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Study of CK Enhancement Factors for Oxygen Induced L Subshell X-rays in Lanthanum Series ($58 \leq Z \leq 70$)

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CK Enhancement Factor (kα,l, kβ and kγ) has been studied for Lanthanum series ($58 \leq Z \leq 70$) with oxygen as projectile in the energy range of 1.5 - 3.5 MeV. It is observed that by changing projectile energy, there is a change in enhancement factor for all the elements. While studying the variation of enhancement factor with atomic number (Z) and the energy of projectile element, it is found that there is an irregular trend in the variation of enhancement factor. The maximum value of enhancement factor is 2.3126 in Nd (Z=60) at 1.5 MeV energy. In all the elements there is a decrease in the enhancement factor with increase in energy of projectile. The value of kα,l enhancement factor is found to be maximum in all cases followed by kβ and kγ.

Key Words: Coster-Kronig transitions, enhancement factors, oxygen ion projectile

INTRODUCTION

The creation of a vacancy in an atomic shell initiates a series of rearrangement processes. The situation is more complicated in the case of higher atomic shells. In the L shell, for instance, there are eight electrons grouped into three subshells (L_1, L_2 and L_3) each of which corresponds to a different quantum state. The L shell x-ray production cross sections depend strongly on L sub shell vacancy distribution as well as on radiative decay rates. The vacancy distribution among the L sub shell depends upon the mechanism of excitation of the L sub shell electron, atomic number (Z) and the energy of incident particle. In case of L sub shell, the vacancy in the more tightly bound L_1 and L_2 sub shells predominantly shifts to L_3 sub shell due to Coster–Kronig transitions, thus making a significant alteration[1] in the initial vacancy distribution prior to L x-ray or auger electron emission.

Mostly researchers have investigated the effect of CK transitions on the average fluorescence yields[2] and x-ray production cross sections[3]. The chemical effect on the enhancement of the CK transitions of L shell x-rays has been investigated by Sogut *et al.*[4] and Oz. *et al.*[5]. They concluded that the non-radiative transitions effect the initial emission parameters to a considerable extent. This work is limited to photon, deuteron and helium induced x-ray emission only, while the alteration brought about by the presence of CK transitions in case of L sub shell x-ray emission cross-sections induced by heavy projectile ions like oxygen still needed to be investigated. Due to this variation of CK-Enhancement factor for oxygen ion induced L sub shell x-rays has been investigated in Lanthanum series ($58 \leq Z \leq 70$).

CALCULATION OF THE ENHANCEMENT FACTORS

The CK Enhancement factors for L-subshell x-rays induced by oxygen projectile were calculated by following equations

$$k_{1,\alpha} = \frac{[(f_{12}f_{23} + f_{13})(\sigma L_1 + \sigma K n_{KL_1}) + f_{23}(\sigma L_2 + \sigma K n_{KL_2}) + (\sigma L_3 + \sigma K n_{KL_3})]}{\sigma L_3 + \sigma K n_{Kl_3}}$$

$$k_{\beta} = \frac{(\sigma L_1 + \sigma K n_{KL_1})w_1 F_{1\beta} + [f_{12}(\sigma L_1 + \sigma K n_{KL_1}) + (\sigma L_2 + \sigma K n_{KL_2})]w_2 F_{2\beta} + [(f_{12}f_{23} + f_{13})(\sigma L_1 + \sigma K n_{KL_1}) + f_{23}(\sigma L_2 + \sigma K n_{KL_2}) + (\sigma L_3 + \sigma K n_{KL_3})]w_3 F_{3\beta}}{(\sigma L_1 + \sigma K n_{KL_1})w_1 F_{1\beta} + (\sigma L_2 + \sigma K n_{KL_2})w_2 F_{2\beta} + (\sigma L_3 + \sigma K n_{KL_3})w_3 F_{3\beta}}$$

$$k_{\gamma} = \frac{(\sigma L_1 + \sigma K n_{KL_1})w_1 F_{1\gamma} + [f_{12}(\sigma L_1 + \sigma K n_{KL_1}) + (\sigma L_2 + \sigma K n_{KL_2})]w_2 F_{2\gamma}}{(\sigma L_1 + \sigma K n_{KL_1})w_1 F_{1\gamma} + (\sigma L_2 + \sigma K n_{KL_2})w_2 F_{2\gamma}}$$

Where (σL_i) is L sub shell ionization cross sections, (σK) is K shell ionization cross section, (f_{ij})[6] is Coster-Kronig transitions probabilities, (ω_i) is L sub shell fluorescence yields, (n_{KLi})[7] is Vacancy transfer probability from K to L_i sub shell and (F_{ij})[8] is the radiative decay rates.

RESULT AND DISCUSSION

The result for the L subshell CK Enhancement factor ($k_{\alpha,l}$, k_β and k_γ) were plotted against atomic number ($58 \leq Z \leq 70$) and are shown figures 1 and 2.

1. The enhancement factors ($k_{\alpha,l}$, k_β and k_γ) values decreases with increase in energy.
2. For a particular energy with increase in Atomic number (Z) the enhancement factor $k_{\alpha,l}$ first increases reaches its maximum value and then start decreasing (Maximum value of $k_{\alpha,l}$ at 1.5 MeV is 2.31 for Z = 60).
3. Enhancement factor were found to be maximum in case of $k_{\alpha,l}$ and then followed by k_β and k_γ (e.g. at E = 2.5 MeV $k_{\alpha,l}$, k_β and k_γ, is 1.81, 1.36, 1.22 respectively).

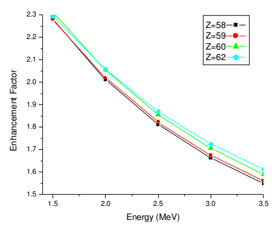

Figure 1. Enhancement factors ($k_{\alpha,l}$, k_β and k_γ) versus projectile energy

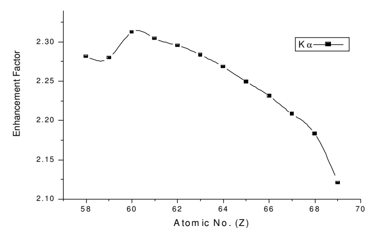

Figure 2. k_α Enhancement factor for ($58 \le Z \le 70$) at projectile energy 2.0 MeV

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