GAS SENSING USING PHOTOLUMINESCENCE FROM PHOSPHOR CONTAINED SILICA GEL

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Abstract: Variations in the photoluminescence (PL) spectra from porous silica gel containing the luminous organic pigments were evaluated before and after the exposure in the vapors of $CHCl_3$. Peak intensity of PL from rhodamine and fluorescein contained silica gel vary with the concentration of pigment. Peak intensity of PL also varies after exposure in the organic vapors of $CHCl_3$. Temperature dependences of PL intensity from rhodamine and fluorescein contained silica gel are also evaluated for sensor applications. The organic luminous pigments contained silica gel is suggested to be useful fluorescent sensor materials.

Keywords: photoluminescence imaging, non-destructive evaluation, food.

1. INTRODUCTION

The sensors for detecting the volatile organic carbons (VOC), such as $CHCl_3$, formaldehyde (HCHO), toluene ($C_6H_5CH_3$), xylene ($C_6H_4(CH_3)_2$) and benzene (C_6H_6) are strongly required because these vaporized organic compounds result in the sick building syndrome [1,2]. Fluorescence sensors using luminous organic pigments contained porous silica gel are expected to be a potentially useful technique for the optical detection of the organic compounds arising the sick building [1-5]. Photoluminescence evaluations of luminous organic pigments contained silica gel [1,2,5] have been done for developing a fluorescence sensor system.

In this paper, fluorescence sensor application of luminous organic pigments contained porous silica is described based on the photoluminescence (PL) study of these pigments before and after exposure in the vapor of organic compounds.

2. EXPERIMENTAL

Porous silica (silica gel) was dipped into 1 % or 0.1 % methanol solutions of luminous organic pigments such as fluorescein ($C_{20}H_{12}O_5$) and rhodamine ($C_{28}H_{31}ClN_2O_3$). The luminous pigments were adhered into porous silica gel with various concentrations. These were then dried at 373 K for 1 hr. Silica gel with organic luminous pigments was, then, exposed in the vapor of $CHCl_3$.

Photoluminescence (PL) spectra before and after the exposure were measured using ultra violet excitation with xenon lamp and/or LED with the wavelength at λ=365 nm as shown in Fig. 1.

3. RESULTS AND DISCUSSION

Figure 2 shows photoluminescence spectra from fluorescein and rhodamine contained silica gel. Broad PL peaking at the wavelengths, λ=460, 510 and 540 nm, is also seen in the fluorescein contained porous silica specimens as shown in Fig. 2. In PL spectra from the specimens exposed in the vapors of $CHCl_3$, peak wavelength of PL does not change after the exposure. Relative intensity ratio of the PL

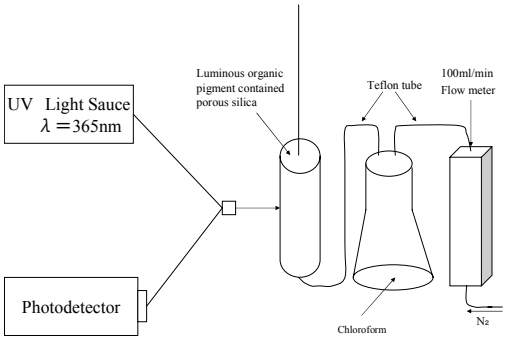

Fig. 1. Fluorescence sensor using rhodamine and/or fluorescein contained silica gel. UV LED is used as an excitation source. Fiber spectrometer is also used as a detector. $CHCl_3$ vapor is adsorbed to rhodamine contained silica gel. Thermal desorption is also evaluated for the future senor application.

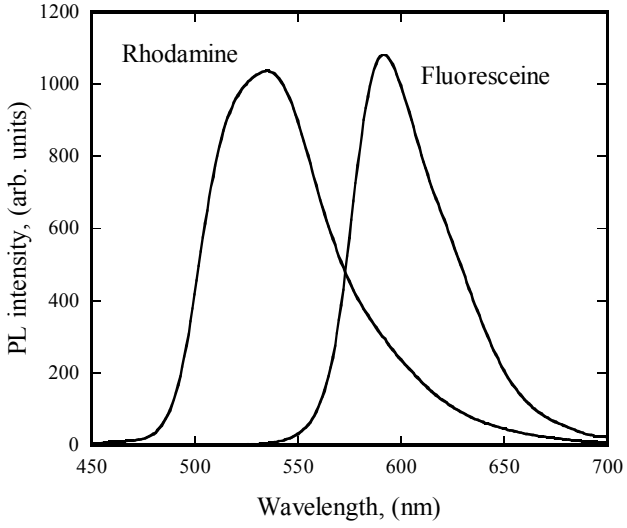

Fig. 2. Photoluminescence spectra from rhodamine and fluorescein contained silica gel specimens.

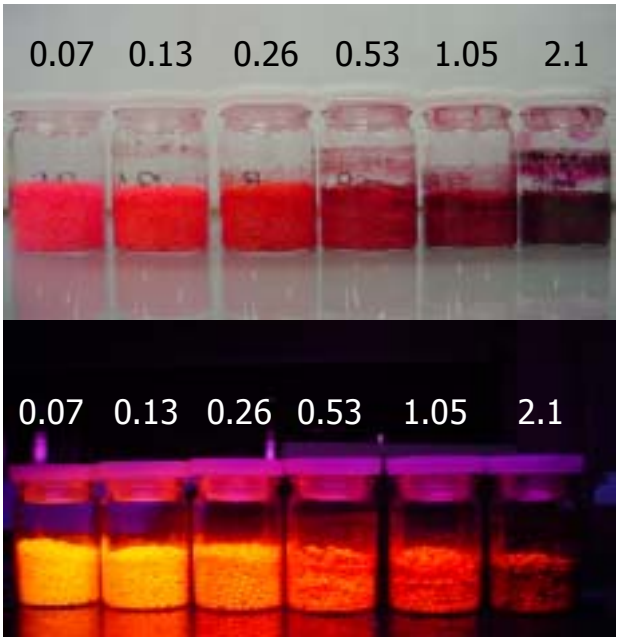

Fig. 3. Rhodamine contained silica gel with various concentrations (upper). Luminescence images under UV light illumination are also shown in the figure (lower).

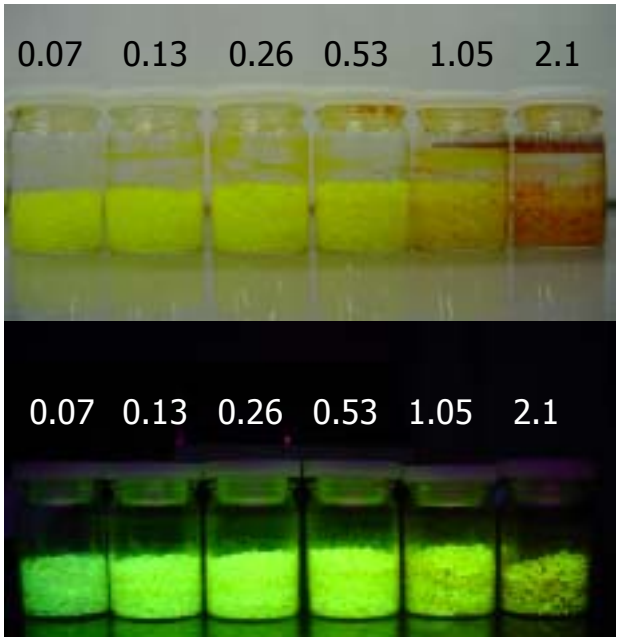

Fig. 4. Fliorescein contained silica gel with various concentrations (upper). Luminescence images under UV light illumination are also shown in the figure (lower).

peaks from the specimens varies after the exposure.

Rhodamine contained silica gel with various concentrations fabricated in this study are shown in Fig. 3 as compared with those under UV light illumination. Strong yellow and orange colored luminescence is seen from the rhodamine contained silica gel. PL intensity decreases with rhodamine concentration.

Figure 4 shows fluorescein contained silica gel with various concentrations. Specimens under visible light illumination and UV light illumination are shown in the figure. Green colored strong luminescence is seen from fluorescein contained silica gel. PL intensity increases with concentration from 0.07 to 1.05 %. It, then, decreases with concentration.

Figure 5 shows PL peak intensity of rhodamine contained silica gel and fluorescein contained silica gel with various concentrations. PL intensity of rhodamine contained silica gel decreases linearly with concentration. It is considered to be due to concentration quenching. While, PL intensity of fluorescein contained silica gel increases with concentration up to 1.05 %. It then decreases due to concentration quenching.

Temperature dependence of PL intensity from rhodamine contained silica gel is shown in Fig. 6. PL intensity of rhodamine contained silica gel decreases with temperature from room temperature to 220 °C. Temperature control and/or compensation are needed for sensor application of rhodamine contained silica gel. This result also suggests a possibility of temperature measurement using rhodamine contained silica gel.

Figure 7 shows Temperature dependence of PL intensity from fluorescein contained silica gel. Similar phenomenon to those of rhodamine contained silica gel is seen in the fluorescein. PL intensity from fluorescein contained silica gel decreases with temperature.

Figure 8 shows PL intensity from rhodamine contained

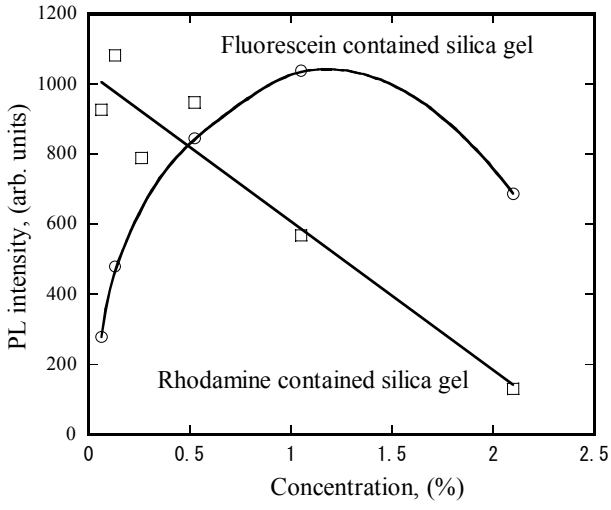

Fig. 5. Variation of photoluminescence intensity from fluorescein and rhodamime contained silica gel specimens with various concentrations. Concentration quenching can be seen in both specimens.

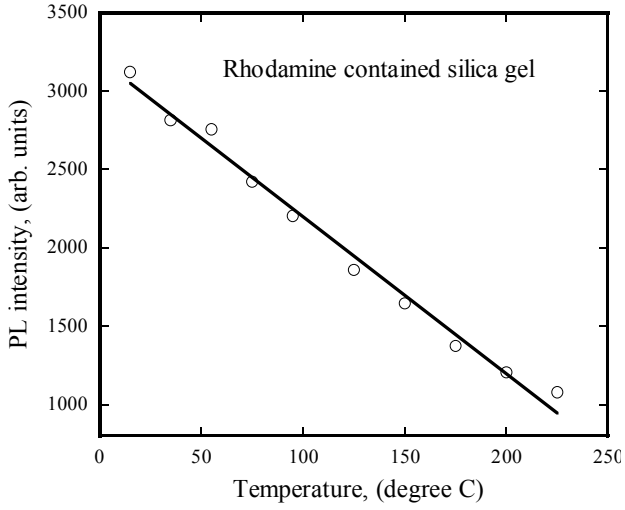

Fig. 6. Temperature dependence of photoluminescence intensity from rhodamine contained silica gel.

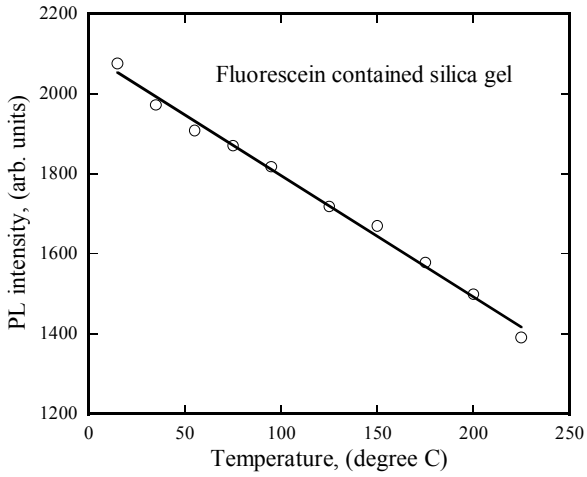

Fig. 7. Temperature dependence of photoluminescence intensity from fluorescein contained silica gel with various concentrations.

silica gel after exposed in the vapors of $CHCl_3$. PL intensity increases more than 15 % after exposure in $CHCl_3$ vapor. This change in PL intensity may be caused by the adsorption of $CHCl_3$. PL intensity decreases with thermal desorption at various temperatures of 60, 100, 140, 160 and 220 °C. From these results, rhodamine contained silica gel sensor can be used again after the thermal desorption process. Similar results are obtained in fluorescein contained silica gel. PL intensity of fluorescein contained silica gel also increases with $CHCl_3$ vapor introduction. Luminous organic pigments contained silica gel may be a potentially useful technique for detecting the vaporized organic compounds such as $CHCl_3$ vapor.

4. CONCLUSION

PL with strong intensity is observed from rhodamine and fluorescein contained silica gel. The PL intensity varies after exposure in volatile organic carbons (VOC), such as $CHCl_3$. Sensor can be used again after adsorption with VOC using thermal desorption process. It suggests that VOC can be detected based on the PL spectrum of the luminous pigment contained silica gel. Temperature control and/or compensation are needed for sensor application because of their temperature variation of PL intensity. Fluorescence sensor using luminous organic pigments contained silica gel is a potentially useful sensor material for detecting the vaporized organic compounds.

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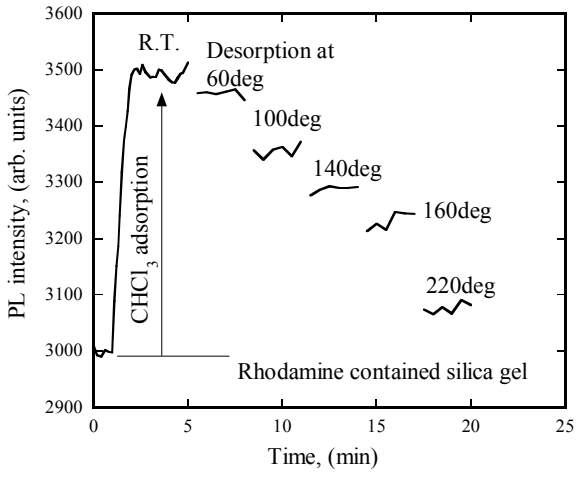

Fig. 8. Photoluminescence intensity from rhodamine contained silica gel after exposure in $CHCl_3$ gas. PL intensity increases with adsorption of $CHCl_3$. It decreases with thermal desorption at various temperatures.

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