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Short communication

K-shell fluorescence yields for potassium and calcium compounds

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Abstract

The K-shell fluorescence yields for potassium and calcium compounds were investigated using a Si(Li) X-ray detector system (FWHM = 155 eV at 5.9 keV). The target samples were excited using 59.5 keV gamma rays from an ^{241}Am annular source of strength 75 mCi. Chemical effects on K-shell fluorescence yield for potassium and calcium were observed. The values were compared with theoretical values of pure potassium and calcium.

Keywords: X-ray spectra; Chemical effect; Fluorescence yield

1. Introduction

Fluorescence yield values play an important role in a variety of fields such as X-ray fluorescence analysis, atomic physics, health physics and industry. The K-shell fluorescence yield of an atom and ion is defined as probability that a vacancy in the K-shell is the ratio filled through a radiative transition and not by a radiationless transition. The excitation of an atom with an inner shell K vacancy results in the emission of X-rays or the ejection of Auger electrons (from radiationless transition).

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The K-shell fluorescence yield is also defined as $\omega_K = S_K^{Rad}/(S_K^{Rad} + S_K^{Auger})$, where S_K^{Rad} and S_K^{Auger} are the total radiative and Auger transition rates, respectively. For low atomic number elements, Auger decay rate is larger than X-ray emission. For high atomic number elements, X-ray emission become more probable. Auger transition probability increase with decreasing binding energies of the other shell electrons. The chemical effects are observed as differences in the X-ray and Auger transition probabilities from a given element incorporated in different chemical compounds.

K-shell fluorescence yields for different elements have been investigated for many years and have been compiled by Krause [1], Bambynek et al. [2,3] and by Hubbell et al. [4,5]. Al Nasr et al. and Balakrishna et al. measured K-shell fluorescence yields for rare-earth and heavy elements [6,7]. Durak et al. [8–10] reported experimental K-shell fluorescence yields for different elements in atomic range $40 \leqslant Z \leqslant 82$. Theoretical values of ω_K were obtained for various elements by Mc Guire [11,12], Walters and Bhalla [13], Kostroun et al. [14] and Chen et al. [15] by using different approaches. Buyukkasap [16] investigated K-shell fluorescence yields in Cr and Ni alloys. Although K fluorescence yields have been studied by some workers, there is a study addressing chemical effects on K-shell fluorescence yield [17]. We investigated chemical effects on K-shell fluorescence yields for Br and I compounds [17]. This is the first analytical investigation of K-shell fluorescence yields for potassium and calcium compounds on chemical effects.

2. Experimental

The target samples were excited by using heavily filtered 59.5 keV γ photons from a 75 mCi ^{241}Am radiative source and X-rays emitted from samples were detected by Si(Li) (FWHM = 155 eV at 5.9 keV) detector system. The purity of commercially obtained materials was better than 99%. Powder samples were sieved for 200 mesh and prepared by supporting a Mylar film at 34×10^{-3} g cm^{-2} mass thickness. The experimental geometry is shown in Fig. 1. Typical K X-ray spectra obtained from CaF_2 and CaO are given in Fig. 2 for comparative purpose. The background was measured by a calculation using the mean of a ten-channel approximation. Then the net peak area was found by subtracting the background from the total peak area. K-shell fluorescence yields ω_K were determined using the following equation semiempirically:

$$\omega_K = \frac{\sigma_{K_\alpha, K_\beta}}{\sigma_K^{photo}},$$

where $\sigma_{K_\alpha, K_\beta}$ is the total K X-ray fluorescence cross-section and σ_K^{photo} is K-shell photoionization cross-section [18]

Experimental σ_{K_α} and σ_{K_β} X-ray fluorescence cross-sections were measured using the equation

$$\sigma_{K_i} = \frac{N_{K_i}}{I_0 G \varepsilon_{K_i} T t},$$

where N_{K_i} $(i = \alpha, \beta)$ is intensity observed for K_i $(i = \alpha, \beta)$ X-ray line of element ε_{K_i} is the detector efficiency for K_i X-rays, I_0 is the intensity of exciting radiation, G is the geometrical factor, t is the mass of the sample in g cm^{-2} and T is self-absorption correction factor of the target material.