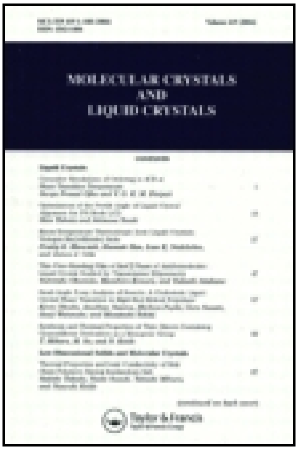

Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl19

Physical and Chemical Properties of Flexible Graphite Foils

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Version of record first published: 24 Sep 2006

Mol. Cryst. and Liq. Cryst., 2000, Vol. 340, pp. 349-354
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Physical and Chemical Properties of Flexible Graphite Foils

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The tensile strength, electrical resistivity, compressibility, elastic recovery, and Young's modulus of foils were studied as a function of the production conditions of graphite foils (the foaming temperature of oxidized graphite, the fraction consumption of graphite, the nature of graphite intercalation compounds and their stage number).

Keywords: graphite foils; GICs; tensile strength; electrical conductivity; compressibility; elastic recovery; Young's modulus

INTRODUCTION

Graphite foils (GFs) are widely used as a sealing material in severe environments, particularly, high temperatures; because they not only exhibit good compressive and recovery capabilities but they also have superior thermal stability and high resistance to chemical attacks. GFs are produced by pressing or molding of exfoliated graphite (EG) without binder, which is obtained by thermal destruction of graphite intercalated compounds (GICs). The graphite compounds of low stages with different acids are used ussually for obtaining EG. The chemical composition of GFs is practically the same as for pristine graphite from which GICs were obtained. GFs are the flexible sheets with thickness to 2 mm which consist from graphite crystallites the basis planes of which are spatially oriented along the molding axes of GFs. The distance between neighbour graphite layers is about 3.37–3.4 Å, and the layers order sequence ABABA... typical for graphite is absent.

In the present work we study physical and mechanical properties of some GFs produced from different GICs: compressibility (C) under pressure and elastic recovery after pressure reducing (R), the Young's modulus along ($E_{\|}$) and perpindicular ($E_{\perp}$) to the texture axis direction, respective elongation at rupture ($\Delta l/l_0$), strength by rupture (σ) and dependence of electrical resistivity on the temperature $\rho(T)$.

RESULTS AND DISCUSSION

Measuremants of C and R were carried out on parallelepide samples with thickness about 1.5 mm. As the thickness of GFs is about 0.3 mm the samples were assembled from 5 pieces. The values of C and R were determined under and after pressure reducing of 35 MPa. The value of C is about 47 % and the value of R is about 9.5 % at the density of GF about 1 g/cm^3 and did not depend on the foil thickness and the nature of graphite. It was shown that the value of C decreases and the value of R increases when the density increases. Mechanical strength at rupture increases with density of GFs [1] and depends on the nature of GICs and on the grain size of oxidized graphite. In Fig.1 the dependence of strength at rupture for GF obtained from GIC with sulfur acid (oxidizer $K_2Cr_2O_7$) and with nitric acid on GF density is shown.

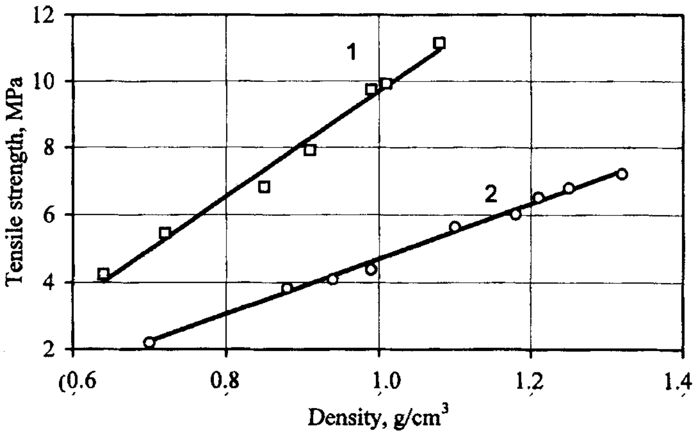

FIGURE. 1 Dependence of strength at rupture of GFs on the density. 1 – foil obtained from GIC with sulfuric acid, 2 – foil obtained from GIC with nitric acid.

The values of strength for GFs obtained from GICs with sulfur acid are higher than those for GFs obtained from GICs with nitric acid. That connected with a higher size of graphite particles in GFs obtained from GICs with sulfur acid. This was confirmed by the observation using electron microscopy [2].

In the Fig. 2. the dependence of strength at rupture for GFs obtained from GICs with nitric acid on the size distribution of pristine graphite used for GF production is shown. Such behaviour of GFs strength is due to the size of particles used for their production [2]. From large size particles the more strong foil is obtained with less number of boundaries between graphite particles along which the destruction of samples by stretching takes place. The presence of such regions is confirmed by the values of electrical resistivity at the same temperatures for GFs obtained from different fractions of graphite.

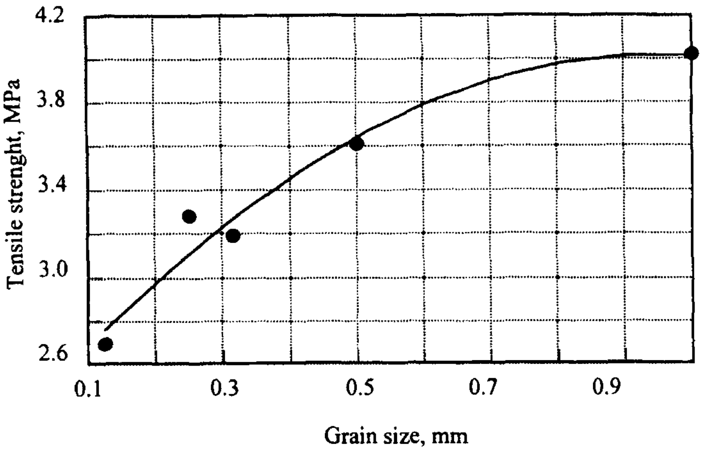

FIGURE 2. Dependence of strength at rupture on the grain size of oxidized graphite for GFs obtained from GICs with nitric acid

It was established that the strength of GFs decreases with number of stage GICs increases and increases with foaming temperature in the temperature range 450–900 ^{0}C. The foaming temperature increases the bulk density of EG decreases significantly. The bulk density of EG does not depend on the nature of oxidizer.

For samples of GFs obtained from GICs with sulfur and nitric acids (GICs were obtained from graphite with high size grains) the value of electrical resistivity is lower than for the samples obtained from graphite with small size grains. Electrical resistivity of GFs obtained from GICs with sulfuric acid using different oxidizers decreases with the stage number and practically does not depend on the type of oxidizer.

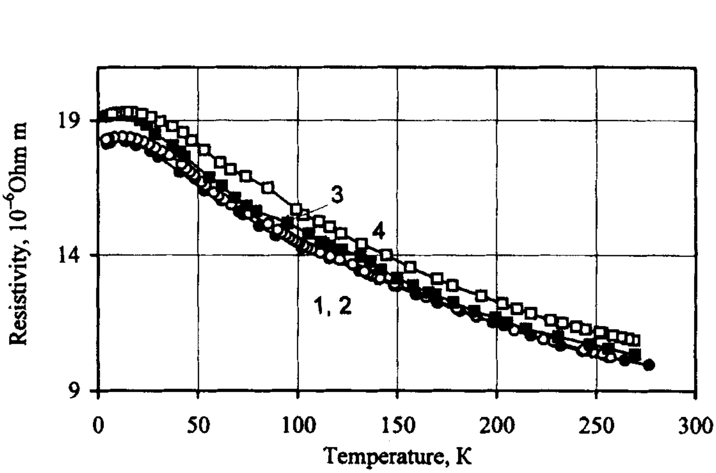

FIGURE 3. Dependence of electrical resistivity of GFs obtained from GICs with nitric acid on temperature. Samples were produced on graphite with different size grains: 1 – 1 mm, 2 – 0.5 mm; 3 – mixture of all the grains; 4 – 0.125 mm.

The values of $E_{||}$ are some hundreds MPa and increase with density of GFs. Simultaneosly the values of $E_{\perp}$ are only tens MPa and also increase with the density of GF. Young's modulus anisotropy is equal to $E_{||}/E_{\perp}$ and is about 32 for GF with density of about 1 g/cm^3 and decreases when density increases. Respective elongation at rupture for GFs is about 1 % and increases slightly with decreasing the stage number of GICs from which the foil was obtained.

CONCLUSION

It is shown that the electrophysical and mechanical properties of GFs are mainly determined by the size of particles of oxidized graphite. The nature of oxidizer used for the synthesis of GICs with sulfuric acid influences weakly physical and chemical properties of GFs. Electrical conductivity, Young's modulus are linearly increasing with the density. The temperature of heat treatment of GICs has influence on the bulk density of EG.

Acknowledgments

The work was done with financial support of the Russian Foundation for Basic Research (Grants 989–03–32615, 98–03–32979).

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