complaints have driven authorities to regulate odour release in Korea. Official methods of measuring odours and regulations on odour release are prescribed by law. Although acceptable concentrations at point sources and boundaries of installations have been prescribed since the early 1900s, there have been little evidence in official literature indicating whether odours have been measured with analytical methods or sensory assessment. Demands to control odour release have lead to stricter compliance with regulation and have finally led authorities to enact the Offensive Odor Prevention Law. Direct sniffing assessment of odours at boundaries of installations in order to judge compliance with odour regulation is supposed to be excluded from executive measurement methods of odours in the odour law and the regulation applicable to odour release may be strengthened. On the other hand, analytical or sensory measurement of odours has been carried out very frequently in fields of industries. Techniques of assessing odours have been very useful in quality control for a variety of products such as foods, beverage, chemicals and plastics and for improving the quality of automobiles and home appliances. In this paper, some of the odour measurements applied in industrial fields are shown. The methods of chemical analysis and the sensory assessment of odours currently being used by both government and industry in Korea are also introduced.

1. Introduction

The olfactory sense provides us a broad range of information about our environment. Some odours increase the quality of our lives but some provoke unpleasantness. Amongst a variety of odours, offensive odours from sewage works, intensive livestock raising, chemical plants, rendering facilities and so on have often led people in their vicinities to feel annoyance. In order to control malodors effectively, it is generally recognized that odours must first be quantified. But odour has often been known to be difficult to measure. Many odorous emissions consist of multiple volatile compounds and the overall odour of any given complex mixture cannot easily be predicted.

In the very highly populated nation of Korea, concerns over odour management have

been driven by complaints over offensive odours, such as those having arisen in residential areas around industrial facilities such as the chemical plants in Ulsan located on the southeastern coast of the Korean Peninsula, and now spread over the whole nation. The establishment of manufacturing facilities, which has brought economic advancement to the Korean people, has lead to more people being exposed to bad odours. In addition, increased awareness of both the environment and individual human rights has led people to be more likely to complain about offensive odours. Nowadays, the plant operators or designers of odour-emitting facilities have come to consider that the control of odour emissions is important in the design of new manufacturing facilities and the solving of odour problems at existing facilities is becoming more important. In the last year, the Ministry of Environment declared legislation targeted at odour emissions – the Offensive Odour Prevention Law.

In spite of the difficulties of measuring odours, a methodology for quantification of odours should have been established for judgment on compliance with the odour laws in Korea[1)]. Like Japan, Korea has adopted analytical measurements of individual odorous compounds using instruments such as gas chromatographs along with sensory measurements such as the triangle odor bag method employing the human nose as official an odour measurement method. Dynamic olfactometry[2)], having been applied to odour measurement in Western countries, is known to be superior to the static method being used in Korea and Japan, in spite of the fact that it is expensive and large amount of sampling volume is necessitated for sensory assessment are both critical reasons to prevent it from becoming more prevalent in Korea.

Having become one of the world leaders in the mass production of home appliances and automobiles, Korea's industries have been improving the technology of odour control. In this paper, several examples of the applications of odour measurement in industry fields will be introduced briefly.

2. Odour measurements for regulation

In Korea, which is one of the most densely populated areas in the world, it has been inevitable for manufacturing installations to be built near residential area and thus many people have been exposed to offensive odours emitted from these facilities with no adequate odour prevention measurements. The Korean Government has guidelines for acceptable levels of odours at boundaries of premises and at gas-releasing points of installations. This regulation on offensive odours has been codified in parts of sections of Korea's Air Conservation Law, but in the newly enacted Offensive Odour Prevention Law, legislated in December 2003, the methodology applied for measuring odours will be suggested to be more substantial and activities releasing odours would be regulated more strictly than under the old law.

The Korean Government had prescribed three odour measuring methods ; direct sniffing assessment at borders, static olfactomtry method using odour bags and instrumental analysis. In spite of the prescription of these methods under this old odour permission law, there had been few substantial events to measure odours with these methods except direct sniffing assessment.

It is thought that the capability for high-leveled chemical analysis of odorants in threshold concentrations and the reproducibility of sensory assessment, and the relatively high cost of odour measurement had prevented from prevailing sophisticated odour measurement of environmental affairs in Korea. But it has been assured that judging the legality of odour release with the odour law by simple sniffing odours over the boundaries of installations in industrial areas have been conducted frequently by relevant officials in Korea.

Regulation of odours by direct sniffing at boundaries and judging the legality of odour release, being simple and characteristic in the old law, would be the reason for unwillingness of carrying out the other methods. The legality of odour releasing at boundaries had been judged by at least 5 relevant officials. If more than half of the official assessors express higher than 2 in odour strength after sniffing the air at odorous sites of boundaries of the premises, the odour release level would be judged as illegal.

In the law, odours in relatively high concentrations such as gases released from stacks have been prescribed to get an assessment with static olfactometry called as dilution method[3)]. The officials who have been obliged to assure compliance with the odour rule have been thinking that it is difficult to grasp emission sources of the odours at boundaries where a lot of odour sources are gathered around and thus, the maximum allowable odour concentrations at emission sources would be a realistic regulation of odours in Korea. Dilution factor 1000 on gas releasing points, seemed to be substantial regulation on companies in industrial areas, is expected to be down to 500 with the new odour law.

3. Applications of odour measurement in industries

The techniques of odour measurements have been applied to a variety of fields of industries in Korea since early 1990. Table 1 shows some of the applications that odour measurements were carried out in industrial investigations.

Odours of foods are strongly related with freshness and influence sales. There were some cases where changes in odours of foods such as pudding made customers apprehensive about buying the product and decreased sales volume. The food with strange odours were assessed by olfactometry to find the most deteriorated ones and analyzed instrumentally to search the cause of deterioration.

In some Korean companies, odour sensors have been used for monitoring the odour quality of food and beverages. Some applications of sensor arrays to environmental problems such as livestock wastes, pig slurry and sewage treatment works have been

reported in literature. In Korea, introduction of an odour monitoring system in the vicinities of industrial areas, where odour complaints have been occurring, has been considered by local administrations. Portable gas analyzers and portable odour sensors have been used to measure removal efficiencies of odour abatement facilities and to expect the odour concentrations of releasing gases in installations

Table 1 Applications of odour measurement in industries

- Foods : Assessment of freshness, quality control of foods and beverages
- Chemicals : Quality monitoring of synthetic chemicals
- Odour abatement facilities : Efficiency check of deodorizing facilities
- Deodorants : Deodorizing efficiencies
- Air cleaners : Efficiencies of deodorization
- Air conditioners : Measurements of malodours from air conditioners
- Refrigerators : Deodorizing system of offensive odours in a refrigerator
- Vacuum cleaners : Treatments for bad smell of exhaust air
- Automobiles : Odours in a new or old cabin, malodours from stuff

Purity of chemicals can be confirmed with chemical analysis of their constituents. But an inspector may assess their content quality by investigating their shapes, colours or odours. Quality assessment by direct sniffing of products is an easy, fast and cheap method for inspection of chemical products. And it would be common that many buyers have assessed merchandise with this sensory method first. Odour assessment of chemicals, synthetic leather and plastics has been performed everyday in chemical plants and there are many investigations concerning the odours of chemical products.

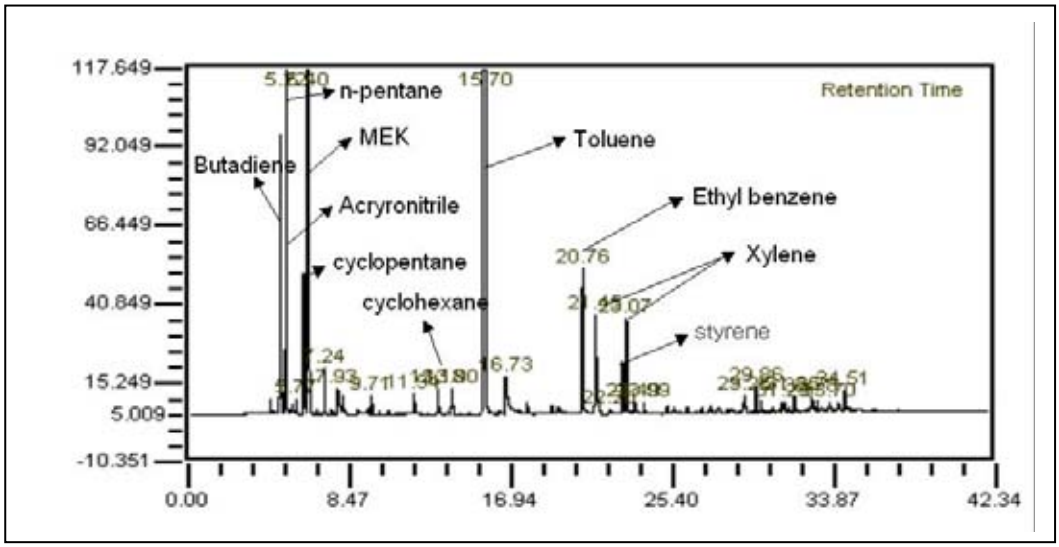


Fig. 1 Gas chromatogram of volatile organic compounds in a new refrigerator

Trying to diminish offensive odours from a refrigerator would be a good example of an application of odour measurement. Figure 1 is gas chromatogram of volatile organic compounds in a newly manufactured refrigerator taken with a GC with a VOC concentrator.

In table 2, concentrations of volatile organic compounds in a newly manufactured refrigerator are shown. In order to appreciate the attributes of each volatile organic compounds (abbreviated as VOCs) in a refrigerator, odour threshold concentrations of each VOCs are given in the table. Odour concentration (factor of dilution to threshold by odorless air) attributed by each VOC can be obtained by dividing the analyzed concentration with the corresponding threshold value, thus 1543 ppb of methyl ethyl ketone is expected to contribute 4 in odour concentration. Toluene and n-pentane showed 772ppb and 377ppb respectively, but they are the concentrations under their odour thresholds, it can be confirmed that they would not be the cause of odours in a refrigerator.

Table 2 Concentrations of volatile organic compounds in refrigerators

Substance	Threshold conc. (ppb)	New refrigerator		In-use refrigerator(2yrs)	
		Concentration (ppb)	Expected odor Conc.	Concentration (ppb)	Expected odor Concentration
n-Pentane	1400	377	-	n.d	-
Dimethyl sulfide	3.0	n.d		13.6	5
Cyclopentane	1700	50	-	n.d	-
M.E.K	440	1543	4	19.2	-
n-Hexane	1500	8	-	10.3	-
Ethyl acetate	870	10	-	9.4	-
Methyl allyl sulfide	0.28	n.d	-	115.0	410
Dimethyl disulfide	2.2	n.d	-	230.8	105
Toluene	330	772	3	98.25	-
Ethyl benzene	170	30	-	4.65	
M,p-Xylene	41	35	-	13.30	
o-xylene	380	26	-	11.35	
Styrene	35	14	-	n.d	
Total		2865	7	525.80	520
Odour concentration		550		347	

The odour concentration of 550 in the lowest row indicates the result of sensory assessment of odours in the new refrigerator carried out with the triangle odour bag method. Because the sum of calculated odour concentrations of each VOC in the new refrigerator is too small to be compared with the observed odour concentration, it could be concluded that those VOCs listed in table 2 are not potent odorants attributing to the odours in the newly manufactured refrigerator.

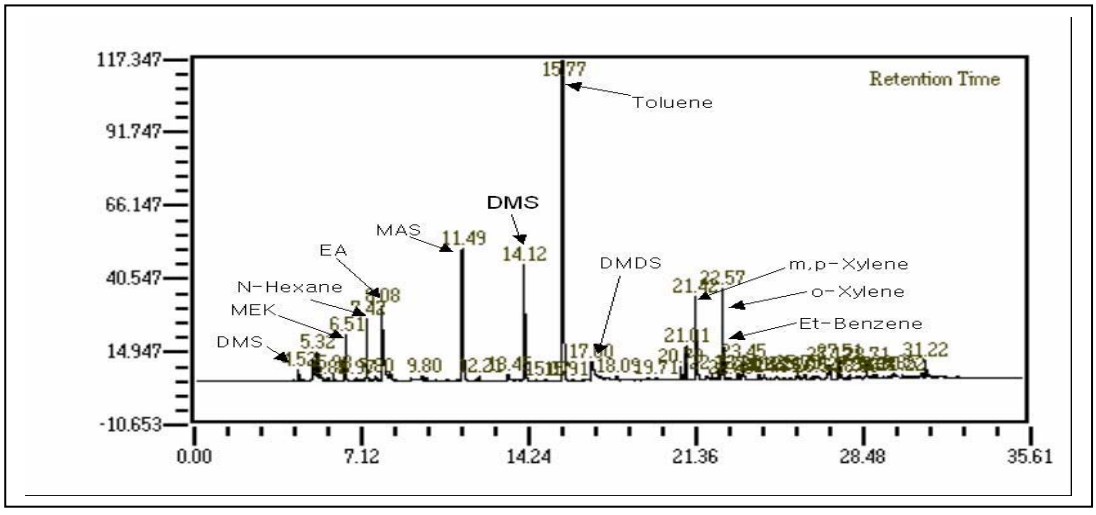
Traditionally, Korean people have a favorite food; now their national dish “Kimchi” widely known around the world. Kimchi is a mixture of garlic, red pepper, salt, spices and fermented Chinese cabbage. It is known to be good for health and is eaten everyday on Korean tables, being preserved under the ground or in a refrigerator. Every refrigerator in a Korean home has some Kimchi and sometimes when the door of a refrigerator is opened,

the odour of Kimchi escapes and brings unpleasantness to those not familiar with it. Therefore, refrigerators used in Korean homes need deodorant in order purpose to reduce the malodors from Kimchi.

Korean manufacturers of refrigerators have investigated the characteristics of Kimchi and tried to improve its flavour and taste. Keeping Kimchi in a refrigerator results in the need for control of the odours therein, and thus, the technique of odor measurement is essential to preserving foods in the refrigerator without odour transfer from one item to another. And so the quality of indoor air might be influenced by odours from the refrigerator, it would be important to control odours in the refrigerator.

Fig. 2 presents a chromatogarm of the VOCs in the refrigerator, having been used for 2 years in a typical Korean resident with no complaint of odours. VOCs were collected with the door closed when the refrigerator was operating. The inner air of the refrigerator was pumped out in a polyester bag with the door closed and VOCs were concentrated in a Tenax TA tube. Subsequently, the volatile components blown out with heat were analyzed with GC.

Fig. 2 Gas chromatogram of VOCs in an in-use refrigerator



In the table 2, concentrations of VOCs in the chromatogram of Fig. 2 are shown simultaneously. The VOCs inherent in the refrigerators would almost be gone out 2 years and those originated from indoor air and emitted from foods or packing materials would consist of constituents in the air therein. As Kimchi is usually kept in the refrigerator of Korean homes, it has been easy to detect volatile sulfur compounds in concentrations over their odour threshold values. Expected odour concentrations due to Methyl allyl sulfide(MAS) and dimethyl sulfide(DMS) are obtainable from their odour thresholds and they are 410 and 105 respectively. The observed odour concentrations (dilution factors assessed by triangle odour bag method) of the operating refrigerator were assessed to be 347. Though it would not be easy to explain the observed odour concentrations clearly

with the concentrations of instrumentally analysed odorants, it could be ascertained that the volatile sulfur compounds emitted from Kimchi are potent contributors to odours in the operating refrigerator in Korea. A Korean engineer relevant to manufacturing sophisticated refrigerators would be keeping odours in a refrigerator in mind.

4. Conclusion

It has been known for long time that odours are very difficult to analyze or interpret. Although there has been a gap between the characteristics observed with sensory assessments and those expected from a constitution of odorants in odours untill now, the difference of the two has become narrower. Reproducibility and accuracy of sensory assessment have increased due to the movement of the global standardization of olfactometry method. The technique of finding the contributing factors to odours is increasing due to the enhancement of the performance of analytical equipments. If the final aim of odour measurement is to control odours, both sensory assessment and chemical analysis would be necessitated. Finding a method to match the analytical data to the sensory character is important and needs much research in order to establish the most effective method.

Odour measurement in Korea has been developed with regulation and control of odours. Range of fields, where odour measuring technique would be needed, will be widened more in the future until human beings have the ability to sniff like dogs.

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