Collisional quenching rate coefficient of $N_2(A^3\Sigma_u^+)$ by xylene

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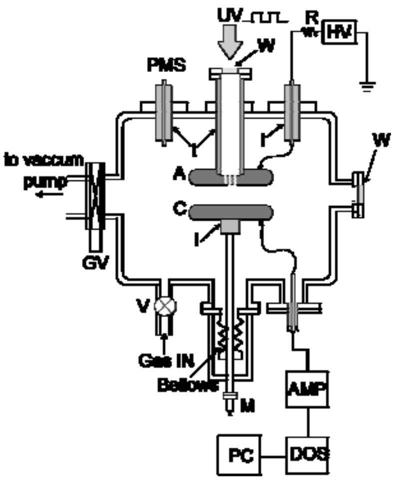
Effective lifetime of $N_2(A^3\Sigma_u^+)$ in N_2/*p*-xylene (C_8H_{10}) mixtures is carried out by the analysis of the transient current waveform after turning off the UV light in the Townsend discharge region. The collisional quenching rate coefficient of $N_2(A^3\Sigma_u^+)$ by *p*-xylene is determined together with the diffusion coefficient of $N_2(A^3\Sigma_u^+)$, and the reflection coefficient on electrode surface of $N_2(A^3\Sigma_u^+)$. The obtained collisional quenching rate coefficient of $N_2(A^3\Sigma_u^+)$ by *p*-xylene is $(6.5\pm0.9)\times10^{-9}$ cm^3/s. The value is higher than that of *m*-xylene and *o*-xylene.

The collisional quenching rate coefficients of $N_2(A^3\Sigma_u^+)$ in the air pollution gases [1]-[3] have been determined from the effective lifetime τ_1 of $N_2(A^3\Sigma_u^+)$. Recently, we investigate the xylene and have reported on the collisional quenching rate coefficient of $N_2(A^3\Sigma_u^+)$ by *m*-xylene(C_8H_{10}) and *o*-xylene [4]. There are three isomers in the xylene, and it is said that it is one of the causative agents with sick building syndrome. In this work, we investigate the determination of the collisional quenching rate coefficient of $N_2(A^3\Sigma_u^+)$ by *p*-xylene, and the result of *p*-xylene is compared with the results of *m*-xylene and *o*-xylene.

A schematic of the apparatus used in this study is shown in Fig. 1. The details of the experimental apparatus and procedure are omitted here, because it has already reported [1]-[4]. The used gas is N_2 (purity 99.999%) mixed with *p*-xylene (purity 99.5%) with a concentration of 0.998ppm.

Fig. 2 shows the gas pressure dependence of the observed effective lifetime τ_1 of $N_2(A^3\Sigma_u^+)$ in N_2/*p*-xylene(0.998 ppm) mixtures. The effective lifetime τ_1 is given by the inverse of the slope of the decreasing transient current waveforms [1]. The obtained effective lifetime is plotted with the error bar of the standard deviation on a log-log scale. The solid lines are given by the curve fitting procedure based on our theory [1]. The curves are proportional to gas pressure up to 5 Torr, beyond which they reach their maxima and become inversely proportional to gas pressure. From these curves, the diffusion coefficient D_{m1}, the collisional quenching rate coefficient *k*' of $N_2(A^3\Sigma_u^+)$ by *o*-xylene and the reflection coefficient *R* are determined as 156 ± 8 cm^2/s, $(6.5\pm0.9)\times10^{-9}$ cm^3/s and 0.18 ± 0.03, respectively.

Fig.3 shows the previous results of effective lifetime τ_1 of $N_2(A^3\Sigma_u^+)$ in *m*-xylene and *o*-xylene. In N_2/*m*-xylene(1.00 ppm) mixtures, from the curve fitting procedure, we determine the diffusion coefficient D_{m1}, collisional quenching rate coefficient *k*' of $N_2(A^3\Sigma_u^+)$ by *m*-xylene, and reflection coefficient *R*. The values are 151.2 ± 0.7 cm^2/s, $(4.4\pm0.6)\times10^{-9}$ cm^3/s and 0.10 ± 0.02. In addition, in N_2/(0.995 ppm) *o*-xylene mixtures, from the curve fitting procedure, we determine the diffusion coefficient D_{m1}, collisional quenching rate coefficient *k*' of $N_2(A^3\Sigma_u^+)$ by *o*-xylene, and reflection coefficient *R*. The values are 155 ± 2 cm^2/s, $(2.3\pm0.3)\times10^{-9}$ cm^3/s and $0.14\pm$



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.

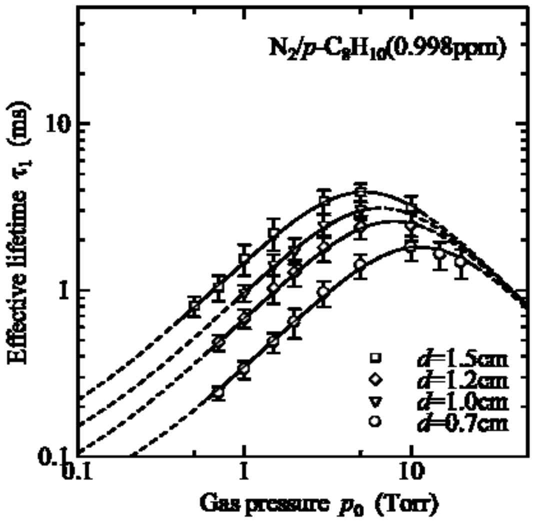


Fig. 2: Effective lifetime of $\mathbf{N_2(A^3\Sigma_u^+)}$ in N_2/*p*-xylene(0.998 ppm) mixtures.

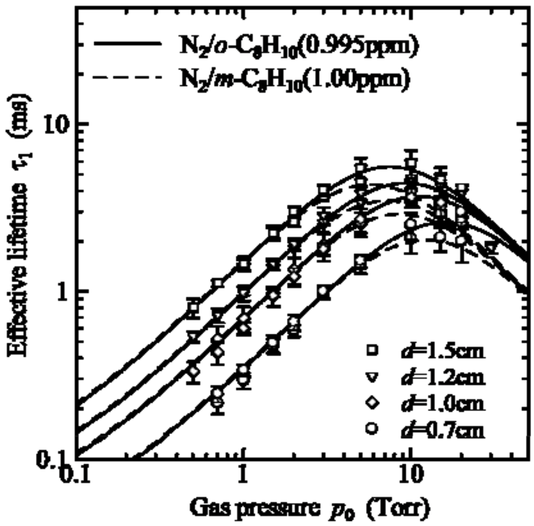


Fig. 3: Effective lifetime of $\mathbf{N_2(A^3\Sigma_u^+)}$ in N_2/*o*-xylene(0.995ppm) mixtures and N_2/*m*-xylene(1.00 ppm) mixtures.

0.01. It is understood that the error of mean square of τ_1 in *m*-xylene and *o*-xylene is smaller than that in *p*-xylene.

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. It is understood that the value of the xylene is the largest in the gas that authors measured, especially the value of *p*-xylene is the largest.

Furthermore, when we repeat the experiment, the result that the current-voltage characteristic changes greatly is obtained. It is thought that this cause is the influence of by-products of the xylene deposited on the cathode surface after exposing it to the discharge in N_2/*p*-xylene mixtures from the result of the analysis by Auger electron spectroscopy (AES) and Fourier transform infrared spectrophotometer (FT-IR).

Table 1: Collisional quenching rate coefficients *k*’ of $\mathbf{N_2(A^3\Sigma_u^+)}$ by air pollution gases.

Gases	*k*’ (cm^3s^{-1})
p-C_8H_{10}	$(6.5\pm0.9)\times10^{-9}$
o-C_8H_{10}	$(2.3\pm0.3)\times10^{-9}$
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	$(3.0\pm0.3)\times10^{-10}$
$C_6H_5CH_3$	$(6\pm3)\times10^{-10}$

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