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# North-Eastern Federal University in Yakutsk (NEFU)
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# EXAMINATION OF THE INFLUENCE OF THE MECHANICAL CO-ACTIVATION TIME ON THE PROPERTIES OF UHMWPE FILLED WITH BASALT FIBERS

### *INTRODUCTION*

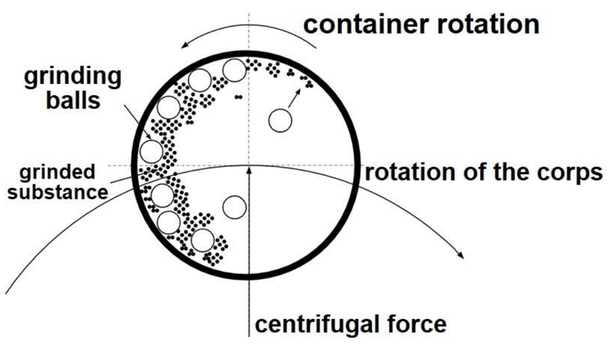
As of today, the issue of purposeful enhancement of the functional properties of the polymer composite materials remains a problem of current importance for the modern material science. In order to create cost-effective manufacturing of the products made of polymer-based composites, it is necessary to find efficient fillers based on natural raw materials and develop new technologies allowing to turn the natural compounds into a high-activity state. In this regard, mechanochemical methods of converting substance into a non-equilibrium metastable state have currently become widespread, particularly, in creation of PCM.

**Polymer matrix** → UHMWPE (Celanese GUR 4130)

**Filler** → BASALT FIBER (BF)

### Mechanical activation

Joint activation of UHMWPE and BF
Pulverizette-5




Mechanical activation schemes

## Mechanical Properties of UHMWPE and PCM

| Sample | Tensile strength $\sigma_{rm}$, MPa | Elongation at break $\varepsilon_{rr}$, % | Elastic modulus $E_r$, MPa |
|---|---|---|---|
| UHMWPE | 34 ± 1 | 372 ± 17 | 600 ± 25 |
| UHMWPE/0.5 wt.% BF | 35 ± 2 | 388 ± 30 | 529 ± 20 |
| UHMWPE/1 wt.% BF | 36 ± 3 | 387 ± 18 | 578 ± 31 |
| UHMWPE/2 wt.% BF | 39 ± 1 | 362 ± 12 | 643 ± 22 |

| Sample | Tensile strength $\sigma_{rm}$, MPa | Elongation at break $\varepsilon_{rr}$, % | Elastic modulus $E_r$, MPa |
|---|---|---|---|
| **Mechanically Co-activated Composites UHMWPE/BF** | | | |
| UHMWPE/0.5 wt.% BF for 2 minutes | 37 ± 2 | 341 ± 14 | 701 ± 22 |
| UHMWPE/1 wt.% BF for 2 minutes | 36 ± 1 | 356 ± 10 | 696 ± 16 |
| UHMWPE/2 wt.% BF for 2 minutes | 36 ± 1 | 332 ± 12 | 687 ± 19 |
| UHMWPE/0.5 wt.% BF for 20 minutes | 39 ± 3 | 340 ± 20 | 705 ± 34 |
| UHMWPE/1 wt.% BF for 20 minutes | 38 ± 2 | 323 ± 12 | 717 ± 26 |
| UHMWPE/2 wt.% BF for 20 minutes | 39 ± 2 | 324 ± 17 | 689 ± 23 |

## Investigation of the structure of UHMWPE and PCM by SEM

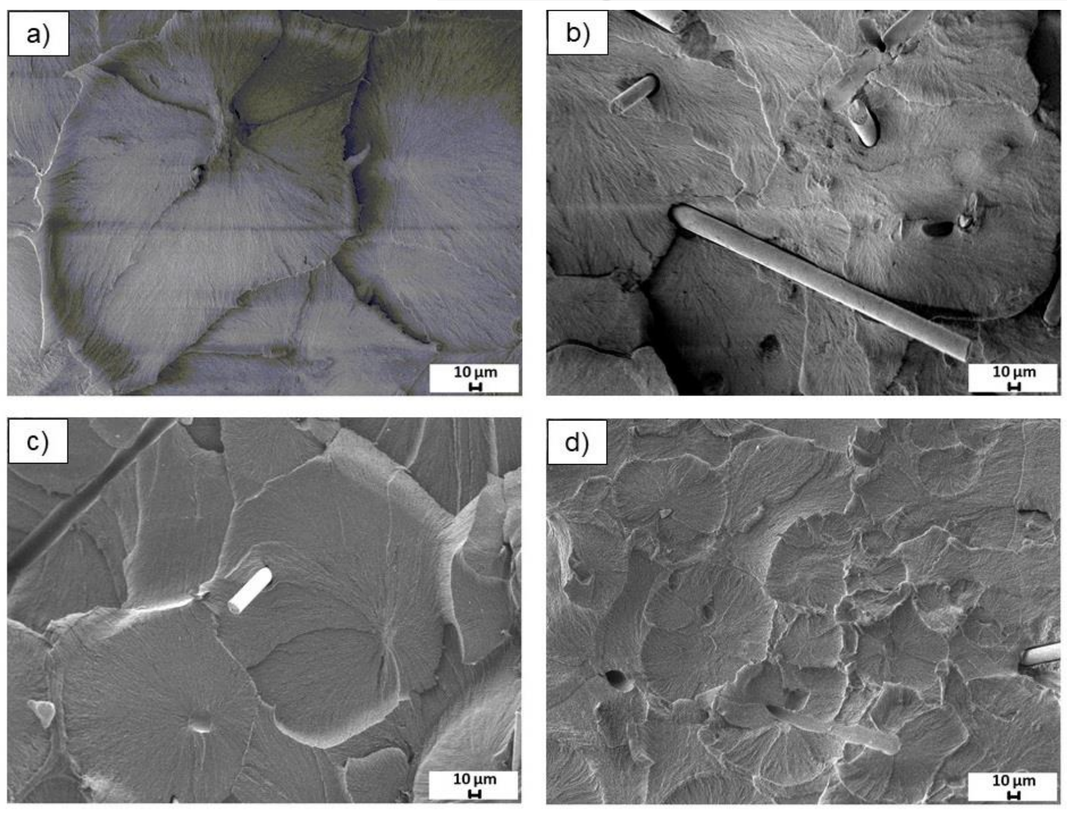



**Fig. 1.** Microphotographs of the composites containing 2 wt.% BF (magnification x300): a – initial UHMWPE; b – BF; c – co-activation with BF for 2 minutes; d – co-activation with BF for 20 minutes

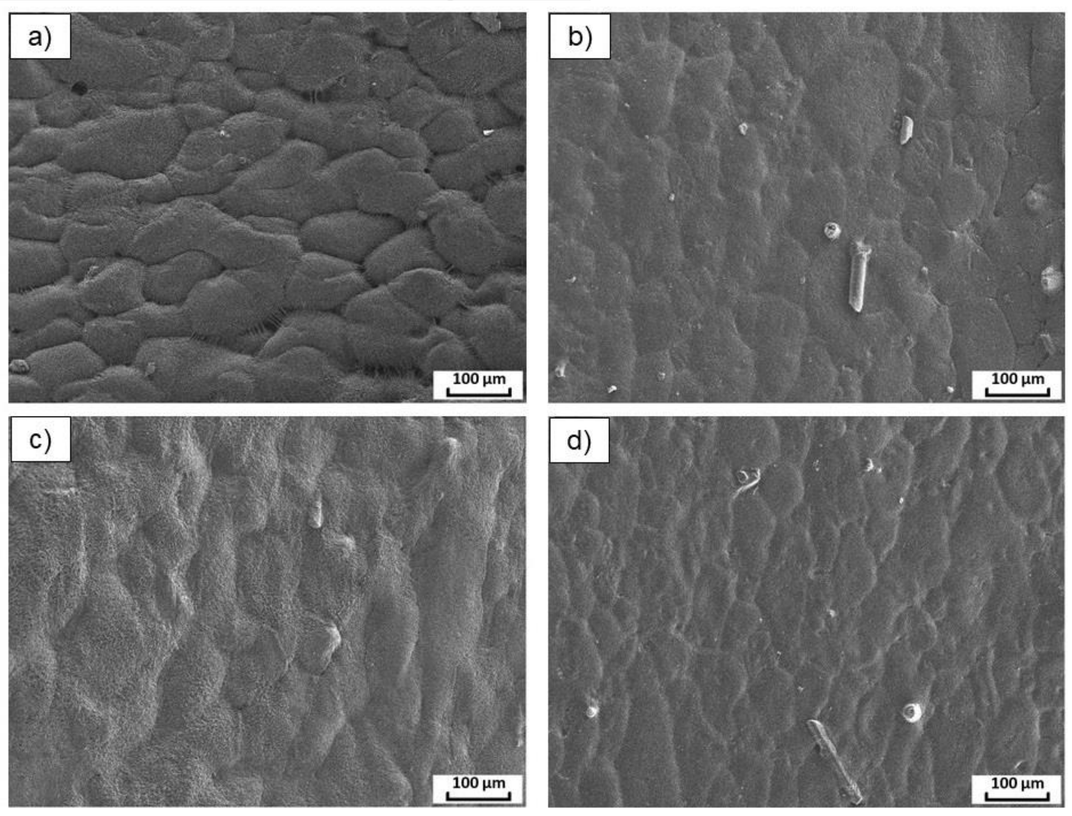



**Fig. 2.** Microphotographs of the etched structure of the composites containing 2 wt.% BF (magnification x 150): a – original UHMWPE; b – BF; c – co-activation with BF for 2 minutes; d – co-activation with BF for 20 minutes

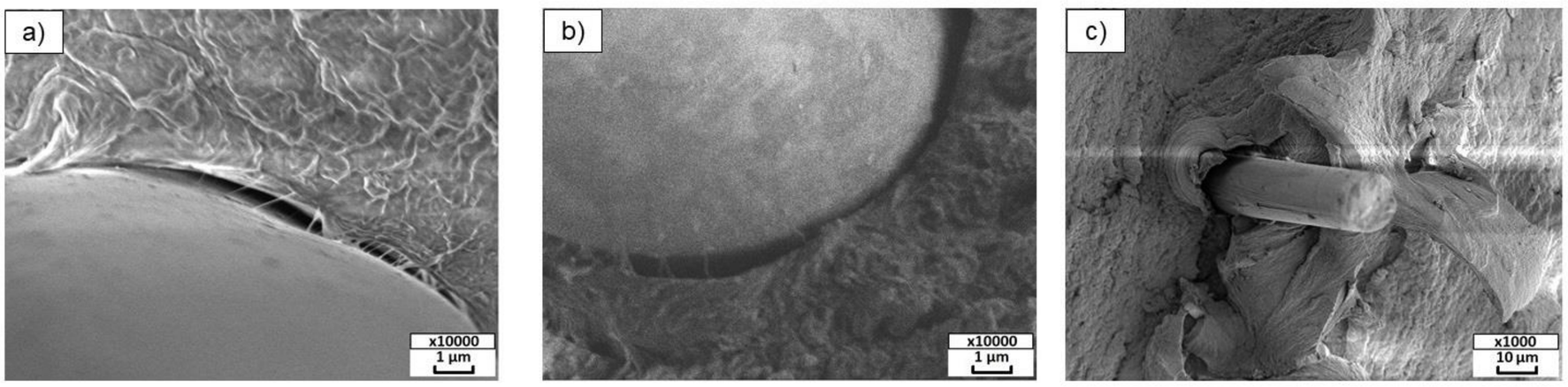



**Fig. 3.** Microphotographs of the rupture points of the PCM based on UHMWPE filled with 2% BF: a – BF (x1000); b – co-activation with BF for 2 minutes; c – co-activation with BF for 20 minutes (x10000)

### *CONCLUSION:*

As a result of the conducted research, it was found that the optimum time for mechanical co-activation is equal to 20 minutes. These composites are characterized by the enhancement of the tensile strength by 14 % and the elastic modulus by 19 % with retaining of the relative elongation at the level of the original polymer. It has been shown that such change in properties of the material is due to the changes of the supramolecular structure of the composites. Structural examinations with the use of electronic microscopy testify to retaining of the spherulitic structure of the PCM, which had been produced by the methods of mechanical co-activation. It was discovered that the increase in the duration of the mechanical co-activation of UHMWPE and BF results in decrease of the spherulite dimensions. Examinations of the rupture points have shown that modifications of BF contribute to the increased adhesion of the fibers to UHMWPE at the phase boundary owing to penetration of the macromolecules into the microcracks on the surface of the fibers that are created after mechanical activation.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