Temperature dependence of ozone loss rate

K. Omiya [1], I.M. Rusinov [2], S. Suzuki [1], H. Itoh [(*)1]

[1] *Graduate School of Engineering, Chiba Institute of Technology, Narashino, Chiba 275-0016, Japan*
[2]*Sofia University, Faculty of Physics, 5 James Bourchier Blvd., 1164 Sofia, Bulgaria*
[(*)] haruo.itoh@it-chiba.ac.jp

The effective lifetimes of ozone molecules in oxygen in a stainless steel cylindrical cell are obtained by monitoring the ozone losses by the HgI 253.7 nm photo-absorption method. To eliminate data biasing due to drifts of the low pressure mercury lamp intensity, a simple and compact version of the double beam setup is used. It is based on the usage of a reference channel with a separate light detector and calculated drift corrections. In this work results on the temperature dependence of the ozone effective lifetimes in the temperature range 20-80 ℃ for oxygen pressure values between 10 and 1000 Torr are reported.

Due to its strong oxidizing potential, ozone is increasingly being used for water treatment, semiconductor processing, and recently also in the medical field. Moreover, ozone transforms into oxygen by natural decomposition in the environment [1]. To study the loss processes of ozone molecules connected with their interaction with solid surfaces, we implement a photo-absorption experimental setup. It is used for long-term monitoring of the ozone density in oxygen contained in a cylindrical chamber – absorption cell. The examined losses of ozone are at low rates and usually lengthy experiments with durations reaching hundreds of minutes are required. To take account for the drift of the light source intensity with time due to temperature variations and other factors during such experiments [2], we use a double beam method [3]. In this work, our measurements are spread to the temperature dependence of the ozone loss rates in a stainless steel absorption cell.

Fig. 1 shows the experimental setup. The ozone–oxygen gas mixture, which is fed to the cell, is prepared from pure oxygen by using a negative corona discharge. The light intensity I_{in} from the UV light source is split by the half mirror in front of the cell, and is measured with the photodiode as a reference signal I_{ref}. The ozone density in the cell is derived from the photomultiplier sample signal $I_{out}(t)$ which is appropriately corrected for drift as shown by equation (1).

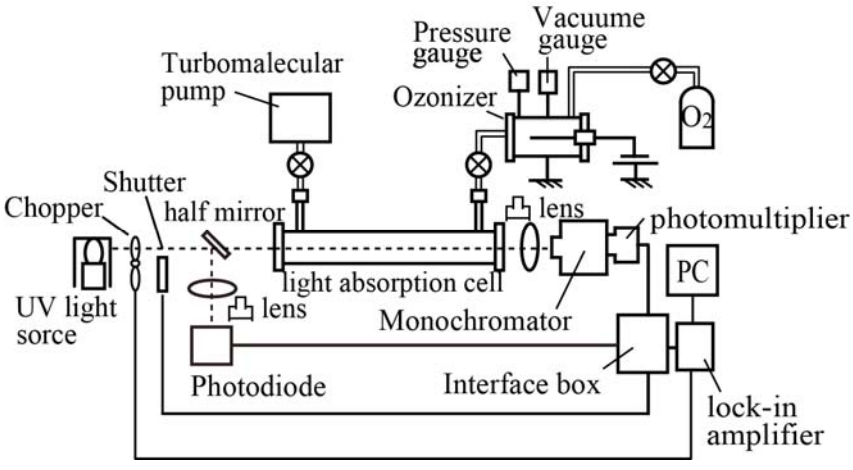

Fig.1: Experimental apparatus.

$$c(t) = \frac{1}{\sigma L}\left(I_{in}(0)\frac{I_{ref}(t)}{I_{ref}(0)}\frac{1}{I_{out}(t)} \right) \qquad \cdots(1)$$

Here, $c(t)$ is the ozone density (cm^{-3}), L is the cell length (cm) and $\sigma = 1.154 \times 10^{-17}$ cm^2 is the photo-absorption cross section of ozone at 253.7 nm [4].

The cell temperature is maintained by circulating water in a copper pipe that is wound and soldered around the cell. Therefore, the gas temperature is considered equal to the cell temperature. The water is kept at constant temperature by a temperature control system. The temporal variation of the ozone density in oxygen is obtained for various gas pressure values between 10 and 1000Torr at several temperatures in the range 20-80℃.

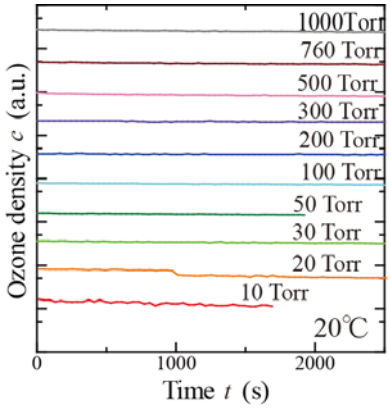

Fig. 2: Temporal decrease of ozone density in the cell at 20℃.

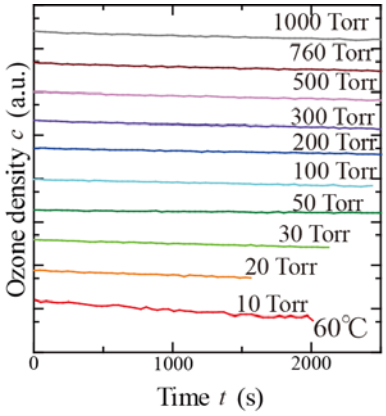

Fig. 3: Temporal decrease of ozone density in the cell at 60℃.

The obtained temporal variations of the ozone density are shown in Fig.2 and Fig.3. In both figures, the ozone density decreases exponentially with time. The slope of the straight line represents the decay rate and its inverse is the effective lifetime τ of the ozone molecules in the cell.

Fig. 4 shows gas pressure dependences of the ozone effective lifetime τ in log-log plots.

Diffusion as well as volume losses contribute to the values of τ, as discussed in previous works [5]. The effective lifetimes tend to decrease for higher temperatures at all pressure values, suggesting more intense decomposition of ozone molecules at the stainless steel wall surface and in the gas phase. A tendency of flattening of the greater portion of the pressure dependence at elevated temperatures is observed as well. This feature seems connected with changes in the wall surface properties and needs further examination.

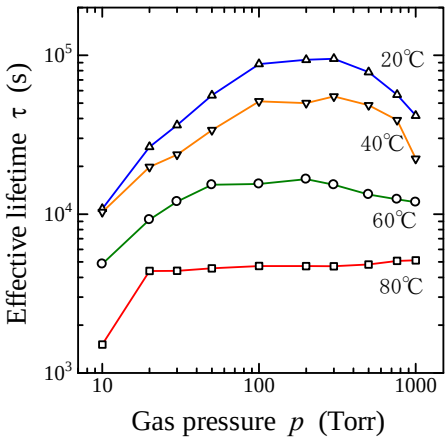

Fig. 4: Observed values of ozone effective lifetime against gas pressure.

More detailed experiment on the reproducibility and at high temperature is currently being carried out.

References

[1] U. Kogelschatz, in *Non-Equilibrium Air Plasma at Atmospheric Pressure*, K. H. Becker, U. Kogelschatz, K. H. Schoenbach and R. J. Barker, *Eds., IOP Publishing Ltd, Bristol, UK*., 551-565 (2005).
[2] H.Itoh, S.Isegame, H.Miura, S.Suzuki and I.Rusinov, Ozone Science&Eng., 33, 106-113 (2011)
[3] H.Itoh, I. M.Rusinov, K.Omiya, and S.Suzuki, Ozone Science&Eng., (in printing)
[4] E. C. Y. Inn and Y.Tanaka, *J. Opt. Soc. America*, 43, 870-873 (1953)
[5] H.Itoh, I.M. Rusinov, T.Suzuki, S.Suzuk, Ozone Science & Eng., 26, 487-497 (2004)