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DEVELOPMENT OF BASALT – FLUOROPLASTIC COMPOSITES FOR TECHNICAL PURPOSES

A.A. Ushkanov, S.A. Sleptsova

North-Eastern Federal University, 58 Belinskogo St., Yakutsk, 677000, Russia

alexanderushkanov@mail.ru, ssard@yandex.ru

Abstract. The development of composites based on polytetrafluoroethylene (PTFE) for their use in friction units of technology in the Arctic climate is an urgent task of modern materials science. The active use of environmentally friendly fibers as reinforcement for composite materials instead of carbon and fiberglass can help reduce environmental problems. Moreover, from an economic point of view, natural fibers are in an advantageous position. In this work, the effect of basalt fiber on the tribotechnical properties and structure of polytetrafluoroethylene is investigated. As a result of the study, it was found that the characteristics of basalt fluorocarbon composites are approximately on par with composites with carbon fibers.

Materials and Methods. PTFE grade PN-90, manufactured by «HaloPolymer» JSC TU 2213-022-13693708-2005, GOST 10007-80. Basalt fibers (BF) produced by LLC «TBM» are crushed in a Fritsch Pulverizette 15 mill with an installed sieve measuring 0.25 mm. The length of the fibers varies in the range of 30-90 µm, and their diameter is 8.0-10.0 µm. Carbon fibers (CF) produced by JSC «SvetlogorskKhimvolokono» were modified by plasma-chemical treatment in an environment of organofluorine compounds. The fiber's width and length are 8–10 µm and 50–500 µm, respectively.

Table 1. Research methods

	Methods	Equipment
Tribotechnical characteristics	(GOST 11629-2017) Mass wear	UMT-3 (CETR, USA)
Differential Scanning Calorimeter (DSC)	Degree of crystallinity	DSC 204 F1 (Phoenix Netzsch, Germany)
X-ray structural analysis (XRD)		ARL X'TRA (Thermo Fisher Scientific, Switzerland)
Scanning electron microscopy (SEM)	Supramolecular structure and friction surfaces	JSM-7800F LV (JEOL, Japan)

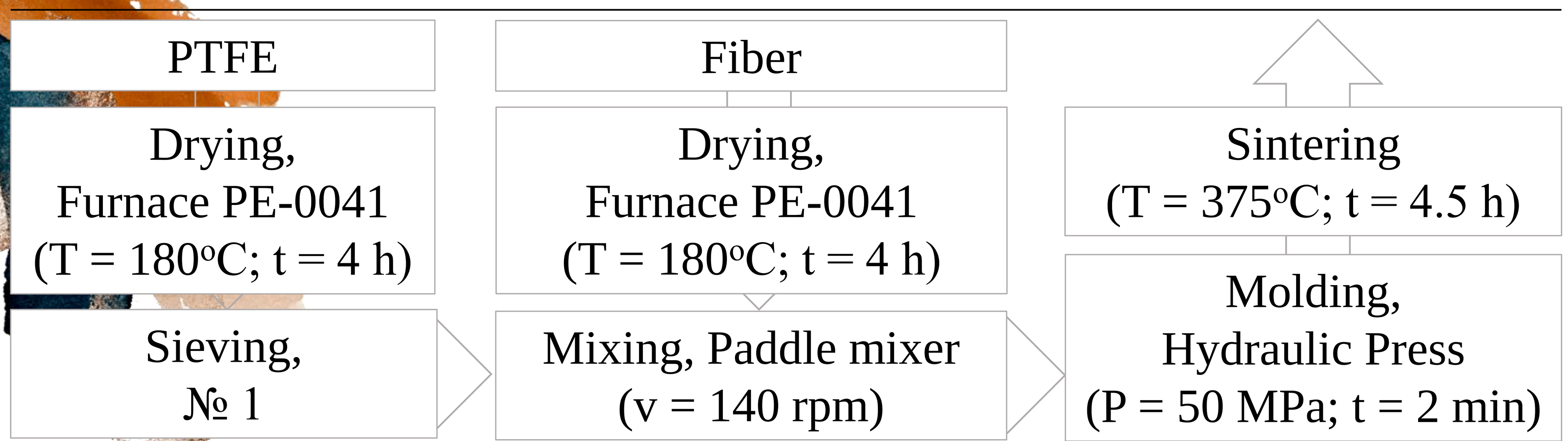

Fig. 1. Technological scheme for obtaining polymer composites based on PTFE

Discussion. As you can see from the table 2, with the introduction of reinforcing fillers into composites based on PTFE, the friction coefficient increases (by 1.8 times), but at the same time, the wear rate is significantly reduced (up to 400-500 times). The literature generally accepts that the coefficient of friction of antifriction materials in the presence of lubricant is 0.005-0.05 and without it 0.04-0.3. In the works of D.A. Negrov and V.Yu. Putintseva Note that low friction coefficients (0.04–0.08) exist only at sliding speeds less than 0.01 m/s, and with an increase in sliding speed, the PTFE friction coefficient increases and is more than 0.3. In the works of O.A. Kurguzova confirms the words of the previous authors, when with an increase in the sliding speed on steel, the PTFE friction coefficient increases by 2-3 times.

Table 2. Results of tribotechnical characteristics and degree of crystallinity

Composites, wt. %	Mass wear rate I, mg/h	Coefficient of friction f	Degree of crystallinity α, %	
			DSC	XRD
PTFE	51.39	0.20	37.65	63.39
PTFE + 18 BF	0.12	0.37	50.10	76.74
PTFE + 18 CF	0.10	0.31	41.47	76.64

It was also shown that the degree of crystallinity of the composites, which DSC and XRD determined for one sample, is slightly different. Such incompatibility of one determined quantity lies in the determination of various amounts, some of which are only indirectly related to the degree of crystallinity.

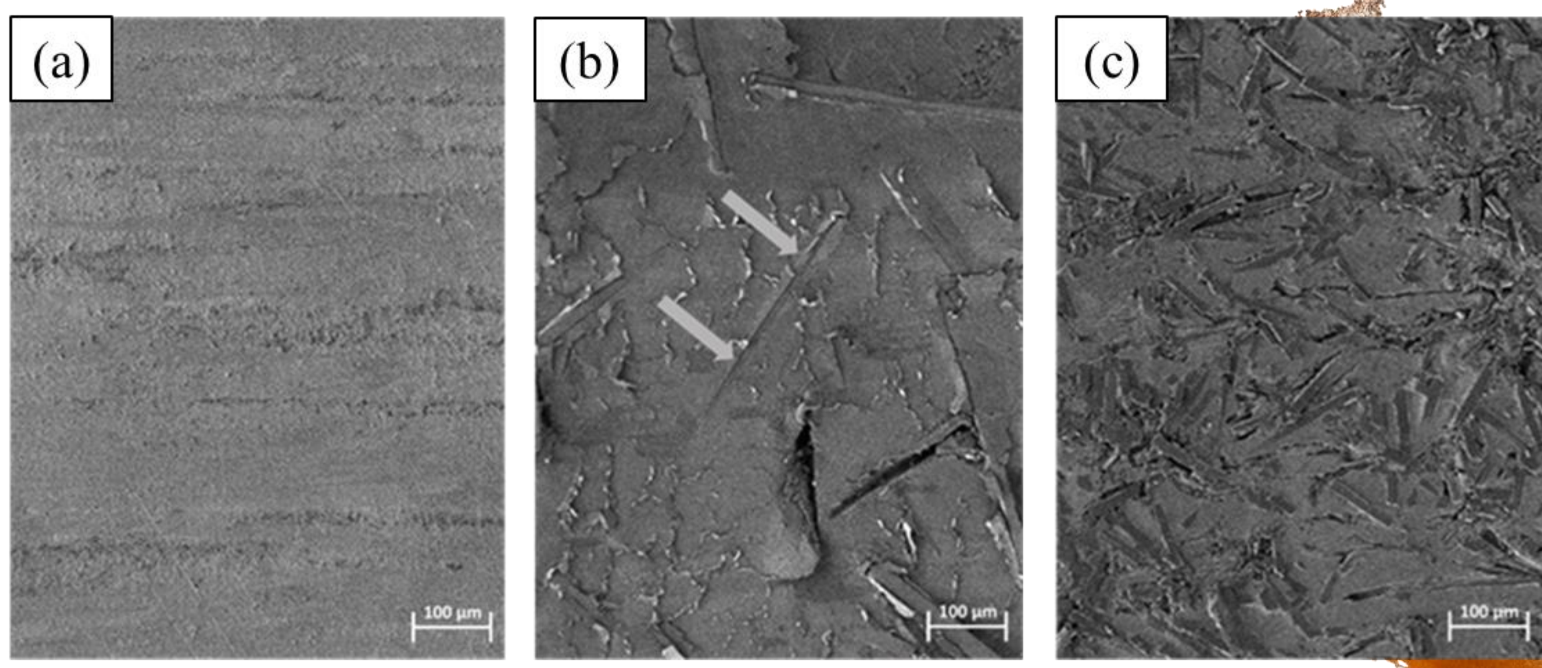

Fig. 2. Micrographs of friction surfaces of PTFE and its composites (x150): (a) PTFE; (b) PTFE + 18 wt.% BF; (c) PTFE + 18 wt.% CF

In fig. 2, visible fibers of different nature on the friction surface of the composites. They are randomly distributed and protrude from worn surfaces. It is possible that the fibers localized on the surface layer of the composites protect it from destruction, due to which the wear resistance increases. To better clarify the effect of natural fiber at the polymer-fiber interface on the properties of composites, the supramolecular structure of the composite has been studied in more detail.

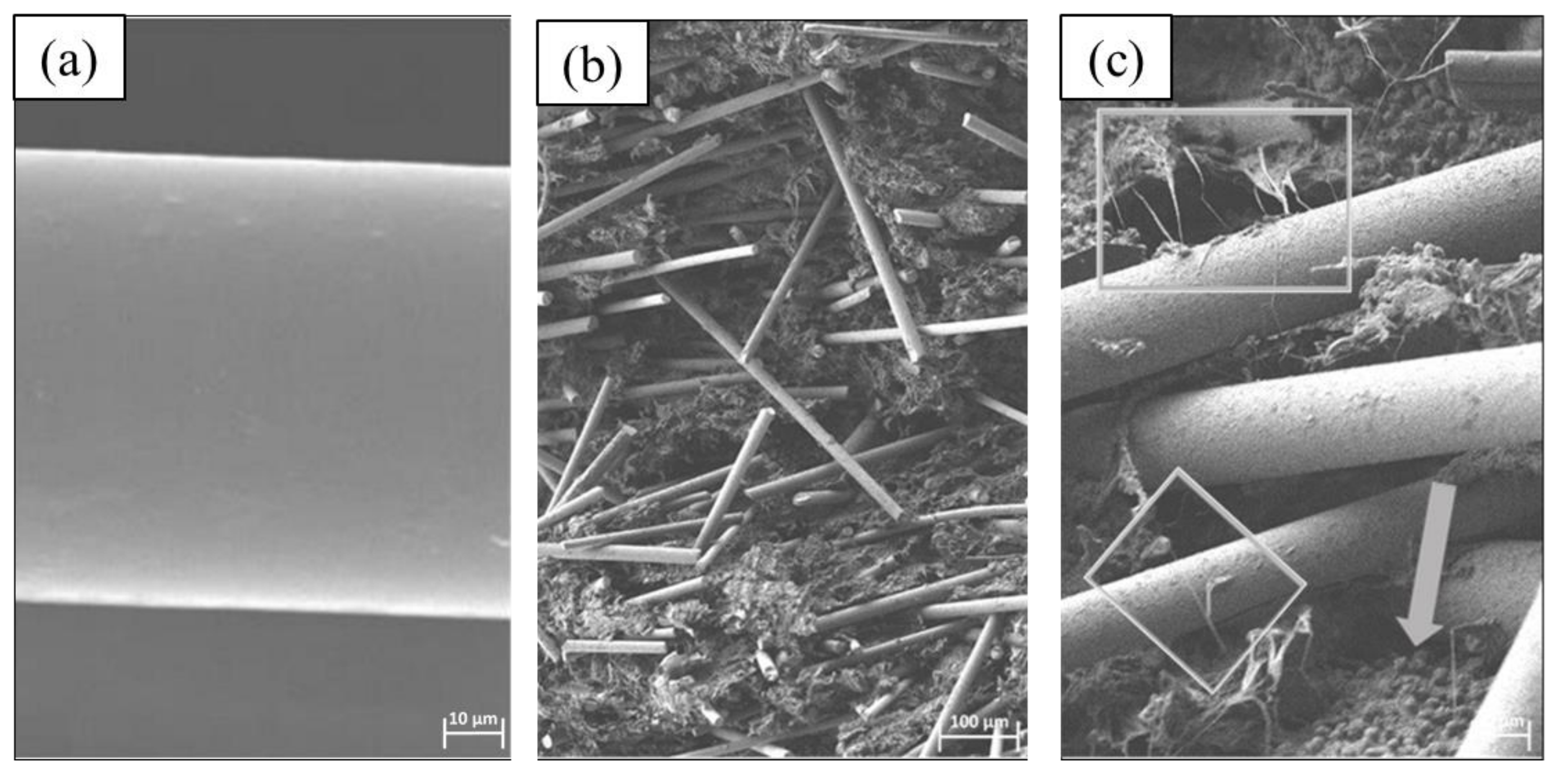

Fig. 3. Basalt fiber surface morphology and supramolecular structure of composites based on PTFE: (a) BF (x5.00k); (b) PTFE + 18 wt.% BF (x150); (c) PTFE + 18 wt.% BF (x500)

As can be seen, in the micrographs of composites with basalt fibers (Fig. 3c), there are fibrillar filaments on the surface of the fibers.

Conclusions. Analysis of the results of the degree of crystallinity, tribotechnical and structural characteristics allows us to conclude that there is an increase in the degree of crystallinity of composites by 20% in comparison with the pure polymer. This is since there is an effect of fillers on the processes of structure formation of the polymer matrix. When the polymer matrix is filled with basalt or carbon fibers, the wear resistance increases up to 500 times compared to the initial polytetrafluoroethylene, which indicates the formation of a protective film, which in turn localizes the shear deformation and protects the surface layer of the composites from destruction. Thus, composites based on polytetrafluoroethylene reinforced with basalt fibers are a good alternative for obtaining lightweight, cost-effective, and more environmentally friendly materials.