Complementary Skin Gas Sensor Based on Hybrid Structure using WO_3 nanoparticles and Zeolites

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1. Introduction

Metal oxide semiconductor based gas sensors are widely used for health care gas sensors, detecting the respiratory and skin gases from human body and it makes health care and disease screening possible. Concentration of acetone skin gas is the index of metabolic data such as fat-burning in human body. By using the biological mechanism, it is possible to take health care analysis in home with mobile device.

Despite of wide use of WO_3 semiconductor for gas sensor, lots of researches are still in progress to improve its gas selectivity.[1] Considering that porous zeolites show the various gas absorption characteristics by different pore sizes. By applying porous zeolites have different pore sizes on the gas sensors, it is expected to get high selectivity by adsorbing targeted gases onto zeolites. In addition that, combination with many kinds of gas sensors which have different gas sensitivity shows much better performance of sensors by signal analysis of each sensor.

2. Experiment

To combine the zeolite concentrator and WO_3 gas sensors, 390HUA and LTA 4A zeolite materials are used in order to get high gas concentrating characteristics against to acetone and NH_3 skin gas respectively. By using two different types of gas sensors, it could be acquired complementary gas detection performance with high sensitivity and selectivity. Fabrication of the zeolite/WO_3 hybrid gas sensors is initiated from preparing the commercial WO_3 nanoparticles with a particle diameter of 7.3 nm. Fabrication process of skin gas is same with previous study[2] except the zeolite layer. Two different types of zeolites are prepared which have 4Å (LTA 4A) and 7.4Å (390HUA) pore size respectively. As a result, 390HUA zeolite combined sensors show very sensitive to acetone gas only and it is hard to detect non-target gases such as ethanol, acetaldehyde, and NH_3 as shown in Fig. 1. (left) Nevertheless, 4A combined gas sensors get changed characteristics as shown in right side of Fig. 1. It responses to NH_3 with higher sensitivity than acetone gas although theirs sensing material is totally same as WO_3 nanoparticle.

Moreover, Langmuir constants between zeolites and skin gases can be calculated through the gas response data matching by Langmuir isotherm model which is correlated with adsorption/desorption energy between skin gases and zeolites. By using calculated desorption energy, it's able to estimate the gas desorption temperature from zeolite and it leads the experiments of gas separation. Representatively, desorption energy of acetone/390HUA is calculated to 136 kJ/mol and desorption temperature is 190℃. These values are quite close to measured values of 138 kJ/mol and 189℃ respectively.

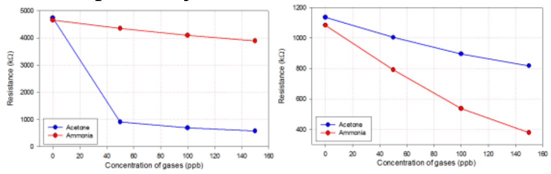

Fig. 1. Grain boundary resistance of hybrid gas sensors using 390HUA (left) and 4A (right)

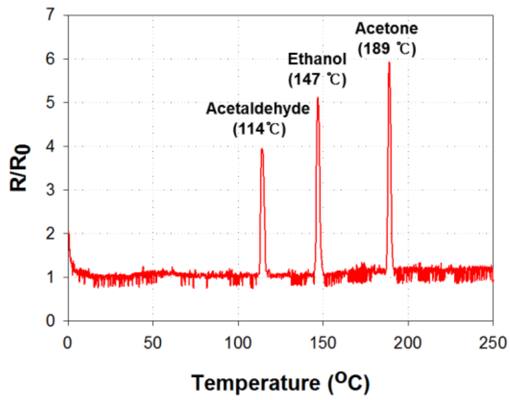

Fig. 2. Response of concentrated skin gases against to device temperature

3. Conclusions

Hybrid structured gas sensors using WO_3 nanoparticles and zeolites are fabricated. Improved response of sensitivity against to acetone and NH_3 gases are acquired by 390HUA and 4A zeolites respectively. Additionally, by analyzing the response signals of desorption temperature of each gases, it is possible to calculate adsorption/desorption energy of skin gases from zeolites as shown in Fig. 2. The results would be useful technique of gas filtering for higher gas selectivity.

References

[1] S. Vallejos *et al.*, Sens. Actuators, B, 132(2008), 209
[2] Y. Yamada *et al.*, Anal. Chem., 7588(2015), 87