$I(K\alpha_4)/I(K\alpha_3)$ x-ray satellite intensity ratios in Mg by photon excitation

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Systematic measurements on $I(K\alpha_4)/I(K\alpha_3)$ x-ray satellite intensity ratios by photon excitation in Mg and several of its compounds are reported and discussed in the light of the available data.

INTRODUCTION

Single K- plus L-shell ionization yield $K\alpha$ x-ray satellites. Though most of the studies are carried out by ion excitation in recent years,[1] investigations have also been carried out by photon and electron excitations, with which the first one or two satellite groups can be studied. Extensive measurements have been carried out on Na, Mg, Al, and Si by both these methods of excitation.[2–8] Keski-Rahkonen *et al.*[7] have recently reported accurate measurements on $I(K\alpha_4)/I(K\alpha_3)$ intensity ratios in Na and in its compounds by electron excitation. Murti *et al.*[8] reported data on $I(K\alpha_4)/I(K\alpha_3)$ intensity ratios in Na with NaF and NaCl compounds by photon excitation. They noticed an agreement between photon and electron excitation measurements in general. Several authors reported Mg $I(K\alpha_4)/I(K\alpha_3)$ intensity ratios by different modes of excitation. But contrary to the measurements of other modes of excitation, photon excitation[4] in MgO yielded an anomalously large ratio. In the present investigations systematic measurements on these ratios in Mg and several of its compounds are carried out by photon excitation to clarify the situation for the first time.

EXPERIMENT

$K\alpha$ x-ray satellite spectra in Mg and four of its compounds are scanned in 2θ steps of 0.02° employing a Philips 1410 wavelength-dispersive spectrometer[9] which consists of a Rh x-ray tube (operated at 40 kV and 30 mA current), an ammonia dihydrogen phosphate (ADP) ($2d = 10.642$ Å) plane-crystal spectrometer and a continuous-flow counter. Typical spectra are shown in Fig. 1. Six to eight runs for each case of Mg and Mg compounds are taken. The spectra are analyzed by means of the usual least-square-fit program. A rough analysis is also carried out by plotting the data on 50×75 cm^2 graph sheets and using the peeling-off technique starting from the high-energy side of $K\alpha_4$. A reasonable agreement is observed between the two procedures of analyses. The average value for all the trials in each case

TABLE I. $I(K\alpha_4)/I(K\alpha_3)$ x-ray satellite intensity ratios in Mg.

Authors	Mode of excitation	Mg	MgO	$Mg(Ac)_2$	$MgCO_3$	$MgCl_2$
Present work	Rh tube x rays	0.57±0.10	0.80±0.15	0.84±0.15	0.77±0.15	0.70±0.20
Watson *et al.*[a,b]	5.4-MeV He ions	0.41±0.06	0.72±0.10		0.70±0.10	0.70±0.10
Fischer and Baun[c]	4–5-keV electrons	0.58	0.97			
Demekhin and Sachenko[d]	Not known	0.46	1.15			
Bonnelle and Sememand[e]	1.5 keV (Al $K\alpha$ x rays)	0.63	1.77			
Bonnelle and Sememand[e]	3–5-keV electrons	0.67	0.93			
Krause and Ferreira[f]	6–12-keV electrons (Photoelectron spectroscopy PAX)	0.56				

[a]The data are read from Fig. 4 of Ref. 1 and hence may be associated with some more uncertainty.
[b]Reference 1.
[c]Reference 2.
[d]Reference 3.
[e]Reference 4.
[f]Reference 5.

is adopted. The overall error in the ratio is expected to range between 10% and 20%. The estimated $I(K\alpha_4)/I(K\alpha_3)$ x-ray satellite intensity ratios along with the available experimental data are presented in Table I. Since the main interest is in $K\alpha_4$ and $K\alpha_3$ only, it is expected that not much uncertainty in the ratios is included other than what is reported.

RESULTS AND DISCUSSION

It can be seen from Table I that the present ratios, particularly in all the Mg compounds, are in better agreement with those by other modes of excitation than with the previously reported photon excitation measurements. The corresponding photon energy used by Bonnelle and Sememand[4] for MgO in the previous measurements is 1.5 keV (Al $K\alpha$ x rays). Hence the possible reason for the large difference between the present and previous measurements by photon excitation may be due to the energy dependence of the ratio as suggested by Baun and Fischer[10] in the case of electron excitation.

Demekhin and Sachenko[3] attributed the smaller $I(K\alpha_4)/I(K\alpha_3)$ intensity ratio in Mg metal rather than

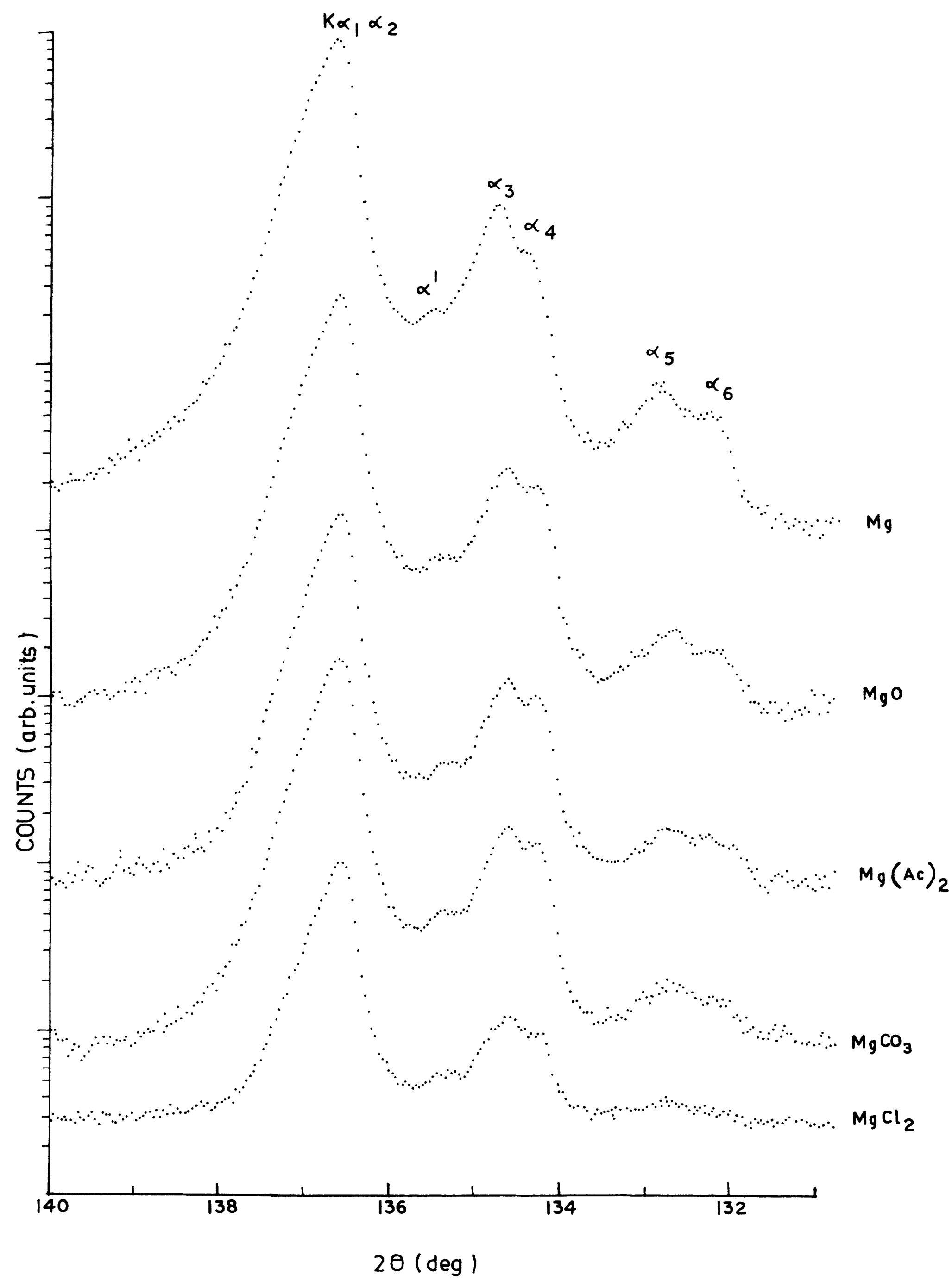

FIG. 1. Typical $K\alpha$ x-ray spectra in Mg and four of its compounds.

that in its oxide to the effect of Coster-Kronig transitions before the emission of $K\alpha$ x ray. Such transitions may be unavailable in compounds due to ionic binding energy. Watson *et al.*[1] evaluated the ratio in two extreme cases—(a) complete Coster-Kronig transitions and (b) no Coster-Kronig transitions—using the statistical excitation probabilities and found the values to be 0.59 and 1.15, respectively. It can be seen from the table that the present value in Mg metal is in good agreement with the ratio with complete Coster-Kronig transitions. The higher value in compounds rather than in the metals are in accordance with the theoretical evaluations. However, the smaller difference in the experimental ratios between the Mg metal and its compounds rather that in the theoretical evaluations suggests that Coster-Kronig transitions or some type of electron rearrangements are also possible in compounds to some extent (based on the theoretical values by approximately 55% to 80% in the present cases), prior to the emission of the $K\alpha$ x ray, relative to that of the Mg metal.

Thus the present investigations clarify that $I(K\alpha_4)/I(K\alpha_3)$ satellite intensity ratios in Mg compounds even by photon excitation are in accordance with the other modes of excitation provided the excitation energy is sufficiently higher than the required threshold energy.

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