

Preliminary Results of the Electrical Conductivity and Magnetic Nature of the Highly Pressed Double Halides of Mercury and their Equimolar Mixtures

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ABSTRACT

A preliminary report of some of the results of the measurements of the electrical conductivity of HgCl_2 , HgBr_2 , HgI_2 and an equi-molar mixture of HgCl_2 and HgBr_2 and another of HgBr_2 and HgI_2 , all these being pressed to 10 tons/cm² of pressure, are reported. The very low value of the electrical conductivity of the two equimolar mixtures, compared to those of the corresponding double halides strongly suggests formation of some new product in both the cases. This is also supported by the X-ray diffractograms of the compounds. Finding the nature of the product is a matter for detailed study before any reliable conclusions can be drawn.

Key words: Mercury double and mixed halides, Electrical Conductivity, XRD of products.

INTRODUCTION

The electrical conductivity of molten mercury halides had earlier been studied¹. Some reactions can be cited where electrical conductivity had been studied during the reaction². Earlier electrical conductivity measurements have been done to show that the crystals prepared are of good crystalline quality³. In the present work, the pellets of the double halides and their equimolar mixture are made from finely ground powders after putting them in a hydraulic press and applying pressure of 10 ton/cm². The object is to measure the resistance and then from the thickness and the radius to get the electrical conductivity of each of the pellets. The very small value of the electrical conductivity of the equi-molar mixture of HgCl_2 and HgBr_2 as well as that of HgBr_2 and HgI_2 , as compared to that of both the concerned double halides, suggests formation of a new product on application of the high pressure. However, knowing the nature of the new product is

a matter for detailed investigation. Here, we report only the preliminary results of the electrical measurements and X-Ray diffractograms that support our contention. The conductivity is measured at the room temperature as well as at 70°C. We find a considerable fall in the conductivity at the higher temperature.

EXPERIMENTAL

The pellet is formed using an automatic hydraulic pellet press, fitted with a pressure gauge, showing the pressure on the scale. The pellet was made in a stainless steel die and no binder was used to bind the compounds. All the compounds used were of Merck Chemicals of 99.9 % purity. All the compounds were taken in same amount (3 gms.) for making their pellet. The pellet of the equimolar mixture was also made from 3 gms. of the mixture. The pellet formed was kept in a desiccator to prevent the moisture absorption.

Measurements of the thickness and radius of the pellets

The thickness of the pellets formed was measured, using a traveling microscope of 0.01 mm least count. For this purpose, first, the traveling microscope was set at a lower curved edge of the pellet, and the reading (X) on the vernier scale of the microscope was noted. Then slowly and carefully, the microscope tube was shifted to the upper curved edge of the pellet and again reading (Y) on the vernier scale was noted. The thickness of the pellet measured is the difference of the two readings. Each measurement was repeated three times to minimize the errors.

The radius of the pellet was measured in a similar way as that of the thickness measurement, but in this case, the microscope was focused over the horizontal face of the pellet. Then first reading (P) at one edge of the pellet circumference was noted on the vernier scale, then microscope tube was shifted to the opposite edge of the pellet circumference, and again the reading (Q) was taken on the vernier scale. The diameter of the pellet is the difference of the two readings. The measurement was repeated three times.

Resistance measurement at the room temperature

The pellets were pasted with silver paste on both sides, but not covering the curved sides. The silver paste makes the pellet surface conducting. Then the resistance of the pellets was

measured using a digital electronic multimeter (Mastech MS8 200 G; ranges 200 Ω to 20 M Ω , the accuracy being 99%). The instrument measures in six ranges, upto 200 Ω , 2K Ω , 20K Ω , 200K Ω , 2M Ω and 20M Ω . First the instrument is set to a required range. The measured resistance is equal to the product of the reading with the maximum of the value of the range. Thus, when the reading is 0.8, and the maximum range of 20 M Ω is being used, the resistance being measured is 16 M Ω . In this particular range, the smallest difference of the resistance that can be measured is 0.2 M Ω . Each measurement was repeated three times to minimize the errors. Then conductivity of the pellets were calculated using the standard formula

$$K = d / RA$$

where K is the conductivity, R is the resistance, d is the thickness, and A is the area of cross section of the pellet.

The results of Resistance measurements at high temperature (70°C)

The resistance of the pellets was also measured at high temperature (70°C). This was done by heating the pellet in the oven, set at 70°C, and quickly carrying out the resistance measurement. In this way, the mean temperature, during the experiment, would be a little lower than 70°C. However, this has been ignored. It was found that all of the compounds show very poor conductivity at the higher temperature.

Table 1: Measurements of the thickness and radius of the pellets (10 ton /cm²)

S. No.	Compd. (cm)	d (cm)	D (cm ²)	A (M Ω)	R* (10 ⁻¹⁰ Scm ⁻¹)	K* (M Ω)	R** (Scm ⁻¹)	K**
1.	HgCl ₂	0.473	1.302	1.331	28.07	127	>400	
2.	HgBr ₂	0.436	1.302	1.331	23.6	139	>400	
3.	HgI ₂	0.354	1.302	1.331	1.39	1913	>400	Below
4.	Equimolar mix. (HgCl ₂ & HgBr ₂) (Room temp)	0.45	1.302	1.331	210.6	16	>400	10 ⁻¹⁰
5.	Equimolar mix.	0.407	1.302	1.331	178.8	17	>400	

* Measurements taken at room temperature

** Measurements taken at 70°C temperature

The results of magnetic nature determination of the mercury mixed and binary dihalides

It was found that, binary dihalides of mercury and their equimolar mixtures (HgCl_2 , HgBr_2 , HgI_2 , Equimolar mixture of HgCl_2 & HgBr_2 , Equimolar mixture of HgBr_2 & HgI_2), at room temperature, are diamagnetic in nature. Solution of all of these compounds were prepared separately in ethanol and kept in a test tube. Then the solution was kept in a U shaped tube, fitted with a funnel at the top, between the poles of electromagnet attached with a constant current power supplier at 100 V potential differences and a current of 10 ampere. It was found that, level of the solution in the tube rises on applying magnetic field, which is the behavior of diamagnetic substances. This happened for all the samples.

RESULTS AND DISCUSSION

Table 1 gives the measurements of the thickness, radius and the area of the pellets. The results of the electrical resistance measurement at the room temperature and at 70°C, electrical conductivity, as calculated from the data at room and at 70°C, are also shown in Table 1. For an equimolar mixture of two substances, one expects the conductivity of the mixture to lie in between the conductivities of the two substances. We find that in all the cases, the conductivity of both the equimolar mixtures is much lower than that of the two separate compounds HgCl_2 and HgBr_2 or HgBr_2 and HgI_2 , as the case may be. This means that a new material is probably being formed which has

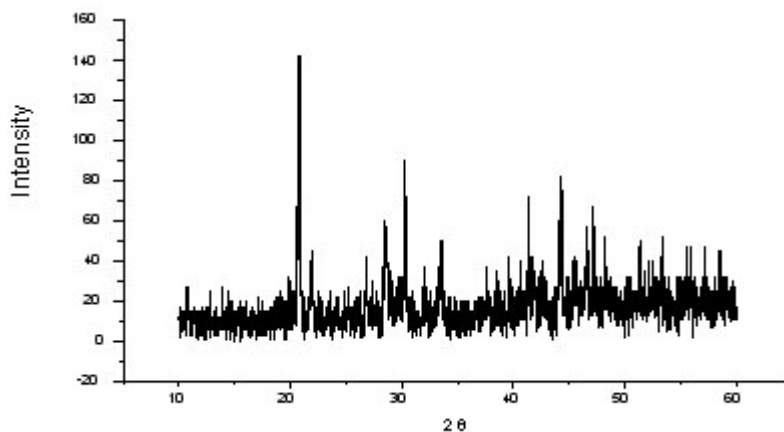


Fig. 1: X- Ray diffractogram of HgCl_2 pellets made at a pressure of 10 ton / cm^2

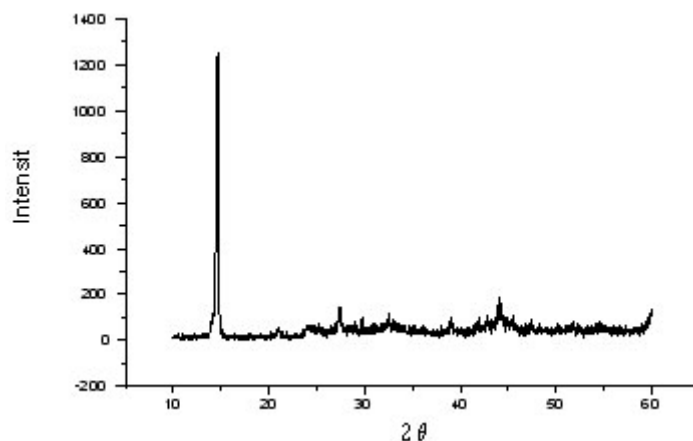


Fig. 2: X- Ray diffractogram of HgBr_2 pellets made at a pressure of 10 ton / cm^2

extremely low conductivity, but this may not necessarily be a new chemical compound. Its identification and characterization is going to be a long drawn out affair.

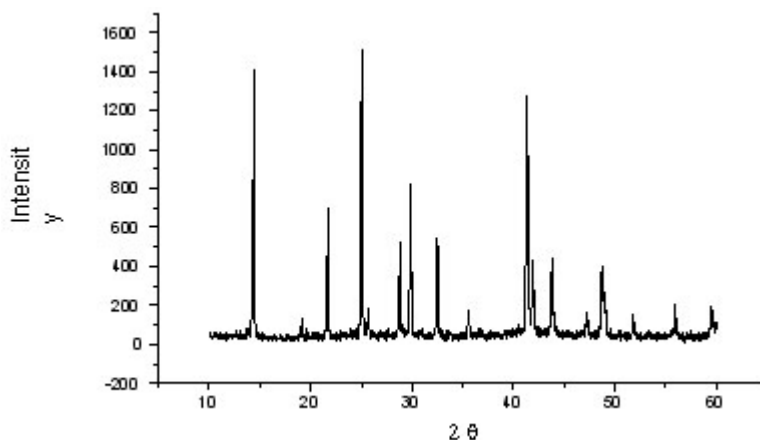


Fig. 3: X- Ray diffractogram of HgI_2 pellets made at a pressure of 10 ton / cm^2

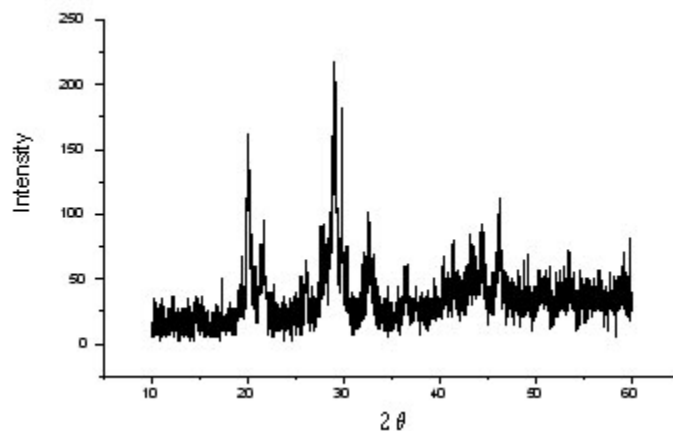


Fig. 4: X- Ray diffractogram of Equimolar mixture ($\text{HgCl}_2 + \text{HgBr}_2$) (Room Temp.) pellets made at a pressure of 10 ton / cm^2

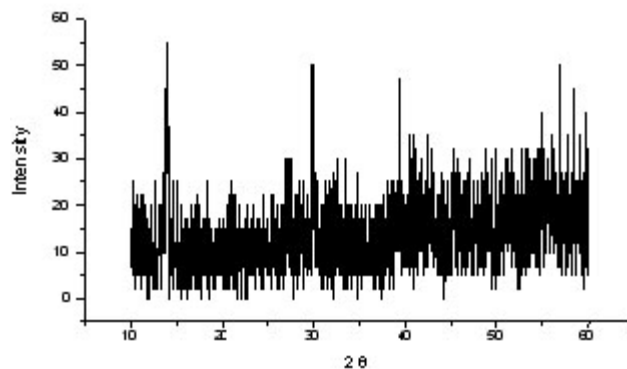


Fig. 5: X- Ray diffractogram of Equimolar HgBrI (Room Temp.) pellets made at a pressure of 10 ton / cm^2

Fig. 1, 2 and 3 gives the X-Ray diffractogram of HgCl_2 , HgBr_2 and HgI_2 pressed at 10 ton pressure. Figures 4 and 5 give the X-Ray diffractogram of equimolar mixture of ($\text{HgCl}_2 + \text{HgBr}_2$) and ($\text{HgBr}_2 + \text{HgI}_2$) pressed at 10 ton pressure respectively taken by Rigaku X-ray diffractometer using Cu K α radiation, voltage applying 40 kV at current 100 mA with step size 0.02, pattern from 10° to 60° (2θ).

CONCLUSION

On the basis of the sharp fall in the electrical conductivity of the compressed equimolar mixtures as compared to the conductivity of their component double halides, and the X-Ray diffractograms, it may be concluded that a new material, of extremely low conductivity, is produced. Pressure seems to have brought about production of the new material.

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