Topic number: 1

DETERMINATION OF COLLISIONAL QUENCHING RATE COEFFICIENT OF $N_2(A^3\Sigma_u^+)$ BY XYLENE

Susumu Suzuki[1,*], Haruo Itoh[1]

[1] Chiba Institution of Techology

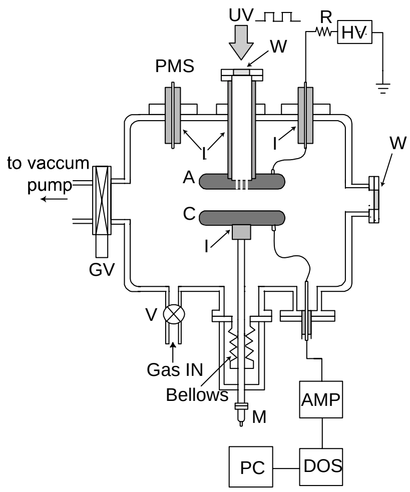
[*] **susumu.Suzuki@it-chiba.ac.jp**

The metastable nitrogen molecule $N_2(A^3\Sigma_u^+)$ performs an important role as an active species in the reaction process in air plasma [1], which is considered to include various environmental pollution gases. We have previously determined the collisional quenching rate coefficient of $N_2(A^3\Sigma_u^+)$ by air pollutant gases, such as CO, CH_4, NO, CCl_2F_2, and CH_2FCF_3 [2]-[4]. Recently, our investigation has expanded to gases that cause sick building syndrome such as benzene (C_6H_6), acetone ($(CH_3)_2CO$), toluene ($C_6H_5CH_3$), and formaldehyde (CH_2O) [5][6].

This paper deals with the determination of the collisional quenching rate coefficient of $N_2(A^3\Sigma_u^+)$ by *m*-xylene (C_8H_{10}). Xylene is used as a solvent and a diluent in adhesives and paints. Among the three isomers of xylene, *m*-xylene, which has the weakest binding strength with methyl groups, is examined. The collisional quenching rate coefficients of $N_2(A^3\Sigma_u^+)$ by xylene (*o*-xylene, *m*-xylene, and *p*-xylene) have not been reported to the best of the authors' knowledge. Therefore, this is the first report in which the quenching effect of $N_2(A^3\Sigma_u^+)$ by xylene is described.

A schematic of the apparatus used in this study is shown in Fig. 1. Because the experimental apparatus and procedure have already been reported [2]-[6], The details are omitted here. The used gas is N_2 (purity 99.999%) mixed with *m*-C_8H_{10} (purity 99.5%) with a concentration of 1ppm, and a gold-plated cathode of Rogowski profile type and a copper disc cathode with 120 mm in diameter are prepared in the experiment.

Figure 2 shows the gas pressure dependence of the effective lifetime τ_1 of $N_2(A^3\Sigma_u^+)$ measured using the Au cathode. τ_1 is determined from the slope of the decay of the transient current waveforms. The experimental data is plotted with a log-log scale with error bars representing the standard deviation. The effective lifetime increases with a slope of approximately unity with the gas pressure. The solid lines are obtained by a curve-fitting procedure based on our



AMP: High-speed current amplifier, DOS: Digital oscilloscope, PC: Personal computer, GV: Gate valve, HV: High voltage, PMS: Gas pressure measurement system, UV: UV light, M: Micrometer, V: Valve, W: Quartz window, A: Anode, C: Cathode, I: Insulator

Fig. 1. Schematic of the experimental apparatus.

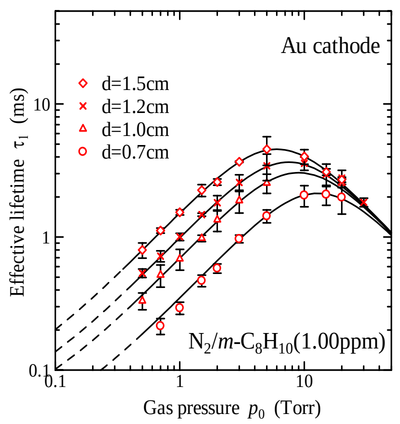


Fig. 2. Effective lifetime of $N_2(A^3\Sigma_u^+)$.

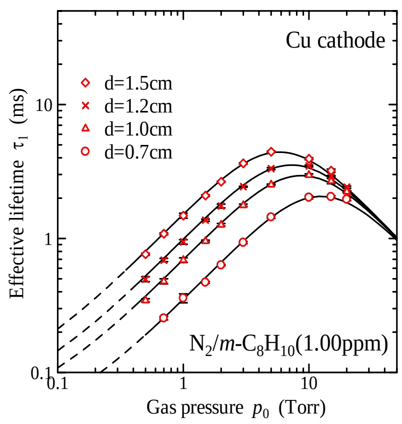


Fig. 3. Effective lifetime of $N_2(A^3\Sigma_u^+)$.

theory [6] using the present results. From these curves, the diffusion coefficient D_{m1}, the collisional quenching rate coefficient k' of $N_2(A^3\Sigma_u^+)$ by *m*-xylene, and the reflection coefficient R are 151 cm^2/s, 4.8×10^{-10} cm^3/s, and 0.01, respectively.

Figure 3 shows the obtained effective lifetime of $N_2(A^3\Sigma_u^+)$ measured using the copper disc cathode. Using the same curve-fitting procedure, D_{m1}, k', and R are 152 cm^2/s, 4.0×10^{-10} cm^3/s, and 0.1, respectively.

No significant difference is found between the results in Figs. 2 and 3 except for the reflection coefficient. The reflection coefficients of the electrode surface are 0.01 for the gold-plated cathode and 0.1 for the copper disc cathode.

Table 1. Collisional quenching rate coefficients k' of $N_2(A^3\Sigma_u^+)$ by air pollutions.

Gases	k' (cm^{3}s^{-1})
m-C_8H_{10}	$(4.4\pm0.6)\times10^{-9}$
CF_4	$(6.9\pm0.9)\times10^{-16}$
CH_4	$(1.6\pm0.1)\times10^{-15}$
CH_2FCF_3	$(2.9\pm0.6)\times10^{-15}$
C_2F_6	$(2.9\pm1.0)\times10^{-15}$
CO_2	$(3.8\pm0.4)\times10^{-13}$
CO	$(5.9\pm1.7)\times10^{-13}$
CCl_2F_2	$(8.3\pm0.2)\times10^{-13}$
CH_2O	$(4.7\pm0.4)\times10^{-12}$
NO	$(4.8\pm0.2)\times10^{-11}$
$(CH_3)_2CO$	$(2.2\pm1.3)\times10^{-10}$
C_6H_6	$(3.0\pm0.3)\times10^{-10}$
$C_6H_5CH_3$	$(6\pm3)\times10^{-10}$

In addition, the measured effective lifetimes are consistent with the theoretical curves shown in Figs. 2 and 3 by solid lines. This is a noteworthy feature of our experiment. The collisional quenching rate coefficients k' of $N_2(A^3\Sigma_u^+)$ by air pollution gases that have been measured so far are shown in Table 1, in which k' for C_8H_{10} is the largest value.

Reference

[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. (2005)
[2] S. Suzuki, H. Itoh, H. Sekizawa and N. Ikuta, J.Phys.Soc.Jpn.,Vol.62, No.8, 2692-2697 (1993)
[3] S. Suzuki, T. Suzuki and H. Itoh, Cont. of HAKONE X Saga, Japan, 132-135 (2006)
[4] S.Suzuki, H.Itoh, H.Sekizawa and N.Ikuta, Jpn. J. Appl. Phys., 36, 4744-4746 (1997)
[5] T.Suzuki, S.Suzuki and H.Itoh: Proc. 13th Asian Conference on Electrical Discharge (Hokkaido University, Sapporo, Japan) P-2-40 (2006)
[6] S.Suzuki, D. Shibuya, M. Aoyagi and H.Itoh: 29th ICPIG, July 12-17, Cancún, México, PA1-8(2009)