A Study on the Development of VOCs Detector

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Abstract

Emission of volatile organic compounds (VOCs) are one of the popular issues of air pollution in Korea, especially in Ulsan city, where much chemical plants are located. It is necessary to detect the VOCs precisely in order to control the air pollution during the plant operation. In general, to examine the concentration of VOCs, gas chromatography (GC) is used. However, most plant operators are using the easy operating handy VOCs detector, which is imported, because GC is difficult to treat and the installation price is high although it is very useful equipment. Therefore, the development of the VOCs detector becomes one of the urgent issues. In this study, sensing characteristics of selected VOCs for the development of VOCs detector was investigated. Semiconductor sensor and several VOCs such as aliphatic, aromatic, and non-homogeneous hydrocarbons were used for the experiment. Through the various experiments, sensor used in the experiment has shown high linearity and sensitivity for most VOCs in the range of 1 - 500 ppm concentration.

Introduction

VOCs are consisted with aromatic, aliphatic (paraffin, olefin), and non-homogeneous hydrocarbon that contain nitrogen, oxygen, and halogen elements[1)]. In general, VOCs make stink odor at even low concentration and photochemical oxidants as a secondary air pollution. Main sources of VOCs emission are as follows: solvent, petrochemical industry, food industry, iron industry, waste treatment plant, and agriculture. Measurement of VOCs and hazardous assessment to human body in petrochemical plant which is considered as a main sources of VOCs have been tried[2)].

Recently, measurement of VOCs is mainly conducted by instrumental analysis, especially GC-Mass (gas chromatography). However, to get the gas sample in the plant, stack gas sampler and handy air sampler is needed, and it need long time to take the gas samples to the laboratory and stand by for measurement. During that period, the gas sample can be changed. If the concentration of VOCs in the samples were too low or high, it has to be concentrated or diluted to analyze. Therefore, many errors could be occurred unless direct analysis was conducted in site.

The petrochemical plant for the above reasons imports many kinds of handy VOCs detectors, and it is more convenient and easy to treat than GC as well as it can detect the VOCs concentration in site. However, production of VOCs detector in Korea has not been achieved.

In this study, simple semi-conductor detector (SCD) has been made for the detection of VOCs concentration in site and the characteristics of VOCs concentration with developed SCD were investigated. Correction factors which represent the relative sensitivity for the detector was determined.

Materials and Method

1. VOCs used in the experiments

Aromatic hydrocarbon (benzene, toluene), aliphatic hydrocarbon (isopropylalcohol, cyclohexane), and nonhomogeneous hydrocarbon (methyl ethyl ketone; MEK) were used as VOCs sources in the sensor characteristics experiments. All reagents used were over first grade and have liquid phase in room temperature. VOCs gas was produced by adding air in the reagents.

2. Sensor characteristics experiment

Experimental apparatus as shown in Fig. 1 was made for investigation sensor characteristics of developed semi-conductor detector (SCD). VOCs gas was developed due to the air supplied from valve 1, and it was got into the measuring chamber through the valve 3 and remained constant concentration. When the concentration of VOCs gas reached at high value, under the condition of stopping VOCs gas input with closing valve 1 and 3, and opening valve 2 and 4 for reducing VOCs gas concentration in the measuring chamber, it was measured by SCD, PID, and GC-FID, simultaneously.

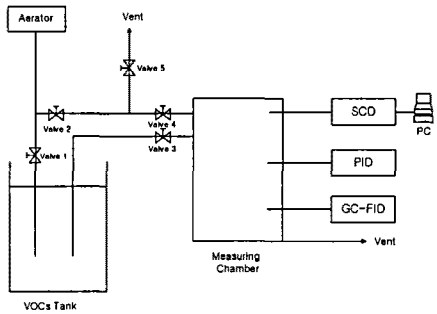
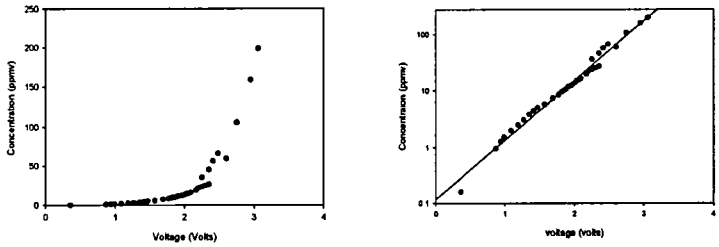


Fig. 1. Apparatus for producing VOCs gas and sensor test used in the experiment.

Results and Discussion

The main features for determining possibility of sensor are linearity and continuity. In this research, especially, the linearity of developed SCD was concentrated upon, because it is essential for representing dynamic response in continuous process of chemical plant. In Fig. 2, the relationship between concentration of benzene and voltage produced by sensor was showed. As shown in Fig. 2(b), almost linear relationship between concentration and voltage in semi-log plot was acquired. Therefore, it could be thought that the sensor used in this experiment had good linearity in benzene

In Fig. 3, the characteristics of sensor developed on several kinds of VOCs were shown. At all VOCs gases, relationship between concentration and voltage had good shapes, which is called S curve that represent a common sensor characteristics.



(a) (b)

Fig. 2. Relationship between concentration of benzene and voltage (a) and fitted with semi-log scale (b).

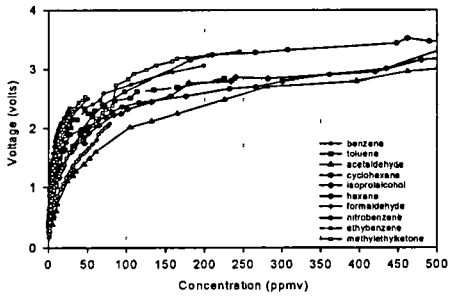


Fig. 3. Relationship between concentration of various VOCs gases and voltage.

Conclusion

In this study, semi-conductor type VOCs detector that can detect VOCs gases emitted by petrochemical plant, oil station, solvent treatment plant, and iron industry easily was developed. Through the various experiments, sensor of developed VOCs detector has shown high linearity and sensitivity for most VOCs in the concentration range of 1 - 500 ppm used in the experiment. It could be considered, if sensing characteristics of developed VOCs detector would be more studied, more sensitive and accurate VOCs detector could be developed for inspecting leakage, industrial hygiene, health, and safety in chemical plant.

References

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