Now $\Delta g_{ij} = S_{ijkl}\, x_{kl}$ or $\Delta g_i = S_{ij}\, x_j$ in the one index form.

Hence

$$-0{\cdot}232 = 2S_{31}(-0{\cdot}127 \times 10^{-2}) + S_{33}(-0{\cdot}1 \times 10^{-2})$$
$$-0{\cdot}170 = 2S_{31}(+0{\cdot}013 \times 10^{-2}) + S_{33}(-0{\cdot}1 \times 10^{-2})$$

giving

$S_{33} = +1{\cdot}75 \times 10^2$ degrees/mm./unit strain

$S_{31} = +0{\cdot}2214 \times 10^2$ degrees/mm./unit strain

elastic compliances of α-quartz in units of 10^{-12} cm.^{2}/dyne are[7]

$s_{11} = 1{\cdot}277$, $s_{12} = -0{\cdot}179$, $s_{31} = -0{\cdot}122$,
$s_{33} = 0{\cdot}96$, $s_{14} = -0{\cdot}431$, $s_{44} = 2{\cdot}004$.

Also since

$R_{ij} = S_{ik}\, s_{kj}$

$\therefore R_{33} = 2S_{31}\, s_{31} + S_{33}\, s_{33}$

$R_{31} = S_{31}(s_{11} + s_{12}) + S_{33}\, s_{31}$

substituting the values one gets

$R_{33} = +0{\cdot}16298$ degree/mm./k bar

$R_{31} = +0{\cdot}002959$ degree/mm./k bar

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THERMAL EXPANSION OF IRIDIUM DIOXIDE

K. V. KRISHNA RAO AND LEELA IYENGAR

Physics Department, Osmania University, Hyderabad-7, India

IRIDIUM DIOXIDE, which has a tetragonal rutile type structure, has been found to exhibit high electrical conductivity typical of metal-like conductors from the study of the electrical transport properties by Rogers *et al.*[1] and Ryden *et al.*[2] The lattice parameters of IrO_2 at room temperature have been reported recently.[1-3] A search of the literature shows that no studies on the thermal expansion of iridium dioxide seem to have been made so far. Hence it interested the authors to include this compound in a general programme of 'Studies on rutile type compounds by the X-ray method'. The present paper gives an account of the precision determination of the lattice parameters at different temperatures and the evaluation of the coefficients of thermal expansion at various temperatures.

The sample used in the present study was kindly supplied by Dr. W. D. Ryden of the University of California. The powder sample for the study was prepared by filling it in a thin-walled quartz capillary. Using a Unicam 19 cm. high temperature powder camera and CuK radiation from a Raymax-60 X-ray unit, powder photographs were taken at different temperatures. The present study was made for the temperature range 28° C. to 702° C. Reflections from the 213, 402, 510, 332, 501, 303, 422, 521, 323, 440 and 004 planes recorded between 55° to 78° Bragg angles were used in evaluating the lattice parameters at different temperatures. The experimental set-up and the computational procedure have been described in an earlier paper.[4]

The lattice parameters of IrO_2 at room temperature obtained in the present study are listed in Table I along with the other values available in the literature. The values from the present study agree well with the two recent determinations.

TABLE I

Lattice parameters of IrO_2 at room temperature

Source		a (Å)	c (Å)
Goldschmidt[5]	..	4·49	3·14
Swanson *et al* [3]	..	4·4983	3·1544
Rogers *et al.*[1]	..	4·4980 ± 0·0002	3·1546 ± 0·0002
Present study	..	4·4985 ± 0·0001	3·1548 ± 0·0001

The lattice parameters obtained at different temperatures are given in Table II and shown graphically in Fig. 1. It can be seen that both

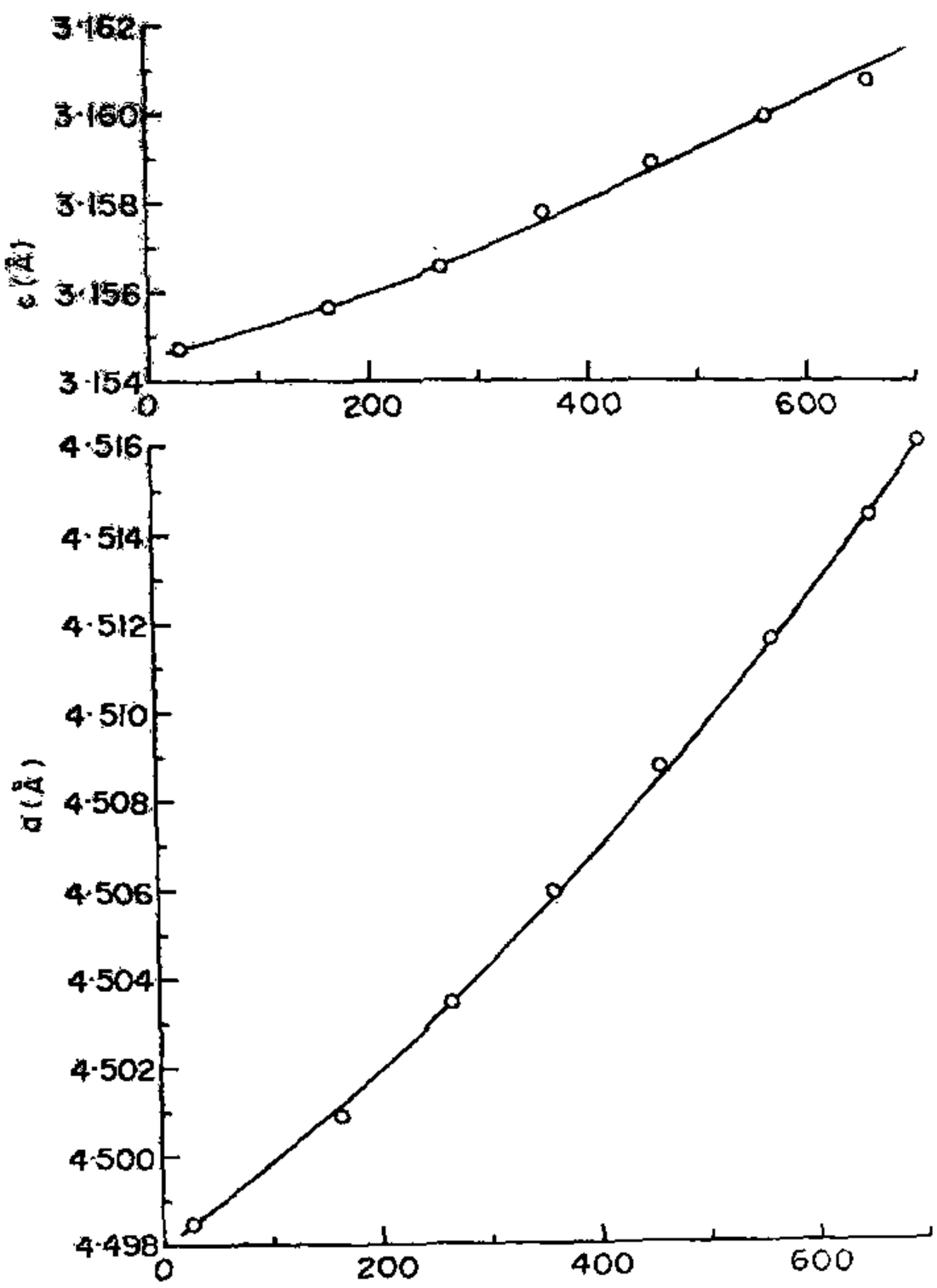

FIG. 1. Variation of the lattice parameters of IrO_2 with temperature.

the parameters increase with increasing temperature. The temperature dependence of the coefficients of thermal expansion, $\alpha_{\parallel}$ and $\alpha_{\perp}$ are represented by the following equations:

$$\alpha_{\parallel} = 1{\cdot}266 \times 10^{-6} + 8{\cdot}823 \times 10^{-9}\ t\ - 6{\cdot}870 \times 10^{-12}\ t^2.$$

$$\alpha_{\perp} = 3{\cdot}532 \times 10^{-6} + 7{\cdot}963 \times 10^{-9}\ t\ - 3{\cdot}825 \times 10^{-12}\ t^2.$$

TABLE II

Lattice parameters of IrO_2 at different temperatures

Temperature °C.	a (Å)	c (Å)
28	4·4985	3·1548
165	4·5009	3·1557
267	4·5035	3·1566
361	4·5059	3·1578
461	4·5087	3·1589
563	4·5116	3·1600
655	4·5144	3·1609
702	4·5161	3·1619

$\alpha_{\parallel}$ and $\alpha_{\perp}$ obtained at different temperatures are listed in Table III.

TABLE III

Coefficients of thermal expansion of IrO_2 at different temperatures

Temp. ° C.	$\alpha_{\parallel} \times 10^6$		$\alpha_{\perp} \times 10^6$	
	Obs.	Calc.	Obs.	Calc.
50	1·66	1·69	3·84	3·92
90	1·90	2·00	4·17	4·22
130	2·22	2·30	4·45	4·50
170	2·69	2·57	4·78	4·78
210	2·85	2·82	5·17	5·04
250	3·09	3·04	5·45	5·28
290	3·41	3·25	5·67	5·52
330	3·57	3·43	5·84	5·74
370	3·57	3·59	5·89	5·96
410	3·65	3·73	6·06	6·15
450	3·73	3 85	6·28	6·34
490	3·80	3·94	6·39	6·52
530	3·88	4·01	6·50	6·63
570	4·04	4·06	6·72	6·83
610	4·20	4·09	7·06	6·97
650	4·20	4·10	7·:8	7·09

The thermal behaviour of IrO_2 is similar to that of CoF_2[6] and rutile type GeO_2[7] in having a negative thermal expansion anisotropy, *i.e.*, $\alpha_{\perp} > \alpha_{\parallel}$. For most of the rutile type compounds so far studied it was found that $\alpha_{\parallel}$ is greater than $\alpha_{\perp}$.

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