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Spatial distribution of radiant intensity from primary sources for atomic absorption spectrometry. Part II: Electrodeless discharge lamps

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Abstract

The spatial distribution of radiant intensity from electrodeless discharge lamps (EDLs) used as radiation sources in atomic absorption spectrometry is investigated with a digital photodiode array imaging system. Intensity distribution over the radial and longitudinal sections of Pb and Hg lamps is measured for both atomic and ionic lines of the analyte and the filler gas. The plasma in the EDLs is highly structured, with metal and filler gas excited species being distributed nonuniformly but in different ways. The clouds of emitting metal and Ar atoms are spatially separated in the volume of the Pb EDL. The excited Pb atoms detected from both the resonance and nonresonance lines have the form of a thin layer concentric to the bulb walls located near the surface of the bulb ("optical skin effect"). In contrast, the emission distribution for Ar atomic lines is bell-shaped with a maximum at the center of the plasma. The spatial distribution of emitting Ar ions is more complex - there is a bulk maximum coinciding with Ar atomic emission maximum and another maximum concentric to the walls coinciding with the maximum of metal atom emission. In the Hg EDL the difference between the spatial intensity profiles of metal and filler gas (Ar) lines is less pronounced because of the use of an increased filler gas pressure in the lamp. Emitting species of both Ar and metal are primarily located in the bulk of the plasma with, however, a small depletion in the vicinity of the lamp axis. Evolution of the spatial intensity profiles during warm-up of the lamps is investigated as well. In both lamps the radial and longitudinal intensity distributions of metal lines are established during the first minutes after lamp ignition, after which there is a slow and monotonic increase of the established intensity profiles. This result implies thermal vaporization as a mechanism of analyte supply to the plasma. The spatial intensity profiles for Ar lines are established in the first seconds after lamp ignition, after which only the absolute values of the established distributions change. The approach to the steady-state intensity of Ar atomic and ionic lines is nonmonotonic; there is a clearly pronounced initial overshoot in intensity of Ar atomic lines that coincides with a decline in the intensity of Ar ion lines. An interpretation for the observed spatial intensity profiles is given on the basis of radial cataphoresis theory.

Keywords

Argon, lead, and mercury lines, Atomic absorption spectrometry, Electrodeless discharge lamps, Radial cataphoresis effect, Spatial distribution of radiant intensity