K_α X-RAY SATELLITES EXCITED BY PHOTONS IN S AND ITS COMPOUNDS

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ABSTRACT — The K_α X-ray satellite spectra of S and some of its compounds, excited by Rh tube X-rays, are studied with a plane crystal spectrometer. The $K_\alpha L^1 / K_\alpha L^0$ intensity ratios based on the assumption of a free Ne core are found to be somewhat higher than our experimental values.

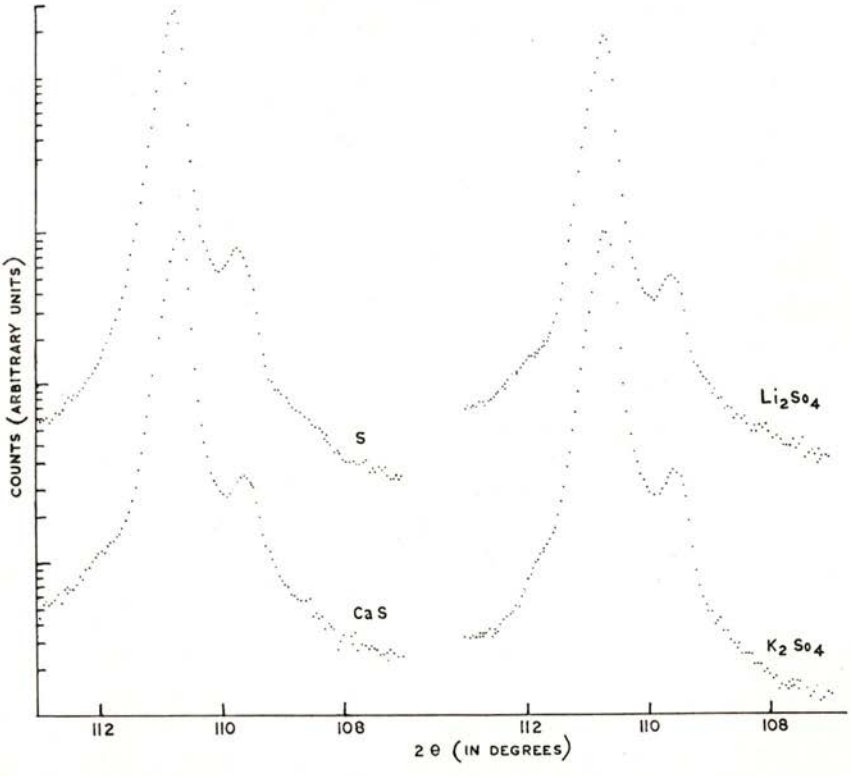
1 — INTRODUCTION

Studies on K_α X-ray satellites arising from single K plus multiple L vacancy states have been a subject of much experimental and theoretical interest. The absence of L shell electrons in addition to one K electron reduces the screening of the nuclear potential felt by the remaining electrons and increases their binding energies. A K_α X-ray emitted from such a state will be at a higher energy than the normal diagram or $K_{\alpha 1\,\alpha 2}$ X-ray line (i. e. K_α X-rays emitted when there are no holes in the L shell). Depending on the number (n) of L shell vacancies, the emitted K_α X-ray multiplets are designated $K_\alpha L^n$ satellites. Correspondly, the X-rays emitted in the absence of one, two, three, etc, L electrons in addition to one K electron are designated as $K_\alpha L^1$, $K_\alpha L^2$,

K_α L^3, etc. satellite groups, respectively, and the ordinary X-ray, which is emitted when there are no L vacancies, is designated as $K_\alpha L^0$. Most of the studies on satellites have been carried out using heavy-ion excitation [1]. However, the first one or two satelites can be studied [2]-[7] by electron or photon excitation. But not much experimental data of satellite relative intensities are available for $Z > 14$ in the case of photon excitation. In the present investigation, an attempt has been made in this direction: K_α X-ray satellites in S and some of its compounds have been studied by photon excitation.

2 – EXPERIMENT

The general experimental setup and the principle of measurement are the same as those reported previously [3]-[7] for photon



K_α X-ray Satellite Spectra in S and some compounds, excited by photons.

excitation. In the present investigation, a Philips 1410 wavelength dispersive spectrometer is used. This, in brief, consists of a Rh X-ray tube, a plane crystal spectrometer and a continuous P-10 (90 % Argon and 10 % methane) gas flow proportional counter. The X-ray tube is operated at 40 kV and 40 mA. Two fine collimators (0.01°), one at the target and the other at the detector are used. Pure powders of S, Li_2SO_4, K_2SO_4 and CaS pressed into pellets 5 mm thick and 50 mm in diameter are used. The spectra are scanned in 2θ steps of 0.05°, with a Ge (111) [2d = 6.532 Å] plane crystal. Typical K_α X-ray satellite spectra of S and its compounds are shown in Fig. 1.

3 – RESULTS AND DISCUSSION

It can be seen from the figure that the spectra exhibit two distinct groups, the diagram line ($K_\alpha L^0$) and the first satellite ($K_\alpha L^1$), in all cases. The spectra are analysed by fitting the groups individually on a computer and the intensity ratios $K_\alpha L^1 / K_\alpha L^0$ are estimated in each case. These ratios are then corrected for i) crystal reflectivity, ii) self absorption in the target, iii) absorption in the detector window and iv) efficiency of the detector. Since the energy difference between the $K_\alpha L^1$ and $K_\alpha L^0$ groups is small, the relative total correction due to the above factors is small. The experimental procedure is repeated in each case for six trials and the average values of the intensities are estimated. The error associated with the ratios mainly include the statistical error.

The estimated $K_\alpha L^1 / K_\alpha L^0$ ratios, together with the ratios measured by electron excitation [5], [6] and the theoretical value of Aberg [2] are given in Table 1. The theory of Aberg [2] is based on the sudden approximation (shake-off). This theory is formulated on the assumption that the formation of an inner hole occurs so quickly that a rapid change in the Coulomb field experienced by the electrons (other than photoelectrons) gives rise to anomalous states, i. e. excitation of a double hole state occurs independently of the excitation mode. In that case, the K_α satellite relative intensities should be same in both X-ray and electron excitation modes. Thus Aberg [2] reported $K_\alpha L^1 / K_\alpha L^0$

ratios for Ne like atoms from F to Ca. The values of the ratio for S and one typical gaseous compound (H_2S) are also given in Table 1. It can be seen from the table that Aberg's theoretical ratio as well as the electron excitation ratios of Baun and Fischer are definitely higher than our experimental values. It is evident from the table that the heavy-ion excitation value of the ratios are very much higher than the present value or the experimental value of Baun and Fischer. This is probably due to the increase

TABLE 1 — $K_\alpha L^1 / K_\alpha L^0$ Intensity Ratios (in percent)

Material	Present work (Photon Excitation)	Baun & Fischer (Electron Excitation)	Parrat (Electron Excitation)	Demarest et al. (Heavy-ion Excitation)	Aberg (Theory)
S	4.6 ± 0.4	5.6 ± 0.4*	4.8	311.4	5.7
K_2SO_4	4.5 ± 0.4	—	—	—	—
CaS	4.5 ± 0.4	—	—	—	—
Li_2SO_4	4.8 ± 0.4	—	—	—	—
H_2S	—	—	—	527.3	—

* Value taken Ref. [2].

of the multiple ionization probability for L shell in the case of heavy-ion excitation; in such a case the sudden approximation theory is no longer valid. The higher value in the case of the gaseous compound (H_2S) may be attributed to the decrease of the electron rearrangement probability by the electron transfer process which is possible in view of the larger interatomic or molecular distances in gases.

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