Synthesis, Structure and Magnetic Properties of $La_2Srln_2S_7$

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Abstract

A new phase with the composition $La_2Srln_2S_7$ has been synthesised by the standard ceramic method. X-ray diffraction studies show that the phase crystallizes in the RP-type (n=3) structure with tetragonal unit cell (a=4.852Å and c=26.390Å). The phase is diamagnetic and magnetic susceptibility is temperature independent.

Keywords: $La_2Srln_2S_7$, RP-type, XRD studies, Magnetic Properties.

Introduction:

Ruddlesden-Popper-type sulphide phases have been subject matter of intense studies for their wide range of properties. These phases are represented by the composition $A_{n+1}B_nS_{3n+1}$ where usually B-site is occupied by one or more transition metal ion (s). Phases of Zr and Hf with n=1,2 and 3 are known in literature [1-5]. It has been observed that these phases, generally crystallise in the phase group 14/mmm or Fmmm with tetragonal or orthorhombic unit cell. As compared to the corresponding oxides of Ruddlesden-Popper type phases, the cell dimensions of sulphides are much extended and transition metal atoms are unusually in distorted octahedral geometries with varying M-S distances. $Ba_3Zr_2S_7$ is reported to have space group Cccm with orthorhombic unit cell, while Ba-Zr-S (n=3) phase crystallizes in the space group Fmmm with orthorhombic unit cell [2].

In the present paper, synthesis of a new RP-type phase with the composition $La_2Srln_2S_7$ has been reported. The deficiency in sulphur is the result of loss of S (3) with position co-ordinates (0, 0.5, and 0.096). However the other S-position remains unaffected as a result of this structural deformation. Its crystal structure has been determined from the power X-ray diffraction data.

Experiment:

Synthesis

Aldrich make Lanthanum (La) Strontium (Sr) Indium (ln) and Sulphur (S) elements (purity 99.9%) have been used for synthesis of the new phase. The constituent elements weighed corresponding to the stoichiometry $La_2Srln_2S_7$, were mixed and homogenised by grinding in cyclohexane. The dried and homogenised mixture, pressed into pellets in hydraulic press was placed in quartz tube and evacuated to $\sim10^{-5}$ Torr, vacuum sealed and was heat- treated at 1273K for 72 hours. The mixture during the heat treatment was subjected to a number of intermediate grindings, pelletizing and sealing under same conditions for the completion of the reaction. The final product was pulverised to fine powder for further investigations [6-8].

Elemental Analysis

The phase was further analysed by atomic absorption spectrophotometry, which is one of the most prevalent methods for the trace element analysis [9-11]. The results of chemical elemental analysis [12, 13] and the atomic absorption spectrophotometry are in good agreement. The data are given in Table 1.

Table 1: Analytical data of the phase ($La_2SrIn_2S_7$).
The theoretical value is given parenthesis. Analysis (%)

Phase	La	Sr	In	S
$La_2SrIn_2S_7$	33.78 (33.90)	10.53 (10.69)	27.91 (28.02)	27.26 (27.38)

X-ray Diffraction studies

Room temperature powder X-ray diffraction data of the product were recorded on a Stoe-powder diffraction system and a Philips diffractometer at a scanning speed of 1deg. /minute in the 2θ#ange using CuKα and FeKα radiations [14-18]. The X- ray diffraction data are given in the Table 2, while the X-ray pattern, intensity, versus 2θ is drawn in the figure1.

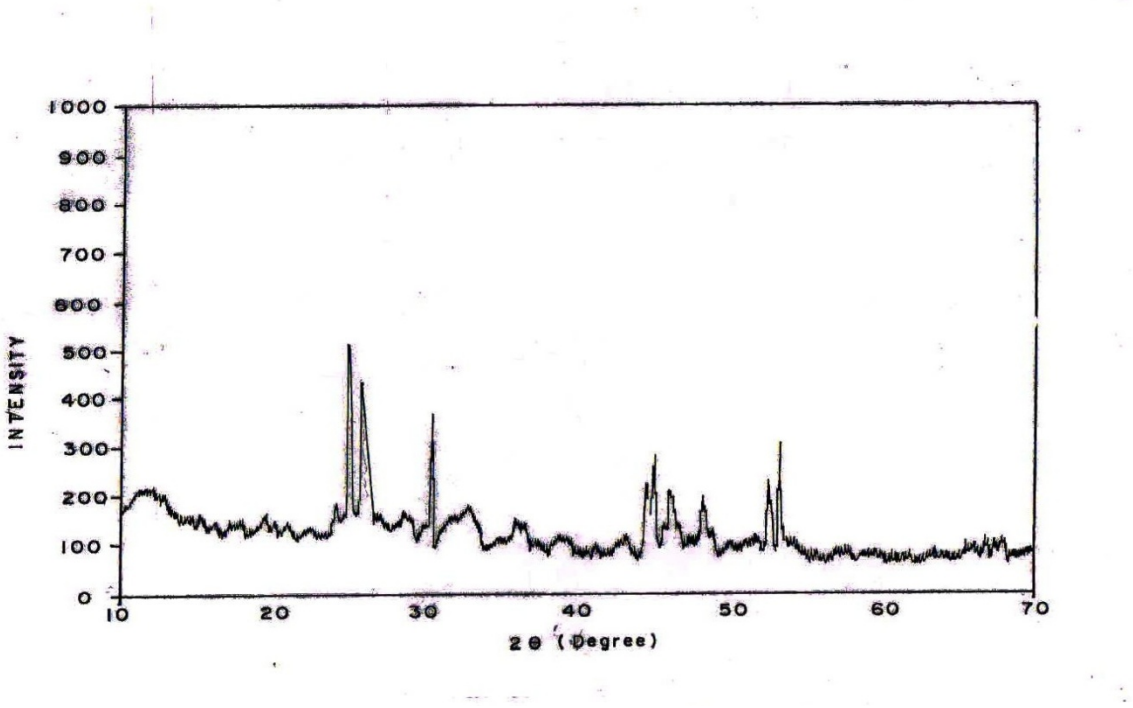

Figure 1: *X-ray Diffraction pattern of $La_2SrIn_2S_7$*

Magnetic Susceptibility Measurement

Magnetic susceptibility of the powdered phase was recorded in a Faraday balance provided with Polytronic Faraday-type electromagnet and a Mettler microbalance. Specially fabricated Dewar flask of the size which could be adjusted within pole gaps of electromagnet was used for keeping liquid nitrogen, which surrounded the phase crucible [16, 17]. The phase was held hanging in the inner tube of the Dewar flask with a fine thread. Magnetic susceptibility in the temperature range 77K-300K could be measured by this arrangement.

Results and Discussion

Crystal Structure

The unit cell parameters of the phase were calculated from X-ray diffraction data (Table 2). The indexing of the data shows that it crystallises in the tetragonal unit cell with a=4.852Å and c=26.390Å. In order to determine the crystal structure, the theoretical X-ray diffraction data were generated by Treor and

Lazy- Pulverix analysis. The d_{cal} values computed from data are in good agreement with the experimental interplanar distances. The data along with the assigned h k l values are given in the Table 2.

Table 2: Powder X-ray Diffraction Data of $La_2SrIn_2S_7$

h	k	l	d_{obs} (Å)	d_{cal}(Å)	I_{obs}	I_{cal}
1	0	5	3.548	3.553	100	100
1	1	0	3.430	3.450	75	68
1	1	4	3.047	3.045	22	2
1	0	7	2.927	2.949	35	7
1	1	6	2.711	2.695	36	20
2	0	2	2.396	2.397	6	1
1	1	8	2.379	2.361	9	3
2	0	4	2.277	2.283	11	3
2	1	1	2.184	2.174	8	1
0	1	11	2.122	2.122	8	1
2	1	3	2.105	2.115	9	1
1	1	10	2.072	2.074	25	22
2	1	5	2.021	2.011	23	43
2	0	8	1.947	1.948	11	1
2	1	7	1.877	1.879	11	4
0	0	14	1.869	1.851	23	2
1	1	12	1.830	1.830	11	4
2	0	10	1.788	1.776	7	33
2	1	9	1.736	1.739	18	4
2	2	0	1.723	1.725	27	20
2	2	2	1.710	1.709	15	1
2	2	4	1.674	1.666	6	1
1	1	14	1.648	1.631	7	2
3	0	3	1.599	1.595	6	1
3	0	5	1.562	1.551	6	9
3	1	12	1.538	1.532	4	1
2	2	8	1.523	1.522	7	1
3	1	4	1.499	1.500	4	1
3	0	7	1.492	1.489	4	1
1	1	16	1.467	1.466	3	4
3	0	9	1.411	1.416	5	1
3	1	18	1.397	1.393	10	1

Space group: 14/mmm

a=4.852Å, c=26.390Å

Table. Positional Coordinates for $La_2SrIn_2S_7$

Atom	X	Y	Z	Occupancy
La (1)	0	0	0.5	0.67
La (2)	0	0	0.3148	0.67
Sr (1)	0	0	0.5	0.33
Sr (2)	0	0	0.3148	0.33
In	0	0	0.0971	1
S(1)	0	0	0	1
S(2)	0	0	0.190	1
S(3)	0	0.5	0.096	1

Magnetic susceptibility studies

The molar magnetic susceptibility measurements as a function of temperature suggest that the phase is diamagnetic and magnetic susceptibility is temperature independent.

Conclusion:

A new phase with the composition $La_2SrIn_2S_7$ has been synthesised by the standard ceramic method. X-ray diffraction studies show that the phase crystallizes in the RP-type (n=3) structure with tetragonal unit cell. The molar magnetic susceptibility measurements as a function of temperature suggest that the phase is diamagnetic and magnetic susceptibility is temperature independent.

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