Behaviour of analytical spectral lines emitted by plasma pencil operated in a continuous and in a pulsed mode

Lukáš Novosád[1], Aleš Hrdlička[1], Pavel Slavíček[2], Vítězslav Otruba[1], Viktor Kanický[1]

[1]Masaryk University, Central European Institute of Technology, CEITEC MU, Faculty of Science, Dep. Chemistry, Kamenice 753/5, 62500 or Kotlářská 2, 61137 Brno, Czech Republic, e-mail: ahrdlicka@chemi.muni.cz, ales2003h@centrum.cz
[2]Masaryk University, Faculty of Science, Dep. Physical Electronics, Kotlářská 2, 61137 Brno, Czech Republic, e-mail: 2220@mail.muni.cz, ps94@mail.muni.cz

Plasma pencil is a universal tool originally developed for solving non–standard problems in the archeology. It is in fact a narrow quartz tube or capillary with a barrier capacitively coupled discharge boosted by a radiofrequency (RF) sinusoidal wave at 13.56 MHz originally in the continuous mode. However, the RF wave can be modulated by various methods, e. g. by frequency or amplitude modulation. The plasma gas is pure argon or helium under atmospheric pressure in this application. Chemical analysis of liquids with the plasma pencil was simulated using sets of standard water solutions of Na^+, Li^+, Ca^{2+}, Mg^{2+}, Cu^{2+} and Zn^{2+} ions. Excitation capabilities, calibration dependences in the range of 1–100 mg l^{-1} and 3σ detection limits for these elements were acquired in the both continuous and in the pulsed mode. Aqueous solutions of calibration standards (0.6 ml min^{-1}) were delivered into a Scott spray chamber with a concentric nebulizer showing an efficiency about 6 %. The produced aerosol was introduced by argon (0.3 l min^{-1}) perpendicularly into the plasma pencil operated in flowing argon (4 l min^{-1}). Electrical input power coming into the plasma was in the range of 120–140 W. To create a pulsed mode the carrying wave 13.56 MHz was internally modulated by rectangular wave 22 kHz with duty cycle 90 %. These electrical parameters guaranteed a high stability of the discharge. Rotational temperatures and electron number densities for the pencil under and without water load and sample load were calculated using OH spectra and H beta line and are very similar for both modes. Atomic lines of the elements above were well observable even if the excitation temperatures are relatively low about 1000 K. Intensities of the calibration lines in the continuous mode are lower than in the pulsed mode. Limits of detection are similar for both modes. Intensities of analytical lines of the elements, rotational temperatures and electron number densities along the discharge tube were acquired in 4 different positions in the range of 11–15 cm from the aerosol entrance. These results indicate that the continuous mode should be rather replaced by pulsed mode in some applications.

Acknowledgement
This work was supported by the projects CEITEC – Central European Institute of Technology (CZ.1.05/1.1.00/02.0068) from European Regional Development Fund and MSM0021622411 of the Ministry of Education, Youth and Sports of the Czech Republic.