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Microchemical Journal

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# Effect of variable ultraviolet wavelength and intensity on photochemical vapor generation of trace selenium detected by atomic fluorescence spectrometry



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## ARTICLE INFO

### Keywords:

Photochemical vapor generation  
Selenium  
Atomic fluorescence spectrometry  
Variable ultraviolet wavelength  
Broadband laser-driven light source

## ABSTRACT

Selenium was taken as an example to investigate the effect of variable ultraviolet (UV) wavelength and intensity on its photochemical vapor generation (photo-CVG) process. A broadband laser-driven light source (LDLS) and a UV lamp were utilized as irradiation sources for the photo-CVG of trace selenium which was sensitively detected by atomic fluorescence spectrometry (AFS). Five filters with bandpass at different wavelength (254 nm, 285 nm, 315 nm, 365 nm and 395 nm) were used to filtrate the light from the LDLS and the UV lamp. The signal change of Se(VI) by photo-CVG-AFS was monitored when a TiO<sub>2</sub>-coated quartz coil was irradiated by variable wavelength and intensity. The experimental results indicated: (1) the efficiency of Se(VI) photo-CVG varied with irradiation wavelength; (2) a synergistic effect existed for the photo-CVG, and the efficiency of the full spectrum was thus better or close to the sum of all wavelengths; and (3) the efficiency of Se(VI) photo-CVG was also affected by the UV intensity.

## 1. Introduction

As one of the most promising new chemical vapor generation (CVG) techniques, photochemical vapor generation (photo-CVG) was first proposed by Sturgeon et al. in the turn of this century [1]. Nowadays, photo-CVG has been extensively applied to analytical atomic spectrometry and related areas, because of its outstanding advantages, such as reduced interference from transition metals, no or less hydrogen generated, greener nature (with only a low molecular weight organic acid, and minimized waste production), and potential speciation analysis [2–4]. In the presence of a low molecular weight organic acid, analytes could be directly converted to their volatile species under UV irradiation, and the volatile species can be transported into analytical atomic/mass spectrometry for subsequent instrumental determination. With photo-CVG, not only some conventional hydride-forming elements (e.g. Se and As) [5–8], but also some transition elements (e.g. Fe and Co) [9–11], noble elements (e.g. Au and Ag) [12,13] and even some non-metals (e.g. Cl, Br and I) [14–16] can be transformed to their volatile species.

A ultraviolet (UV) lamp usually serves as an irradiation source in photo-CVG, however, its main emission wavelength is limited to

365 nm (a high pressure Hg lamp) or 254 nm (a low pressure Hg lamp) [17–20], even though its spectrum consists of several spectral lines. Furthermore, a UV lamp has many inherent disadvantages such as large size, high power consumption and even potential mercury pollution [21].

The wavelengths of the UV radiation (between 100 and 400 nm) could be classified as UV-A (400–315 nm), UV-B (315–280 nm) and UV-C (280–100 nm), and the applications of UV-C are less frequently, because the irradiation wavelength range of 200–100 nm occurs under vacuum or suffers from the strong molecular absorption by atmospheric components [22]. Recently, Wang et al. [23] coupled photo-CVG to miniaturized solution cathode glow discharge-atomic emission spectrometry for mercury speciation analysis based on different wavelengths and powers from the UV lamp and irradiation time. Mercury speciation was also fulfilled by differential photo-CVG under UV-B vs UV-C wavelengths for mercury atomic fluorescence spectrometry (AFS) determination in fish oil supplements [24]. Though there are several publications reporting the mechanisms of photo-CVG [22,25,26], the effect of variable wavelength and intensity on photo-CVG has not been thoroughly investigated yet. In this work, therefore, the LDLS and the UV lamp were utilized as the irradiation source for selenium photo-

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**Table 1**  
Parameters of filters with different wavelengths.

Filter name	Model	Center wavelength (nm)	Transmission band (nm)	Guaranteed Minimum Bandwidth (nm)	Transmittance (%)
254 nm	Hg01-254-25	250	244–256	12	> 65
285 nm	FF01-285/14-25	285	278–292	14	> 60
315 nm	FF01-315/15-25	315	307.5–322.5	15	> 75
365 nm	Hg01-365-25	366	360–372	12	> 93
395 nm	FF01-395/11-25	395	389.5–400.5	11	> 85

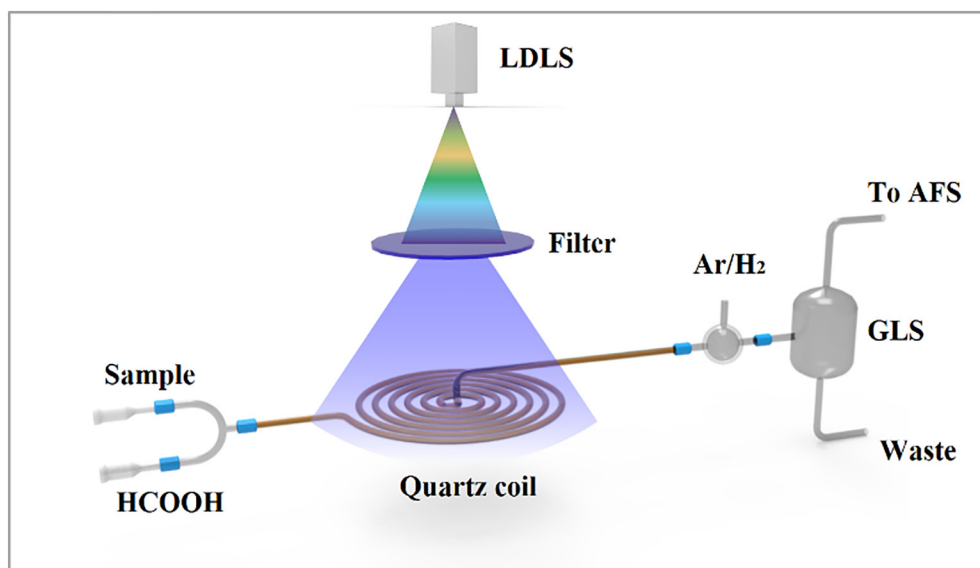


Fig. 1. Schematic diagram of the experimental setup. GLS: gas/liquid separator.

**Table 2**  
Instrumental parameters of AFS.

AFS			
Lamp current (mA)	80	Observation height (mm)	8
High voltage of PMT (V)	– 300	Measurement mode	Peak area
Flow rate of the carrier gas ( $\text{mL min}^{-1}$ )	300	Reading time (s)	10
Flow rate of the shielding gas ( $\text{mL min}^{-1}$ )	900	Delay time (s)	1

CVG, and different wavelengths (254 nm, 285 nm, 315 nm, 365 nm and 395 nm) were selected for investigation. The signal change of trace Se (VI) photo-CVG was monitored by AFS when a  $\text{TiO}_2$ -coated quartz coil was irradiated by variable wavelengths and intensity.

## 2. Experimental

### 2.1. Instrumentation

A broadband laser-driven light source (LDLS, TLS30471-EQ99, Zolix Instruments Co. Ltd., Beijing, China) and a UV lamp (Philips, TUV 15 W/G15 T8, Philips, Netherlands) were used as the irradiation sources for the Photo-CVG. Filters (254 nm, 285 nm, 315 nm, 365 nm and 395 nm) were purchased from Semrock Co. Ltd. (USA) and their parameters are summarized in Table 1. A quartz coil (coil diameter: 3 cm; quartz tube: 1 mm i.d., 3 mm o.d., 25 cm long; customized from Chengdu Haihong Glass Co., Chengdu, China) was

used as a photo-CVG reactor in this work. The produced selenium-containing volatile species was transported to an atomic fluorescence spectrometer (AFS-2202E, Beijing Haiguang Instrument Co., Beijing) for determination after a gas-liquid separation step. To form a stable Ar- $\text{H}_2$  flame for atomization of the selenium volatile species, additional mixture of argon ( $300 \text{ mL min}^{-1}$ ) and hydrogen ( $100 \text{ mL min}^{-1}$ ) was supplied before the GLS. The schematic diagram is shown in Fig. 1 and the working parameters of the AFS are summarized in Table 2.

### 2.2. Reagents and samples

All reagents used in this work were at least of analytical grade. Deionized water (DIW,  $18.2 \text{ M}\Omega \text{ cm}$ ) was from a water purification system (Chengdu Ultrapure Technology Co., Ltd., China). Se(VI) stock solutions were prepared from  $\text{Na}_2\text{SeO}_4$  (Xiya Chemical Industry Co. Ltd., Shandong, China). Standard solutions were

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