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Total photon attenuation coefficients in compounds at 80.895 keV

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Interaction of photons with matter gained interest due to their greater penetrating power than the charged particles. With the development of fast computers, variety of tabular data by Storm and Israel (1970), Scofield (1973), Hubbell *et al* (1975) and Hubbell and Overbo (1979) on total cross sections and its partial processes using different models are available with an accuracy of 0.1 per cent. Several attempts are available on the measurement of photon attenuation coefficients in elements, but no systematic attempts are available in compounds directly. Photon cross sections in compounds are generally obtained by adding the mass attenuation coefficients of the elements in the respective proportions in which they exist in the compound. However in this method, the sum or mixture rule is assumed to be accurate. Deslattes (1969) pointed out that this rule is valid when the effects on the atomic wave function of molecular binding and chemical and crystaline environment are negligible. Hence if one adopts this method, one has to ascertain that these effects do not impair the accuracy of the estimation. With a view to check the sum rule and the possibility of obtaining the elemental cross section from their respective compounds by subtracting the other contributions, the present investigations are carried out at 80.895 keV photon energy, using Bicron Scintillation detector in elementry Al, Zn, Pb and compounds of varying atomic numbers B_2O_3, LiF, Al_2O_3, NaCl, ZnS, NaBr, $AlCl_3$, HgO, $HgCl_2$, HgI_2, PbO_2 $PbCo_3$, PbF, PbS using radio-isotope of Ba^{133}

The total atomic cross sections can be estimated accurately by conducting transmission experiments on a good-geometry set up (Davisson and Evans 1952, Radhakrishna Murty *et al*, Pardhasaradhi and Hansen 1974, Umesh *et al* 1981, 1982). A graded type of slits consisting of Pb, Cd, Cu and Al are employed with suitable thicknesses. NaI(Tl) scintillation detector used in the present studies is imported from Bicron Corporation, Newbury, Ohio, USA. It is a monoline

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integral assembly containing a 1" dia 0.040" thick NaI(Tl) crystal with cleaved surface directly coupled to a 2" dia bialkali photomultiplier tube to convert extremely weak output of a scintillation pulse to corresponding electrical signal without adding a large amount of random noise to the singal. The entrance window 0.005" beryllium is treated for optimum light reflection. The Bicron detector is coupled to the main amplifier and the voltage system using the standard three stage emitter follower system, the necessary decoupling network and a 1024 channel analyser. The Bicron NaI(Tl) assembly offers better pulse height resolution (50% to 5.9 keV). A few drops of Ba^{133} source solution obtained from Bhabha Atomic Research Centre, Bombay are evaporated at the central dip of the Lucite holder under infrared lamp and covered with thin mylar foil rigidly sealed is used for 80.895 keV (Weighted average of 79.63 keV and 80.9 keV γ-rays). A fine amorphous powders of B_2O_3, LiF, Al_2O_3, NaCl, ZnS, NaBr, $AlCl_3$, HgO, $HgCl_2$, HgI_2, PbO_2, $PbCo_3$, PbF and PbS are uniformly filled in perspex annular rings and thickness of the absorber foil in grams/cm^2 is estimated by knowing the difference between the two weights. The perspex ring with sufficient thickness is covered with thin mylar foil. During transmission experiment a dummy perspex ring covered with mylar foil is used while measuring the direct ray intensity. The uniformity of the thickness of each absorber is found by determining the cross section exposing different areas of the absorber. Highly pure 99.99% foils of Al, Zn, Pb with uniform thickness are punched to $\frac{1}{2}$" dia and weighed correct to milligram.

The measured total photon attenuation coefficients at 80.895 keV in the compounds are shown in Table 1. The present experimental values are compared

Table 1. Total photon attenuation coefficient of compounds in cm^2/gram.

Sl. No.	Element/ Compound	Experimental (Error 2%)	Storm and Israd (1970)	Scofield (1973) and Hubbell *et al* (1975)
1.	Al	0.2000	0.1997	0.1999
2.	Zn	0.8139	0.8131	0.8153
3.	Pb	2.3210	2.3050	2.3530
4.	B_2O_3	0.1612	0.1606	0.1609
5.	LiF	0.1546	0.1554	0.1557
6.	Al_2O_3	0.1843	0.1813	0.1846
7.	NaCl	0.2301	0.2308	0.2316
8.	ZnS	0.6277	0.6290	0.6300
9.	NaBr	0.9444	0.9448	0.9458
10.	$AlCl_3$	0.2522	0.2513	0.2523
11.	HgO	2.0100	2.0100	2.0500
12.	$HgCl_2$	1.6604	1.6624	1.6934
13.	HgI_2	2.8340	2.8360	2.8740
14.	PbO_2	2.0580	2.0190	2.0610
15.	$PbCo_3$	1.8583	1.8248	1.8621
16.	PbF	2.1430	2.1250	2.1690
17.	PbS	2.0260	2.0310	2.0720

to the theoretical total cross sections estimated using the tables of Storm and Isreal (1970), Scofield (1973) and Hubbell *et al* (1975). The errors in experimental value arise mainly from statistics in counting, impurities in compounds, uncertainities in the preparation and weighing of the absorber are evaluated to 1 per cent. The overall error is estimated to be less than 2 per cent. The sum rule for the binary compounds consisting element 1 and 2 with fractional weightages W_1 and W_2 as

$$(\mu/e)_{comp} = W_1(\mu/e)_{e_1} + W_2(\mu/e)_{e_2}$$

$(\mu/e)_{e_1}$ and $(\mu/e)_{e_2}$ are mass attenuation coefficients of the constituent elememts of the compound. It can be seen from the table that there is general agreement between the two sets of data. In Tabls 2, the deduced elemental cross sections

Table 2. Total photon attenuation coefficients in barons/atom.

	Experimental (error 2%)	Theoretical
1. Oxygen from B_2O_3	4.46	4.43 (SI) 4.44 (Sc H)
2. Fluorine from LiF	5.10	5.14 (SI) 5.15 (Sc H)
3. Al directly measured	8.96	8.95 (SI) 8.96 (Sc H)
Al from Al_2O_3	8.92	
4. Cl from $AlCl_3$	15.62	15.56 (SI) 15.63 (Sc H)
Cl from NaCl	15.47	
5. Zn directly measured	88.34	88.25 (SI) 88.50 (ScH)
Zn extracted from ZnS	87.92	
6. Bromine from NaBr	154.5	154.6 (SI) 154.6 (Sc H)
7. Hg from HgO	718.4	718.4 (SI) 731.8 (Sc H)
Hg from $HgCl_2$	717.4	
Hg from HgI_2	703.6	
8. Pb directly measured	798.35	793.06 (SI) 809.57 (Sc H)
Pb from PbO_2	808.40	
Pb from $PbCo_3$	807.83	
Pb from PbF	799.54	
Pb from PbS	790.99	

ars presented by subtracting the contributions of other elements taken from semi-experimental valuas of veigele *et al* (1971) and present experimental values, wherever avariable. It can be seen that there is general agreement between the theory and experiment within 1 to 2%. However, a close observation of the Hg cross section deduced from three different compounds, perhaps support the view that there is

endure for chemical effect, through small as the atomic number of the other element in the compound increases.

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