ATOMIC CAPTURE OF μ^- MESONS IN CHEMICAL COMPOUNDS

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(Presented by V.G. ZINOV)

Several experimental studies [1–4] and only one theoretical paper [5] deal with atomic capture of μ^- mesons in chemical compounds. From the very onset it was clear that the internal structure of the substance may be important. Insufficient experimental material, however, did not make it possible to draw definite conclusions concerning the possible regularities of atomic capture of μ^- mesons in chemical compounds.

The present study was carried out on the synchrocyclotron of the Joint Institute for Nuclear Research. Here the atomic capture of μ^- mesons in oxides and halides was investigated. For compounds containing chemical elements with atomic number $Z \lesssim 20$ and for AgI, the capture probability was determined from the ratio of the K-line intensities of the mesic X-radiation in the pure substance and in its chemical compound. For substances containing elements with $Z > 20$, the atomic capture probability was determined from the total γ yield from the nuclear capture of μ^- meson and from the K-lines of the mesic X-radiation in the pure substance and in its chemical compound. The γ quanta were recorded by means of a NaI(Tl) crystal, and their spectrum was recorded in a 256-channel analyzer.

The results of the investigation are given in Tables 1 and 2. The errors listed include statistical and measurement errors.

Fig. 1 gives the results of the present study together with the results of other research groups for metal alloys and compounds of metals with halogens. The entire set of plotted points is well described by a linear relationship

$$\frac{W(z_1)}{W(z_2)} = a\frac{K_1}{K_2}\cdot\frac{z_1}{z_2},$$

Table 1

Compound	Ratio	z_1/z_2	$W(Z_1)\cdot K_2/W(Z_2)K_1$
NaF	F/Na	0.82	0.64±0.05
$CaCl_2$	Cl/Ca	0.85	0.64±0.07
AgI	I/Ag	1.13	0.69±0.12
NaCl	ClNa	1.55	0.95±0.07
KI	I/K	2.79	2.38±0.2
NaI	I/Na	4.82	3.45±0.4
PbF_2	Pb/F	9.1	5.0±0.6

Table 2

Compound	Z_1	$W(Z_1)\cdot K_2/W(O)K_1$
BeO^+	4	0.33±0.15
$B_2O_3^+$	5	0.22±0.05
MgO^+	12	0.83±0.07
MgO_2	12	0.58±0.03
$Al_2O_3^+$	13	0.85±0.06
SiO_2^+	14	0.79±0.07
CaO^+	20	1.36±0.1
TiO_2^+	22	2.70±0.2
$V_2O_5^+$	23	3.05±0.2
Cr_2O_3	24	2.86±0.2
ZnO	30	2.66±0.3
ZrO_2^+	40	2.38±0.16
Sb_2O_3	51	3.48±0.35
$Sb_2O_5^+$	51	1.74±0.1
PbO	82	5.8±0.7
Bi_2O_3	83	4.3±0.5
UO_3	92	6.0±0.5

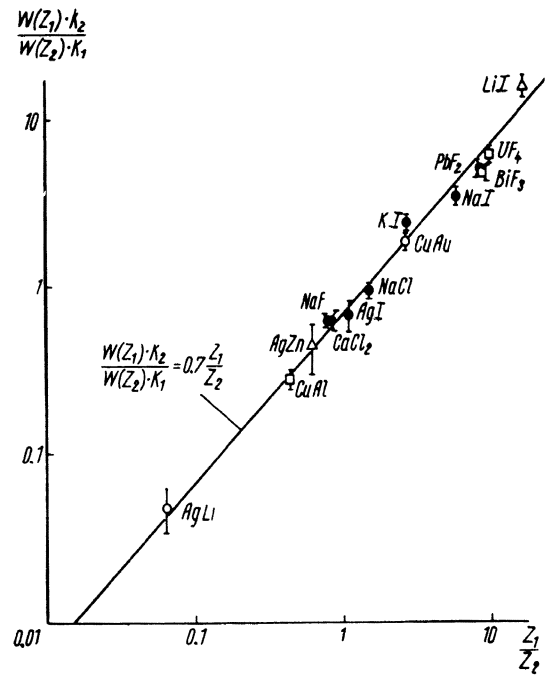

Fig. 1. Relative probability of atomic capture of muons in halide compounds and alloys.

• – the present study; □ – from [3]; ○ – from [4]; △ – from [2].

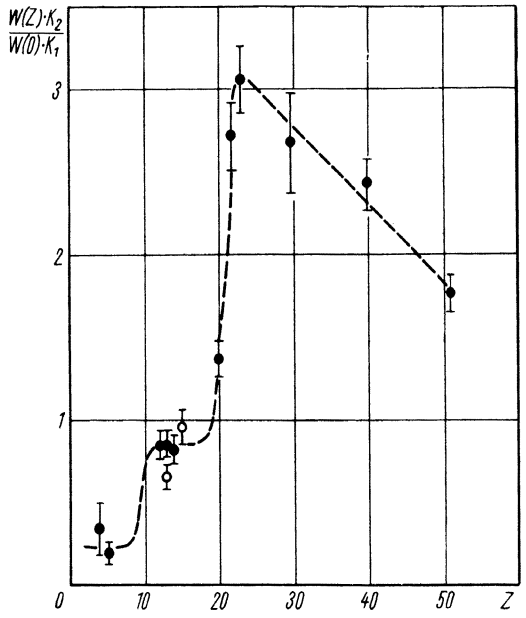

Fig. 2. Relative probability of atomic capture of muons in oxides.

• – the present study; ○ – from [1].

where $W(z)$ is the probability of atomic capture of a μ^- meson by the element z; K_1 and K_2 are the atomic concentrations of the elements z_1 and z_2, respectively.

It may thus be hoped that, in the case of alloys and compounds of metals with halogens, the approximate predictions of the theory for the metals, whereby atomic capture is proportional to the charge z, prove correct.

It is of interest that the ratios of the atomic capture probabilities of μ^- mesons in MgO, CaO, and PbS, having the same cubic lattice as NaCl, are consistent with the above relationship LiI, NaI, KI, NaF, and partly Ag I have a cubic lattice like NaCl.

In the case of oxides the situation is more complicated. It follows from Table 2 that the atomic capture probability for oxides of Mg and Sb is strongly dependent on the chemical composition. For other oxides the situation is very likely similar. Thus, in Fig. 2 are given the probabilities of atomic capture of μ^- mesons only for the case of "normal" oxides (the valence of the element forming the oxide corresponds to the group number). In Table 2 these are indicated by a small cross. The dashed curve in Fig. 2 points to a possible step-like trend of the dependence of the atomic capture in oxides.

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