Topic number: 1

MERCURY EXCITATION IN NITROGEN POST-DISCHARGE

V. Mazankova(*), F. Krcma, I. Bockova

Faculty of Chemistry, Brno University of Technology, Purkynova 118, 612 00 Brno, Czech Republic
(*)e-mail: mazankova@fch.vutbr.cz

Nowadays nitrogen flowing post-discharges are used for extensive field of applications [1]. It was pointed more times that nitrogen post-discharge is very sensitive to various impurities. The presented work extends our recent research of nitrogen DC flowing post-discharge containing mercury traces [2].

The DC discharge was created in a Quartz tube of 13 mm inner diameter at current of 100 mA. Hollow molybdenum electrodes in the distance of 120 mm were placed in the side arms of the main discharge tube. Nitrogen was of 99.9999% purity and it was further cleaned by Oxiclear and liquid nitrogen traps. The reactor system was pumped continuously by a rotary oil pump separated from the discharge tube by another LN_2 trap. The total pressure in the discharge tube was kept at 1000 Pa during experimental studies and it was measured by a capacitance gauge. Mercury was added into the main pure nitrogen flow before the active discharge using saturated vapor of mercury (partial mercury pressure was 0.6 Pa at 300 K). The mercury concentration in pure nitrogen flow was of about 0.06 %. Spectra of light emitted during the post-discharge were measured by Jobin Yvon TRIAX 550 spectrometer with CCD detector in the wavelength range of 180–800 nm. The light was lead to the entrance slit of the monochromator by a multimode quartz optical fiber movable along the discharge tube. The optical fiber holder (length of 6 cm with optical fiber mounted at its center) had to be filled by liquid nitrogen and thus the reactor wall temperature around (± 3 cm) the observation point was kept at 300 K or 77 K. Temperature inside the decaying plasma at 77 K wall temperature was calculated of about 100 K [3] by using the simulated nitrogen 1st positive ($N_2\,(B\,^3\Pi_g) \rightarrow (A\,^3\Sigma_u^+)$) 2-0 band spectrum. Nitrogen 1st and 2nd positive and 1st negative systems were recorded in all spectra. Compared to the previous study made in Pyrex tube [2] also the mercury line at 254 nm was recognized. In previous paper [2] we supposed also possibility for the mercury line at 185 nm emission but this have not been confirmed by these new experiments. No other mercury lines were observed.

The examples of recorded spectra during the post-discharge with mercury 254 nm line are shown in Fig. 1 for both reactor wall temperatures. The wall, or plasma, temperature decrease has a great influence on the line intensity that is typical for some resonance processes responsible for this line excitation. Figure 2 shows the dependence of mercury 254 nm line during the post-discharge at both wall temperatures. Intensity is normalized to the maximal intensity at wall temperature of 77 K. The intensity at ambient wall temperature is more or less constant during the post-discharge, the initial increase corresponds to up pumping v-v processes at the post-discharge beginning [1]. The explanation of experimental results obtained at 77 K is not such easy and the numeric modeling of post-discharge kinetics will be applied.

As we proposed in paper [2], the mercury excitation under post-discharge conditions can be described by the following reaction

$$N_2\,(X\,^1\Sigma_g^+,\, v = 19) + Hg\,(^1S_0) \rightarrow N_2\,(X\,^1\Sigma_g^+,\, v = 0) + Hg\,(^3P_1)$$

The strong temperature dependence of the mercury line excitation shows that the energy resonance is observed at low rotational levels of $N_2 (X\ ^1\Sigma_g^+,\ v = 19)$ vibrational state. This should help us for the verification of this vibrational level energy. Recently it was pointed [4] that nitrogen ground state should have up to 60 vibrational levels (instead of commonly used 46) but for confirmation of this statement the data of high vibrational level energies are missing up to now.

The other proposed reactions populating upper state of mercury line at 185 nm

$$N_2 (X\ ^1\Sigma_g^+,\ v = 28) + Hg\,(^1S_0) \rightarrow N_2 (X\ ^1\Sigma_g^+,\ v = 0) + Hg\,(^1P_1)$$

$$N_2 (X\ ^1\Sigma_g^+,\ v = 4) + Hg\,(^1S_0) \rightarrow N_2 (X\ ^1\Sigma_g^+,\ v = 0) + Hg\,(^1P_1)$$

have not been confirmed by our experimental observations. This should be due to stopping of post-discharge up pumping processes at nitrogen ground state level 19. To confirm this hypothesis we are preparing new experiments with introduction of mercury vapor directly into the post-discharge.

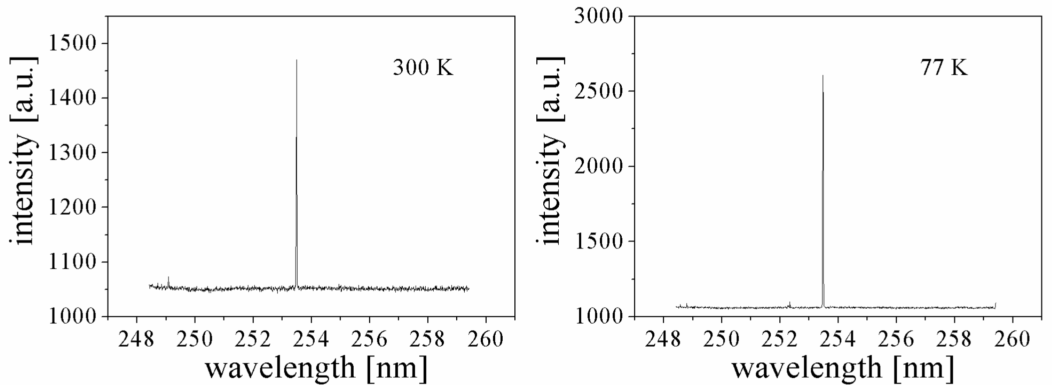

Fig. 1: Parts of recorded spectra for decay time of 50 ms and two different reactor wall temperatures.

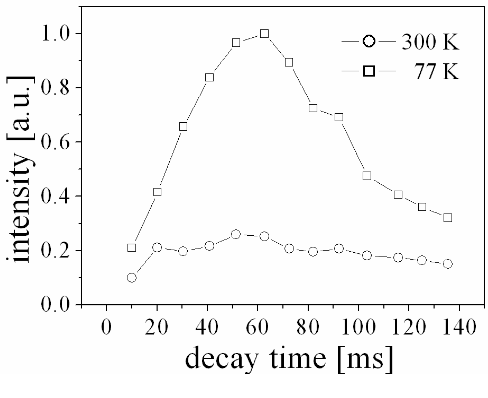

Fig. 2: Dependencies of mercury spectral line intensity, wavelength of 254 nm, on decay time during the post discharge for two different reactor wall temperatures.

Acknowledgements

This work was supported by Czech Science Foundation, project No. 202/08/1106.

Reference

[1] C. D. Pintassilgo, J. Loureiro, V. Guerra, 2005 *J. Phys. D: Appl. Phys.* **38** 417
[2] V. Kanicky, V. Otruba, A. Hrdlicka, P. Krasensky, F. Krcma, 2007 *J.Anal. At. Spectrom.* **22** 754
[3] F. Krcma, V. Mazankova, I. Soural, M. Simek, 2007 *Proc. ICPIG XXVIII*, Prague, 1722
[4] M. L. da Silva, J. Loureiro, V. Guerra, 2009 *Chem. Phys.***358** 123