Study of ozone oxidation of dimethyl sulfide and surface analysis of iodine catalysts

Yoshinori Mizuno[1, 2], Ahmad Guji Yahaya[2], Jaroslav Kristof[2], Eizo Murakami[1] and Kazuo Shimizu[2]

1 Asahikogyosha Co. Ltd., Japan. 2 Shizuoka University, Japan.

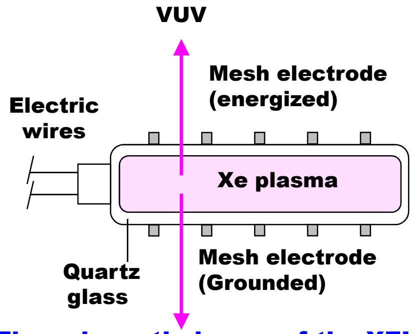
1. Introduction

Wastewater treatment facilities are attracting much attentions owing to the sustainable development goals (SDGs). These facilities emit dimethyl sulfide ($(CH_3)_2S$, DMS) due to the decay of organic compounds, and air purification systems are needed to prevent offensive odor pollution.

In this research, ozone catalytic oxidation using xenon excimer lamp (XEL) and iodine (I^- and IO_3^-) catalyst were studied to compose the air purification equipment inexpensively. XEL was used for ozone generation. Catalytic ability was investigated by gas treatment experiment, and surface analysis was conducted by pH measurement and XPS analysis.

2. Materials

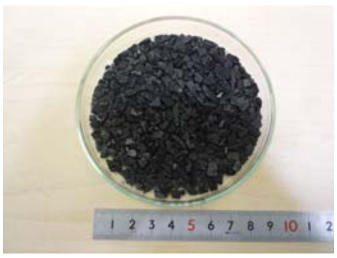
1. XEL: Ozone generator



The schematic image of the XEL

Pulsed negative high-voltage was applied to the XEL. Vacuum-Ultra-Violet (VUV) was emitted from Xe plasma. Oxygen molecules was decomposed by VUV ozone was generated.

2. Activated carbon (catalysts)



The photo image of activated carbon

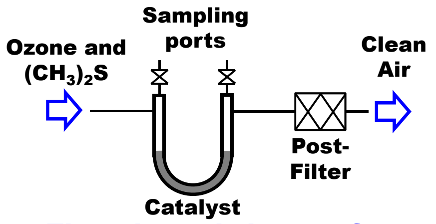
In this research, 3-types granular activated carbons were tested as catalyst. Impregnation materials are described as below.

- No impregnation (AC)
- Iodine (AC-I)
- Iodine and H_2SO_4 (AC-I/S)

Iodide (I^-) can be oxidized to iodic acid (IO_3^-) by ozone. And, iodic acid could oxidize the dimethyl sulfide due to the high oxidation potential. Thus, iodine could be useful as an ozone oxidation catalyst.

3. Methods

1. Experimental setup



The schematic image of the experimental setup

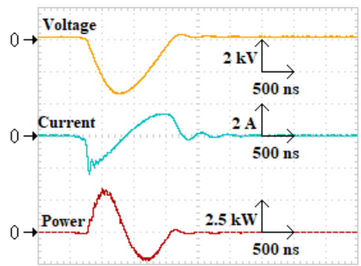
When outlet of dimethyl sulfide concentration approached 5 % of inlet, the catalyst is regarded as breakthrough. Breakthrough time of dimethyl sulfide was measured

2. Experimental condition

Inlet $(CH_3)_2S$: 3 ppm
Inlet Ozone: 0 - 12 ppm
Flow velocity: 0.15 m/s
Filling length: 72 mm
Residence time: 0.48 s
Environment: 25 ℃ 45 %

4. Results and discussions

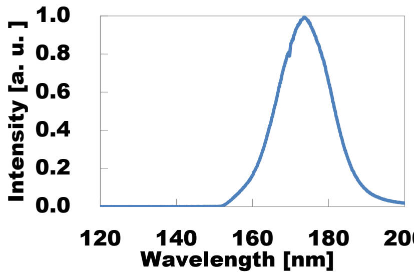
1. Discharge power of XEL



The Discharge power waveform of the XEL

Power consumption of one-shot pulse was calculated by integration of the discharge power and its value was 187 μJ. Power consumption was controlled by pulse frequency.

2. Emission spectra of XEL



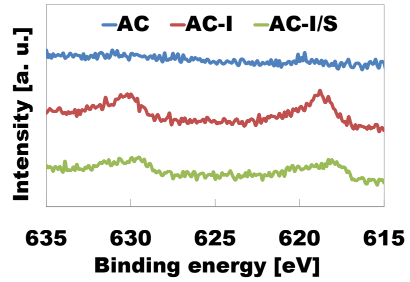
The emission spectra of XEL

Light emission of peak wavelength of 172 nm, full width at half height of 16 nm was observed. This characteristic light is emitted by xenon excimer.

3. Ozone generation by XEL

Ozone generation efficiency of XEL was 19 kWh/kg. And, NOx/Ozone was less than 0.3 %. XEL could generate ozone without NOx generation.

4. Surface analysis of catalyst



Iodine XPS analysis

pH measurement

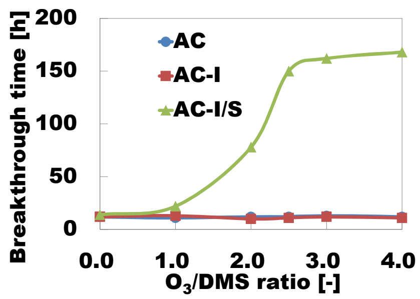
AC	AC-I	AC-I/S
9.7	9.8	2.4

pH decrease could be due to the acid dissociation of H_2SO_4.

According to the XPS analysis, Iodine (3d) peaks were detected from AC-I and AC-I/S. The binding energy of $I_3d_{5/2}$ was about 617 ~ 618 eV for both AC-I and AC-I/S. Thus, iodide was the major state in AC-I and AC-I/S.

These results show difference between AC-I and AC-I/S in surface acidity, however, iodine states were similar.

5. Gas treatment experiment



Breakthrough time versus ozone concentration

In AC and AC-I, breakthrough time did not change by ozone addition. However, in AC-I/S, breakthrough time was increased by ozone addition. Thus, surface acidity is important in iodine catalyst and acidic property is suitable.

5. Conclusion

- XEL emit 172 nm VUV by Appling negative pulsed high voltage.
- XEL could generate ozone without NOx generation.
- Activated carbon impregnated with only iodine was not applicable as ozone catalyst. However, activated carbon impregnation with iodine and H_2SO_4 could be utilized as ozone catalysts.
- surface acidity is important in iodine catalyst, and acidic property was suitable for applicable in ozone catalytic oxidation.