

# Ozone Generation by Superimposing Silent Discharge and Ultraviolet Irradiation

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## Abstract

Ozone generation by superimposing silent discharge and ultraviolet irradiation is experimentally investigated. The superimposing silent discharge and ultraviolet irradiation reactor consists of double coaxial cylinders. The outer tube is made of a pylex glass with an electrode rolled aluminum foil, while the inner tube is made of a quartz with an electrode coiled nickel wire. AC 50 Hz high voltage is applied between both electrodes. The inner tube is consisted of mercury lamp used for ultraviolet irradiation. The experiments are conducted for discharge power from 0 to 3W, gas flow rate from 0.3 to 1.3  $\ell$  /min, and silent discharge, ultraviolet irradiation and superimposing both mode. The generated ozone is measured with the iodometric method. Ozone is generated from pure oxygen. These experiments show that ozone generation by superimposing silent discharge and ultraviolet irradiation has an optimum condition on the number of turns of coiling electrode and is confirmed to be useful in high flow rate.

## 1. INTRODUCTION

The production of ozone for industrial purposes is exclusively performed in so called silent discharges. And it is well known that surface discharges are also an effective method for the production of ozone. We previously proposed an ozonizer in which silent discharge and surface discharge can be superpoed in same space, and its results confirmed of synergestic effect on ozone generation under special condition [1].

By electronic collisional dissociation of  $O_2$ , atomic oxygen is produced which is necessary for the ozone generation. The cross sections for vacuum ultraviolet dissosiation of  $O_2$  are well known than those for electronic

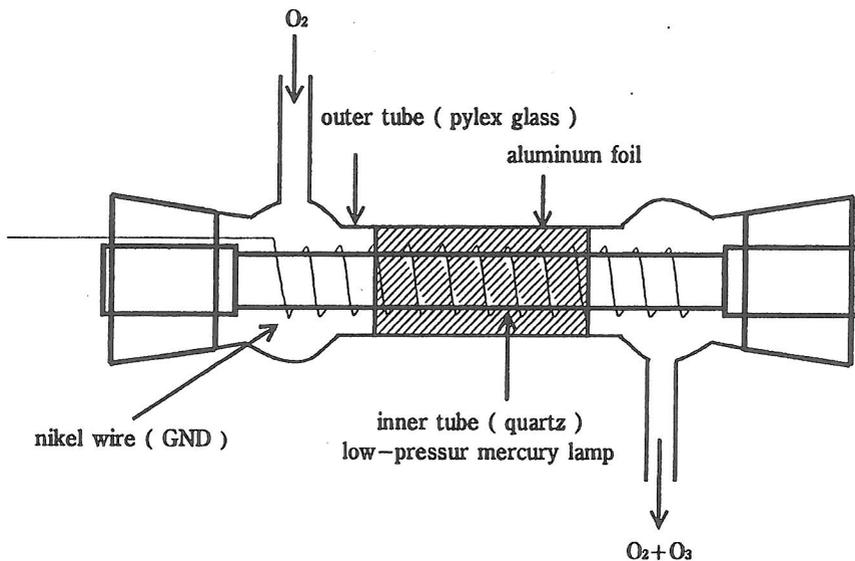


Figure 1 Schematic reactor

dissociation, and ozone generation by irradiation with the vacuum ultraviolet-light at 157.6nm was reported in [2].

In this work, an experimental investigation has been conducted to generate ozone in pure oxygen by superimposing silent discharge and irradiation to oxygen gas with the ultraviolet-light.

## 2. Experimental Apparatus And Methods

The superimposing silent discharge and ultraviolet irradiation reactor is consisted with double coaxial cylinders as shown in Figure 1. The outer tube ( 35cm longs, i.d. 3cm ) is made of a pylex glass with an electrode rolled aluminum foil, while the inner tube ( 35cm longs, i.d. 1.8cm ) is made of a quartz with an electrode coiled nickel wire.

The inner tube is consisted of low-pressure mercury lamp used for ultraviolet irradiation. Low-pressure mercury lamp is produced with Sen Lights corporation UVL-15. In this lamp, approximately 0.01mg of mercury vaper is sealed in the lamp and ultraviolet-light is radiated by electric discharge. The strongest rays produced by a low-pressure mercury lamp occur at wavelength 253.7nm. The second stronger rays are at 184.9nm. More than 90% of the light

energy of a low-pressure mercury lamp is concentrated at these two wavelengths.

Oxygen gas of atmospheric pressure can flow between the outer and inner tubes. Oxygen gas is irradiated with ultraviolet-light. On the other hand, when AC50Hz high voltage is applied between aluminum foil and nickel wire electrodes, the silent discharge is produced in oxygen gas.

The experiments are conducted for discharge power from 0 to 3W, oxygen gas flow rate from 0.3 to 1.3 l /min and the number of turns of coiling electrode on the inner tube. The input discharge power is measured by Lissajou figures. The generated ozone is measured with the iodometric method. Ozone is generated from pure oxygen. Experiments were carried out only silent discharge ( silent discharge mode ) and superimposing silent discharge and ultraviolet irradiation ( superimposing mode ).

### 3. RESULT AND DISCUSSION

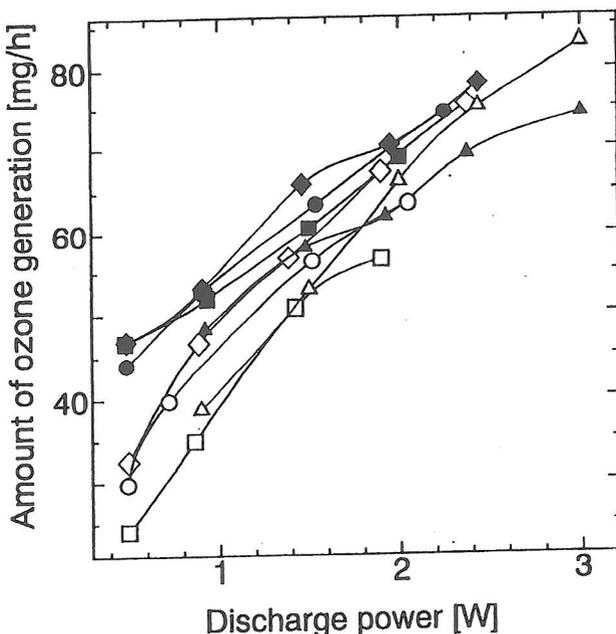


Figure 2 Ozone generation as a function of discharge power

- flow rate : 1 [ l /min]
- :silent discharge mode 3 turns
  - :superimposing mode 3 turns
  - :silent discharge mode 6 turns
  - :superimposing mode 6 turns
  - ◇ :silent discharge mode 15 turns
  - ◆ :superimposing mode 15 turns
  - △ :silent discharge mode 40 turns
  - ▲ :superimposing mode 40 turns

The ozone generations with various number of turns of coiling electrode on the inner tube are shown in Figure 2 as a function of discharge power. This Figure shows the amount of ozone generations by superimposing mode and discharge only mode. The amount of ozone generation increase with increasing discharge power. In each discharge power, ozone generation by superimposing mode is much higher than by silent discharge mode for each turns except for 40 turns.

The ozone generations are shown in Figure 3 as a function of the number of turns of coiling electrode on the inner tube. In both superimposing mode and silent discharge mode, the maximum amount of ozone generation was shown with 15 turns of coiling electrode. It is considered that the cause of low ozone generation amount at 40 turns is a rise in temperature in discharge space.

The ozone generations are shown in Figure 4 for superimposing mode and the silent discharge mode, as a function of discharge power. This figure shows

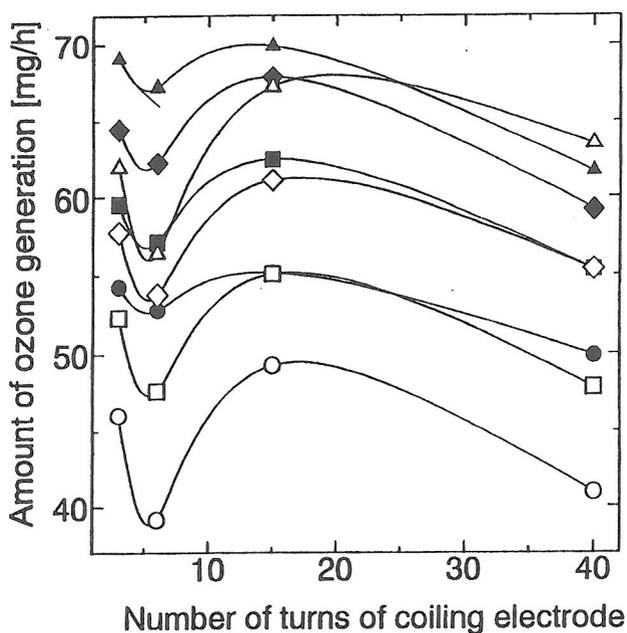


Figure 3 Ozone generation as a function of the number of turns of coiling electrode

- :silent discharge mode 1.0 W
- :superimposing mode 1.0 W
- :silent discharge mode 1.3 W
- :superimposing mode 1.3 W
- ◇ :silent discharge mode 1.6 W
- ◆ :superimposing mode 1.6 W
- △ :silent discharge mode 1.9 W
- ▲ :superimposing mode 1.9 W

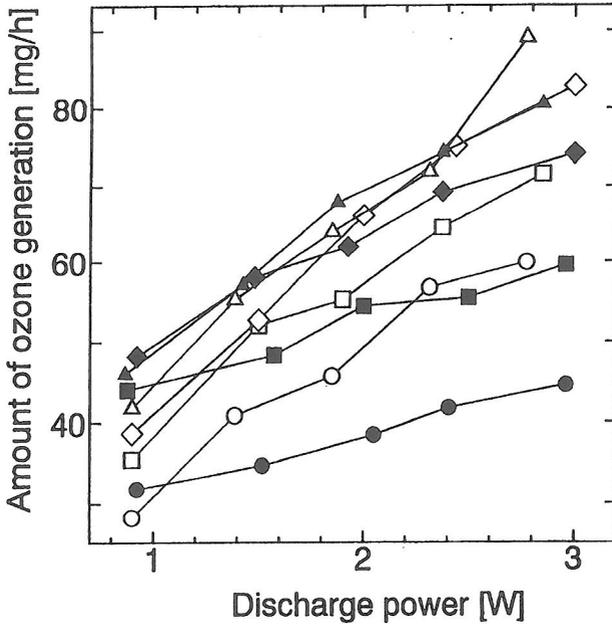


Figure 4 Ozone generations with various flow rate

- :silent discharge mode 0.3 m l /min      ● :superimposing mode 0.3 m l /min
- :silent discharge mode 0.5 m l /min      ■ :superimposing mode 0.5 m l /min
- ◇ :silent discharge mode 1.0 m l /min      ◆ :superimposing mode 1.0 m l /min
- △ :silent discharge mode 1.3 m l /min      ▲ :superimposing mode 1.3 m l /min

the result of the condition that the number of turns of coiling electrode on the inner tube are 40 turns. In both mode, the amount of ozone generation increase with increasing oxygen flow rate. Ozone generation by superimposing mode is much higher compared with the silent discharge mode in low discharge power. However, this relation have been reversed in high discharge power.

The turning point in this relation with each gas flow rate is plotted in Figure 5 as function of discharge power. This figure shows that the discharge power increase with increasing gas flow rate when superimposing mode is much higher than the silent discharge mode. It is considered that this increased range is due to the fact that ozone concentration decrease with increasing gas flow rate. Therefore, superimposing mode were confirmed to be useful for ozone generations in high gas flow rate.

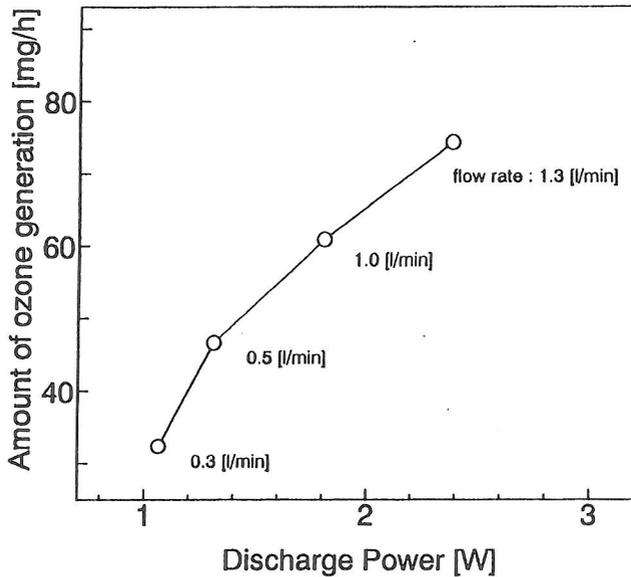


Figure 5 The turning point in relation between silent discharge mode and superimposing mode

#### 4. CONCLUSIONS

We investigated ozone generations by superimposing silent discharge and ultraviolet irradiation using the special discharge tube which is designed to irradiate ultraviolet-light from inner tube. The result was as follows,

- (1) Ozone generation increases with discharge power and gas flow rate.
- (2) Ozone generation by superimposing silent discharge and ultraviolet irradiation is much higher compared with only silent discharge mode in high gas flow rate.
- (3) Ozone generation by superimposing silent discharge and ultraviolet irradiation has an optimum condition on the number of turns of coiling electrode.

#### 5. REFERENCES

- [1] T.Ito, Y.Ehara and H.Onouchi : Proc. of ISPC 11th, vol.4 p1350-1355
- [2] B.Frisinger, U.Kogelschatz, J.H.Schfaer, J.Uhlenbush and W.Viol : Proc. of ISPC 9th, vol2 p793-744 (1989)