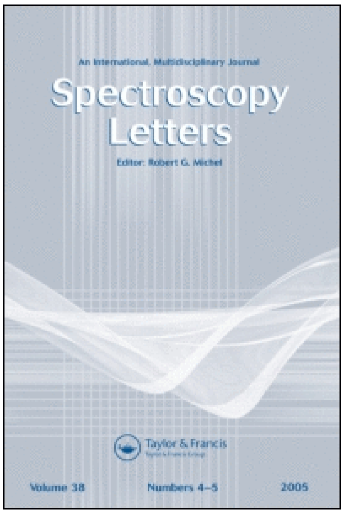

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A New Source of Atomic Uranium for Absorption Spectroscopy and Other Applications

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A NEW SOURCE OF ATOMIC URANIUM FOR ABSORPTION SPECTROSCOPY AND OTHER APPLICATIONS

Key Words: Uranium absorption spectroscopy

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The absorption spectrum of atomic uranium has been observed in furnace[1], flash discharge[2], and flash photolysis[2] experiments. Furnace absorption requires high temperatures (ca. 2300°C), so that the lines are relatively wide and many levels are populated. More important, uranium liquid and vapor are extremely reactive, making furnace design and lifetime critical factors. For quantitative line intensity studies in a furnace, it is also difficult to determine the atomic uranium concentration. The flash discharge experiment in UF_6, while producing uranium quite suitable for high resolution absorption spectroscopy, is not well suited for quantitative studies of line strengths.

Flash photolysis of a suitable uranium compound would make possible the measurement of good relative, and perhaps absolute oscillator strengths for the lower lying lines of U I. This technique has been outlined in the literature[3] for Fe I. However, flash photolysis requires a relatively volatile uranium compound which is also sufficiently unstable to be decomposed photochemically. An earlier study[2] used UI_4 vapor to produce successfully the atomic uranium absorption spectra by flash photolysis. To obtain enough UI_4 in the vapor phase, a temperature of ca. 600°C is needed, and there is the problem of determining the amount of UI_4 initially present and actually photolyzed to free atomic uranium. The most volatile compound of uranium, UF_6 cannot be used (as was verified by experiment) because of its great stability. Several possible organometallic uranium compounds[4] were considered but appeared unsuitable due to low vapor pressure or poor stability.

Two borohydride compounds of uranium were found which appear promising. Uranium borohydride[5], $U(BH_4)_4$, is relatively volatile (ca. 0.1 torr at 20°C) and stable in dry air. It does decompose readily above ca. 150°C and has a strong UV absorption spectrum below 280 nm. Another borohydride[6], $U(BH_4)_3(BH_3CH_3)$, has a higher vapor pressure (ca. 1.1 torr at 25°C) but is more difficult to prepare.

A conventional flash photolysis apparatus was used with a one meter quartz cell. The linear photolysis flash lamp was fired with a 15 μf capacitor charged to 13 kV. A 5 meter Czerny-Turner spectrograph (JACO 72-360) was used as described earlier[2]. Uranium borohydride vapor at an estimated pressure of 0.02 torr was used either alone or diluted with argon. Time delay between the photolysis and background flash lamps was 35 μ sec. Uranium lines were identified from the most recent list[7].

The regions between 411 and 478 nm and between 478 and 598 nm were investigated at high resolution. The former region was filled with a high density of sharp absorption lines, some of which were identified as those of U I. Most of the remaining lines are due to the band spectrum of the BH free radical[8] although the presence of other atomic or molecular lines cannot be ruled out. These BH lines would make difficult any measurements on the atomic uranium lines in this region.

The region between 495 and 598 nm contained only 89 lines. Sixty-one were identified as those of U I with lower levels up to 10347 cm^{-1}. Eight lines of U II were found with lower levels up to 7166 cm^{-1}. The lower level lines of U I dominated in strength and the U II lines were relatively weak. The U II presumably arises from secondary photoionization of U I because the ionization potential is only 6 ev. The remaining twenty unidentified lines are weak and probably also due to U I or II. The presence of U I lines with rather high lower levels implies some heating of the gas by the photolysis flash. This might be decreased by the addition of more argon or other inert gas to the starting gas mixture. Since this region appears free of molecular spectra, quantitative studies of the U I lines should be possible.

These preliminary experiments have uncovered a useful source of atomic uranium for fundamental studies, such as oscillator strength measurements for low levels of U I and collision width measurements. Another possibility is the use of uranium borohydride as a source of simple uranium-containing molecular spectra. In addition, uranium borohydride might have some practical applications as a source of atomic uranium.

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