Effect of internal conversion process on K-shell X-ray intensity ratios of Barium and Thallium

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INTRODUCTION

The information obtained from experimental K shell X-ray intensity ratios of elements is of great importance in the study of some basic phenomena in atomic molecular and radiation physics. Nuclear processes like orbital electron capture(EC) or internal conversion (IC) of gamma transition and interaction of photons or charged particles with matter give rise to X-ray fluorescence. The K shell X-ray intensity ratios of elements have been extensively studied by several researchers by photon exciation methods employing reflection geometries [1-2]. From the literature we understand that the probability of emission of X-rays by decay process is different from the probability of emission of X-rays by photoionisation [3-5]. This may be due to the requirement of the radioactive sources of the order of 200 mCi and preparing many electron capture and internal conversion sources of this strength may be a difficult task. A simple method was developed earlier by our group for the measurement of K shell X-ray fluorescence parameters employing 2π geometrical configuration and weak gamma source of the order of 2 μCi [6].

In internal conversion followed by beta minus decay, nuclear charge suddenly changes from Z to Z+1 and as the beta particle passes through the atom with high velocity its atomic core suffers shake off, shake up, direct collision etc. due to the net change in the nuclear electrostatic field [7]. All these effects depend on various factors like atomic number of the element, nuclear transition energy, binding energy of the K shell electron, etc. In this work, we have made an attempt, adopting 2π-geometrical method to study the effect of internal conversion on the probability of X-ray emission of Thallium and Barium by determining K-shell X-ray intensity ratios from weak internal conversion sources ${}_{80}Hg^{203}$ and ${}_{55}Cs^{137}$respectively. Internal conversion process followed by beta decay in these nuclei produces characteristic X-rays.

EXPERIMENTAL

In the present investigation, we have employed an X-ray fluorescence spectrometer consisting of a Si(Li) detector (sensitive surface area 20 mm^2, 3.5 mm thickness, Be window of thickness 12.5 μm) connected to a PC based 8k multichannel analyser (MCA) to detect the characteristic X-rays arising from internal conversion electron sources (Fig. 1). The Si(Li) X-ray detector spectrometer was calibrated using various gamma and X-ray sources. The weak internal conversion electron sources were obtained from from Radiopharmaceuticals Division, Therapeutic and Reference Sources Section, BARC, Mumbai. These sources (2 μCi) were

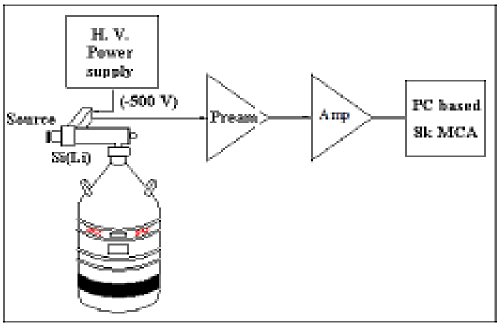

Fig. 1: Experimental arrangement

prepared on a plastic disc and covered with aluminised mylar film of thickness 0.7 mg/cm^2. The beta particles and internal conversion electrons from the sources were stopped using aluminium foils of suitable thickness.

The intensities of K shell x- rays are measured as follows. The K X-ray spectra of ^{203}Hg and ^{137}Cs were acquired by placing source close to the window of the detector in the 2π-geometrical configuration. A Gaussian fit of the K_α and K_β X-ray peaks were done and the areas under the peaks were estimated. The mean of ten channels on each side of the peaks was used to calculate the average background of the peak and to determine the channels used to define the peak. The observed countrate is corrected for the efficiency of the detector at particular energies. The $I_{K\beta}/I_{K\alpha}$ intensity ratios were calculated using estimated K_α and K_β X-ray intensities of Tl and Ba following IC decay.

RESULTS AND DISCUSSION

The weighted average values of intensity ratios for Tl and Ba determined from the experimentally measured K shell X-ray intensities in three trials are presented in Table 1 along with the theoretical values and others' experimental values measured using radioactive decay and photon excitation methods. From the table, it is clear that K X-ray intensity ratios for the elements thallium and barium by decay of radioisotope ^{203}Hg and ^{137}Cs is 2 to 12% higher from both the experimental and theoretical values. This deviation may be attributed to the effect of beta decay in addition to internal conversion which may alter the X-ray emission probability. The bremstrahlung background may also be contributing to this deviation. In order to understand this further, the preparation of various IC sources of low to high Z elements and studies on K X-ray intensity ratios are in progress.

Table 1: The measured and theoretical values of K shell X-ray intensity ratios of Tl and Ba.

XRF Parameter	Present	Theoretic-al	Other's Experimental
Thallium (Z = 81)			
$\frac{I_{K\alpha 2}}{I_{K\alpha 1}}$	0.609± 0.041	0.593[8]	0.637±0.032 [1], 0.580±0.030 [5]†
$\frac{I_{K\beta 1}}{I_{K\alpha 1}}$	0.360± 0.032	0.333[8]	0.366±0.017 [5]†
$\frac{I_{K\beta}}{I_{K\alpha}}$	0.287± 0.026	0.2679[8]	0.2695± 0.005 [2], 0.2795±0.0056 [5]†
Barium (Z = 56)			
$\frac{I_{K\beta}}{I_{K\alpha}}$	0.251± 0.021	0.2273[8]	0.2472±0.005[2] 0.2118± 0.0013 [3]† 0.2364±0.0047 [4]†

† Following decay process

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