Application of the highly siloxane-tolerant mesoporous silica absorbents to improve the lifetime of gas sensors

Junpei Furuno[1], Hiroki Kita[1], Kuniyuki Izawa[2], Ken-ichi Yoshioka[2], Tatsuya Tanihira[2], Masaya Matsuoka[1], Masato Takeuchi[1]

[1]*Department of Applied Chemistry, Graduate School of Engineering, Osaka Prefecture University, Osaka, Japan*

[2]*FIGARO Engineering inc., Osaka, Japan*

*E-mail: masato-t@chem.osakafu-u.ac.jp

Various gases, especially, siloxane compounds, in indoor environment damage gas sensors, causing false alarms [1]-[5]. Recently, low power-driven MEMS-type gas sensors have been developed. However, the quite smaller gas-sensing parts easily deteriorate by siloxane compounds as compared to commercial print-type gas sensors. The main purpose of this study is a development of highly siloxane-tolerant adsorbents to achieve long-term durability of MEMS-type gas sensors. Particularly, mesoporous silica materials containing Zr^{4+} and sulfo-groups have been fabricated and applied for the MEMS-type gas sensors.

Mesoporous silica materials such as SBA-15-p, Zr-SBA-15-p, SA-SBA-15-p and SA-Zr-SBA-15-p (p: platelet, SA: sulfo-group), were prepared and applied for removal of siloxane compounds. For comparison, a composite of alumina and MOR zeolite was used as a standard adsorbent. The adsorbents were characterized by XRD, N_2 adsorption-desorption isotherm, UV-Vis, SEM and FT-IR measurements. Adsorption properties for siloxane compounds were evaluated by adsorption isotherms of octamethylcyclotetra-siloxane (D4). Moreover, siloxane-derivatives adsorbed on those adsorbents were extracted by chloroform and examined by ^1H NMR. Durability against siloxane compounds were evaluated for proto-type MEMS sensors equipped with the prepared adsorbents.

From the pyridine-IR measurements, the Zr^{4+} sites and sulfo-groups were confirmed to work as Lewis and Brönsted acid sites, respectively. Adsorption isotherm of D4 siloxane revealed that the adsorbents containing Zr^{4+} sites efficiently adsorbed D4 siloxane thinly diffused in gas phase. In contrast, the Brönsted acidity of sulfo-groups played an important role in oligomerization of D4 into D5 or Dx (x > 6). The figure shows the results of the durability tests of the proto-type MEMS sensor modules in the presence of siloxane compounds (30 ppm). The sensor modules equipped with the SA-SBA-15-p (d) and SA-Zr-SBA-15-p (e) showed 12.5 and 25 times higher durability, respectively, as compared to the one equipped with a conventional filter material (Al_2O_3+MOR zeolite). Furthermore, the platelet shaped mesoporous silica also gave a solution for efficient diffusion of iso-butane (a target molecule of the MEMS-type gas sensors).

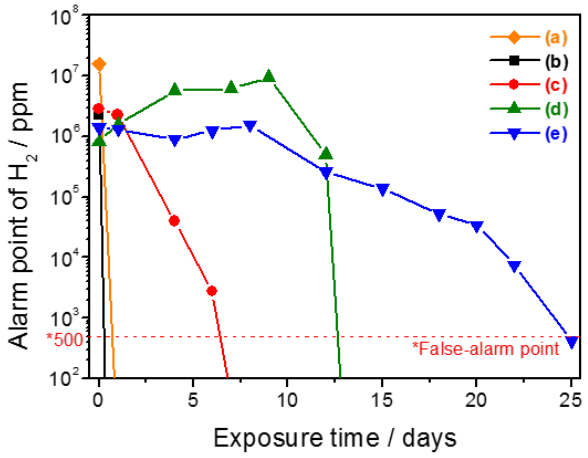

Fig. Results of the durability test of the sensor modules equipped with various adsorbents against siloxane compounds. Adsorbents : (a) Al_2O_3+MOR zeolite, (b) SBA-15-p, (c) Zr-SBA-15-p, (d) SA-SBA-15-p and (e) SA-Zr-SBA-15-p.

REFERENCES

[1] K. Park, E. M. Logothesis, *J. Electrochem. Soc.*, **124**, 1443 (1977).

[2] N. Yamazoe, K. Kurokawa, T. Seiyama, *Sensors and Actuators*, **4**, 607 (1983).

[3] R. G. Bright, *National Bureau of Standards (U.S.)*, NBSIR76-990 (1976).

[4] R. W. Bukowsk, R. G. Bright, *National Bureau of Standards (U.S.)*, NBSIR74-591 (1974).

[5] R. W. Bukowski, *Fire Safety Journal, Washington*, 78 (1976).