

The C-Dy (Carbon-Dysprosium) System

12.011

162.50

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No phase diagram is available for the Dy-C system, but some structural data have been reported. [58Spe] found that at compositions near Dy₃C, the Dy atoms are arranged in a cubic close-packed structure, with the C atoms distributed randomly in the octohedral interstices of this cubic structure, forming an NaCl defect structure or an Fe₄N-type structure (see The Carbon-Rare Earth Systems," in this issue). Structure details for Dy₃C are given in Table 1 for both the C-rich compound and the Dy-rich phase reported by [79Aok]. The Fe₄N-type phase is the high-temperature form that can exist at room temperature in a metastable state. The stable room-temperature form has the approximate composition Dy₂C and the rhombohedral CdCl₂-type structure. The lattice parameter for trigonal Dy₂C is given in Table 1. No melting or decomposition temperature is available for this phase.

The sesquicarbide, Dy₂C₃, was reported by [58Spe] to have the bcc Pu₂C₃-type structure with lattice parameters as shown in Table 1 for the Dy-rich and C-rich compositions. There is no information on the melting point or deformation temperature of this compound.

[58Spe] found that the room-temperature form of DyC₂ has the bct CaC₂-type structure (Table 1). [67Kri] confirmed this structure and reported that the transition to cubic DyC₂ occurs at 1295 ± 20 °C. Other investigators reported lower and higher transformation temperatures (1250 °C [73Mcc] and 1300 to 1317 °C [76Loe]), and the average of these reported temperatures, 1290 ± 30 °C, is in good agreement with that indicated by systematics.

No report was found that detailed the high-temperature structure of DyC₂, although investigators who measured the transformation temperature mentioned a cubic structure. Because the βREC₂ structures that have been deter-

mined (RE = La, Ce, Eu, Tb, and Lu) all have the CaF₂-type cubic form, we believe that DyC₂ also has this form. A third structure has been reported for DyC₂, but high pressures are required to form it from the C11_a CaC₂-type structure. See Table 1 and "The Carbon-Rare Earth Systems," in this issue, for details.

[67Kri], using thermal analysis methods, found the DyC₂-C eutectic temperature to be 2290 ± 25 °C. [70Yup] and [71Kos] reported the melting point of DyC₂ as 2250 ± 60 and 2245 °C, respectively, but because these values are lower than the reported value of the eutectic, some adjustment is necessary. In this situation, we considered these melting temperatures actually to be eutectic temperatures, and we included them in the calculation of the average eutectic temperature. Treatment of the available data for the REC₂-C eutectic temperatures by systematics indicates that the calculated average for DyC₂, 2260 ± 25 °C, must be close to the true value. Other than the two reported melting temperatures for DyC₂, which were treated as eutectic temperatures, no melting-point data are available for this compound, and the lack of corresponding data for the neighboring dicarbides makes an application of systematics impossible.

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Table 1 Dy-C Crystal Structure and Lattice Parameter Data

Phase	Composition range, at.% C	Pearson symbol	Space group	Strukturbericht designation	Prototype	Lattice parameters, nm			Density, g/cm ³	Reference
						a	b	c		
(αDy).....	0	<i>hP2</i>	<i>P6₃/mmc</i>	A3	Mg	0.35915	...	0.56501	8.551	[86Gsc]
(α'Dy).....	0	(a)	...	...	...	0.3595	0.6184	0.5678	8.551	[86Gsc]
(βDy).....	0	<i>cI2</i>	<i>Im3m</i>	A2	W	0.398(b)	...	...	8.56	[86Gsc]
αDy ₂ C.....	~33	<i>hR3</i>	<i>R3m</i>	C19	CdCl ₂	0.6312(c)	...	...	8.437	[81Ato]
βDy ₃ C.....	~25 to ~33	<i>cF5</i>	<i>Fm3m</i>	L ₁ '	Fe ₄ N	0.5001(d)	...	...	8.419(d)	[79Aok]
Dy ₂ C ₃	~54 to ~60	<i>cI40</i>	<i>I43d</i>	D5 _c	Pu ₂ C ₃	0.5079(5) (e)	...	...	8.543(e)	[58Spe]
						0.8198(2) (d)	...	...	8.517(d)	[58Spe]
						0.8215(1) (e)	...	...	8.650(e)	[70Kru]
αDyC ₂	~66.7	<i>tI6</i>	<i>I4/mmm</i>	C11 _a	CaC ₂	0.3669(2)	...	0.6171(4)	7.459	[58Spe, 67Kri, 68Ato, 76Ada, 80Sak, 81Sak]
βDyC ₂ (f)....	~66.7	<i>cF12</i>	<i>Fm3m</i>	C1	CaF ₂	...	...	...	...	[67Kri]
α'DyC ₂ (g) ..	~66.7	<i>o??</i>	...	...	LuC ₂	1.355	2.697	0.7100	...	[68Kru]
(C).....	100	<i>hP4</i>	<i>P6₃/mmc</i>	A9	C (graphite)	0.24612	...	0.67090	2.266	[Pearson2]

(a) Orthorhombic distortion, $T \leq 86$ K. (b) Determined by extrapolation to 0% solute of a versus composition data for Dy-Mg alloys. (c) $\alpha = 32.99^\circ$. (d) Dy-rich. (e) C-rich. (f) Structure for this form has not been reported, but is assumed because it is in agreement with known βREC₂ data. (g) High-pressure form.

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The C-Er (Carbon-Erbium) System

12.011

167.26

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No phase diagram is available for the Er-C system, although some information has been reported for the compounds and their structures. Tri-erbium carbide, Er_3C_x (where $0.25 < x < 0.65$) forms a cubic Fe_4N -type structure in which the anion sites are partially occupied by C atoms. This structure exists immediately below the melting point, but if x is close to 0.5, the structure transforms at lower temperatures to a trigonal CdCl_2 -type structure (see "The Carbon-Rare Earth Systems," in this issue). [81Ato] stated that if x is much different from 0.5, the cubic structure is retained at all temperatures. Lattice parameters for cubic Er_3C are presented in Table 1, but no values were given for trigonal Er_2C . No melting point or transformation temperature data are available for these compositions.

An intermediate compound of Er having a lower than cubic symmetry can be obtained by arc melting. [58Spe] stated that erbium sesquicarbide is isostructural with Y_2C_3 . The structure of the latter compound was eventually determined by [71Bau] to be tetragonal $\text{Sc}_{15}\text{C}_{19}$ type and the composition to be $\text{Y}_{15}\text{C}_{19}$ instead of Y_2C_3 . [74Bau] determined the equilibrium concentration of erbium

"sesquicarbide" to be $\text{Er}_{15}\text{C}_{19}$ and reported pseudocubic tetragonal lattice parameters for this structure (Table 1). It was shown by [70Kru1], [70Kru2], and [80Nov] that Er_2C_3 can be obtained with the cubic Pu_2C_3 -type structure by a solid-state synthesis at elevated temperatures and pressures (30 to 90 kbar, 1200 to 1400 °C). The lattice parameter is included in Table 1. No melting information is available for these Er intermediate compounds.

In the region between 55 and 60 at.% C, the phase relationships in the Er-C phase diagram may be quite similar to those observed in the Y-C system (see "The C-Y (Carbon-Yttrium) System," to be published).

The dicarbide, ErC_2 , was reported by [58Spe] to have the bct CaC_2 -type structure. The average value of lattice parameters from several sources is listed in Table 1. An $\alpha \rightleftharpoons \beta$ transformation from the tetragonal to a cubic form occurs at a temperature above 1300 °C; the lowest of four values is 1275 °C reported by [73McC], and the average of these values is 1310 ± 25 °C. This is in good agreement with the systematic trends of the $\alpha \rightleftharpoons \beta$ transformation of RE_2C_2 compounds. In view of the $\alpha \rightleftharpoons \beta$ transformation,