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INTERRELATION OF CONDITIONS OF PRODUCING PRODUCTS OF NEW TYPES OF GRAPHITE AND GRAPHITIZED MATERIALS WITH THEIR THERMOPHYSICAL PROPERTIES

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ABSTRACT

We characterized heat capacity and thermal expansion of a wide variety of new graphite and graphitized materials depending on conditions of their preparation and regimes of their forming into compact products.

INTRODUCTION

The problem to produce materials fit to withstand rigid conditions defines an interest in studying thermophysical properties of new artificial graphite and graphitized materials. However such an information is practically missing in the literature.

The aim of this paper is to show a variety of thermophysical properties of some new types of graphite materials and their distinction from those of natural graphites using data on thermal expansion and heat capacity (C_p) of thermally exfoliated graphites (TEG), carbon fibrous materials (CFM) and their composites.

EXPERIMENTAL, RESULTS AND DISCUSSION

We investigated CFM, prepared by heat treatment up to 2500 K in the presence of inorganic additions of regenerated cellulose (RC) and polyacrylonitrile (PAN) raw materials, their composites, as well as TEGs, synthesized by means of high-rate heating of a number of products prepared when intercalating bromine, sulphuric acid, iodine chlorides, chlorides and bromides of p- and d-elements, etc. into graphite(so-called graphite intercalation compounds - GICs). The materials were formed into compact products by pressing, rolling, thermal treatment and electric thermal treatment.

The results of determination of some thermophysical characteristics /heat capacity, $C_p(\pm 3\%) = a + b \cdot 10^{-3}T - c \cdot 10^{6}T^{-2}$, (J/mol.K)

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linear thermal expansion coefficient, α (±5%),(K^{-I}), relative elongation ($\Delta l/l_0$) in axial and radial directions/ for different graphite materials are given in Table I,2 and in Figure I.

Table I. Heat capacity of graphite materials.

Material	a	b	c	T,K
I	8.I4468	I4.69I6	0.4I2537	350-620
2	9.89361	I2.I922	0.497793	350-650
3	I0.I484	II.984I	0.528764	360-650
4	9.8I59I	I2.7870	0.493544	360-600
5	9.9805I	I2.7760	0.499000	360-650
6	II.8088	9.62259	0.552849	350-650

Table 2. Thermal linear expansion coefficient of graphite materials.

Material	α.I0^6,K^{-I}	T,K	Material	α.I0^6,K^{-I}	T,K
I	26	300-I200	I0	88	300-490
7	22.3	300-I200		45.5	490-I200
8	27.4	300-I200	II	42.5	300-I200
9	50.5	300-I200	I2	5I.4	300-I200

Here: I-Zavalievsk, 2- Ceylon, 3-Madagascar, 4-electrode, 5-quasi-monocrystalline, 7-Tazkazgan, 8-Taiginsk graphites ;
6,9-I2 -TEGs obtained of GICs at corresponding temperatures: 6- of GIC-H_2SO_4(2800 K), 9- of GIC-$FeCl_3$(2300 K), I0- of GIC-$CoCl_2$(2900 K), II- of GIC-$NiCl_2$(2300 K), I2- of GIC-$CuCl_2$(2300 K).

It was revealed that heat capacities of all investigated materials slightly depended on CFM and TEG preparation conditions and within an experimental error they agreed with those for natural graphites. This proves that graphitization degree of the above materials is sufficiently high.

For HC-based (unlike PAN-based) CFM we revealed a heat treatment temperature region, a type and quantity of an inorganic addition, for which samples, obtained in such conditions, were characterized by considerably anomalous C_p temperature dependence (within 300-420 K with an extremum at 370-380 K), which in our opini-

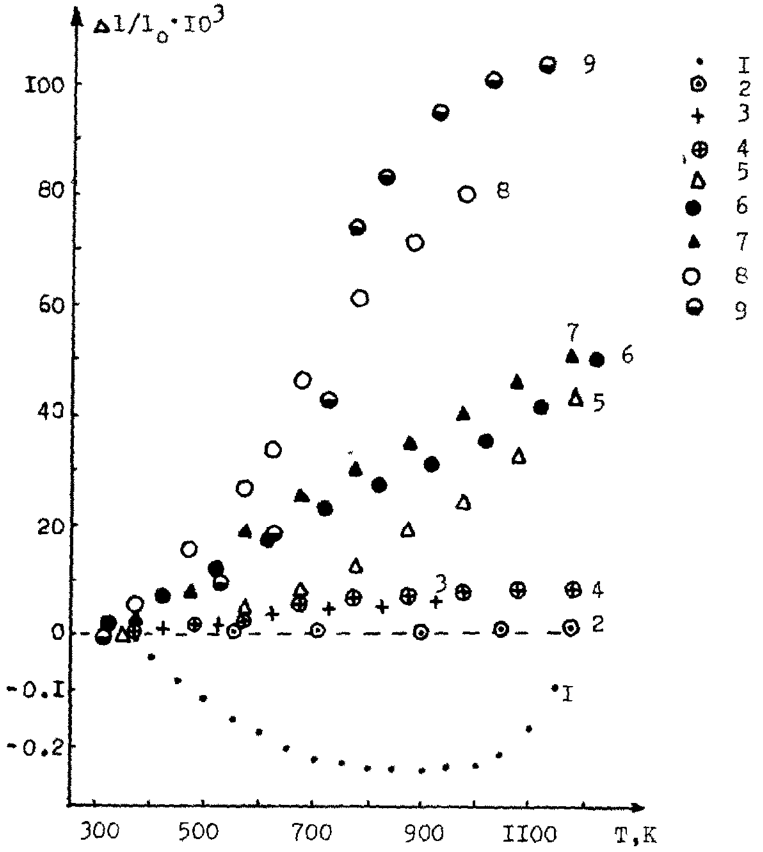

Figure I. Temperature dependence of some graphite materials relative elongation :

I- composite (d= I.23 g/cm^3); 2- composite (d= I.54 g/cm^3);
3- TEG of GIC-$CuCl_2$(2273 K), radial direction ;
4- TEG of GIC-$CuCl_2$(I273 K), radial direction ;
5- TEG of GIC-$FeCl_3$(2273 K), axial direction ;
6- TEG of GIC-$CuCl_2$(2273 K), axial direction ;
7- TEG of GIC-$CoCl_2$(2273 K), axial direction ;
8- TEG of GIC-$CuCl_2$(I273 K), axial direction ;
9- TEG of GIC-H_2SO_4(2500 K), axial direction .

on was due to a high specific surface of such materials.

We revealed a large anisotropy of CFM-based composites thermal expansion. It was shown that one could obtain products having either slight values of thermal linear expansion coefficients, or even negative one (when materials shrinkage took place with the temperature rise up to I000-II00 K) depending on conditions of their forming.

It was stated that TEG compact products thermal expansion was also essentially anisotropic and it greatly depended on the nature of the initial raw materials, conditions of their thermal treatment, methods of the products forming, a density and a form of samples. In a number of cases it was characterized by a residual elongation.

It was shown that CFM and TEG thermal expansion considerably differed from that of the natural graphites, which made in necessary to carry out detailed experimental investigations of them. We also showed that heat capacity and thermal expansion coefficients data for natural graphites from different deposite differed too, but not so greatly as for artificial graphite materials.

CONCLUSIONS

Thus, on the basis of the present paper results one can come to a conclusion, that in spite of the fact graphite is one of the key substances in chemical thermodynamics and its thermophysical properties can be found in fundamental reference books as recommended ones, however, when making accurate calculations one should use thermophysical data for each graphite material concerned (both natural and artificial). Unfortunately at present such data are known not for all similar materials.