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Application of Multi-Step Excitation Schemes for Detection of Actinides and Lanthanides in Solutions by Laser Spectroscopy

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Development of laser spectroscopy with tunable lasers gives rise to new procedures for detection of trace amounts of various substances in various media. A possibility to tune a wavelength of laser radiation allows selective action on certain atoms and molecules and, hence, selective detection of these species [1]. The practical application of laser spectroscopy to analysis of different samples is confronted with one essential difficulty, namely the element to be detected must be permanently located in the area of interaction with laser radiation. Therefore the use of solutions of the substances to be analyzed is the most attractive from the practical standpoint. When the pulse (1ns) UV radiation produced by nitrogen laser is used for lanthanide and actinide excitation in solutions the UV radiation is absorbed with different impurity molecules and as a consequence the background radiation is increased. Using short laser pulses for excitation of molecules and ions in liquids and time resolution for registration of luminescence or chemiluminescence produced by actinide and lanthanide ions we can separate target signals from short-lived background luminescence [1]. Selective excitation of detectable molecules can additionally decrease the intensity of background radiation. In addition, UV radiation is absorbed with chemiluminogen (luminol in our experiments) molecules, which makes difficult interpretation of the results. Therefore a key problem of chemiluminescence application to detection of lanthanides and actinides in solutions is an increase in the selectivity of detection. Appropriate selectivity of lanthanide or actinide excitation can be reached by initiation of transitions within 4f- or 5f-electron shell, which correspond to visible spectral range of absorbed laser radiation. Since the energy of one-quantum excitation in visible range may be insufficient for initiation of chemiluminescence it was proposed to excite lanthanide and actinide ion by multi-quantum absorption of visible light [1-3]. The use of laser radiation with tunable wavelength allows selective excitation of actinide or lanthanide species with subsequent registration of luminescence or chemiluminescence. The details of multi-step luminescence/chemiluminescence excitation in solutions are considered. It is shown that a multi-step scheme of luminescence/chemiluminescence excitation increase both the sensitivity and selectivity of lanthanide and actinide detection.

References

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