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«MIST: Aerospace - 2020: Advanced Technologies in Aerospace, Mechanical and Automation Engineering»

«An Effect of Fillers on the Structure and Abrasive Wear of Polyurethane Urea»

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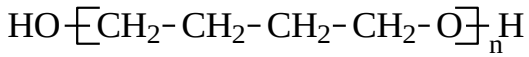
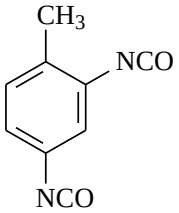
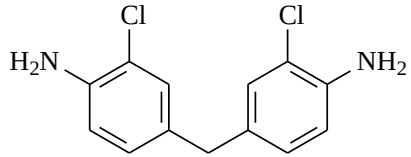
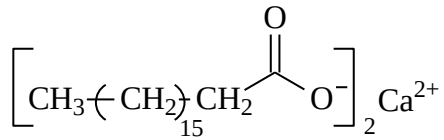
Problem

- Various parts and structures based on polyurethanes are used in the building materials industry, at processing plants, in non-ferrous and ferrous metallurgy, as well as at the enterprises of the mining and processing complex.
- The problem of protecting parts and structures from abrasive wear is now especially acute.

The aim of this work is to study the effect of fillers on the structure and mechanism of abrasive wear of polyurethane urea elastomers.

Materials

Table 1. Components used for the synthesis

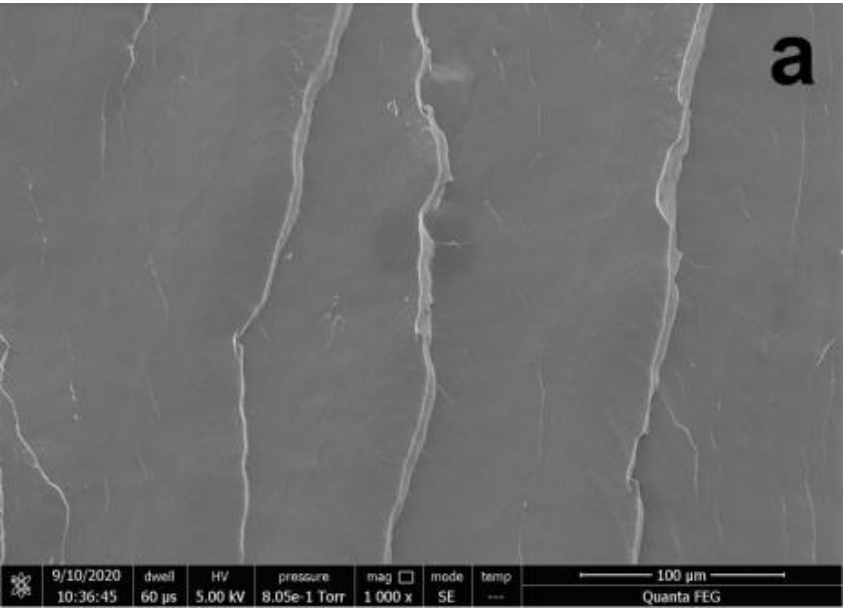
Name	M*w*	Function	Chemical structure
Polyoxytetra-methylene diol	~1000	polymer base of binder	
2,4-Toluene diisocyanate	174	polymer base of binder	
3,3'-dichloro-4,4'-diaminodiphenylmethane (MOCA)	267	chain extender	
Calcium stearate ($CaSt_2$)	607	filler	
Molibdenum Disulphide	160	filler	MoS_2

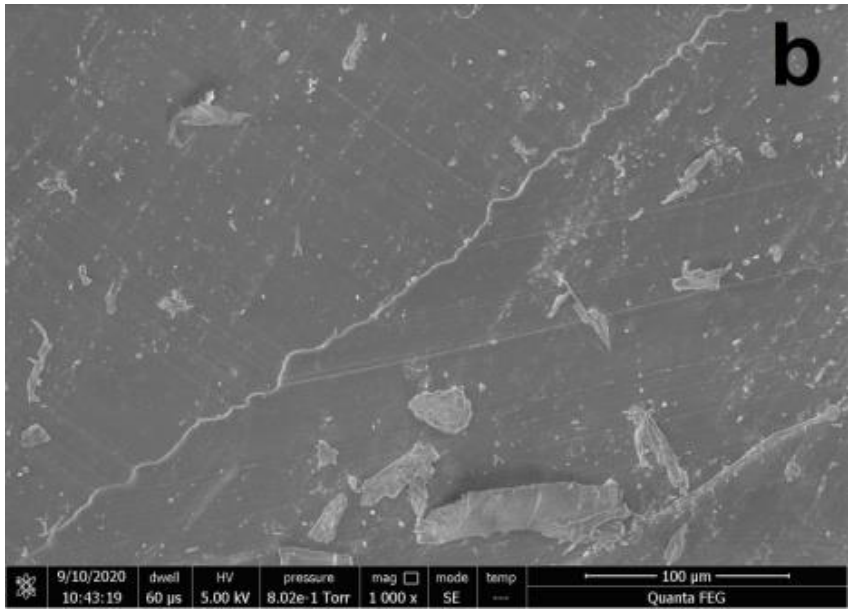
Materials

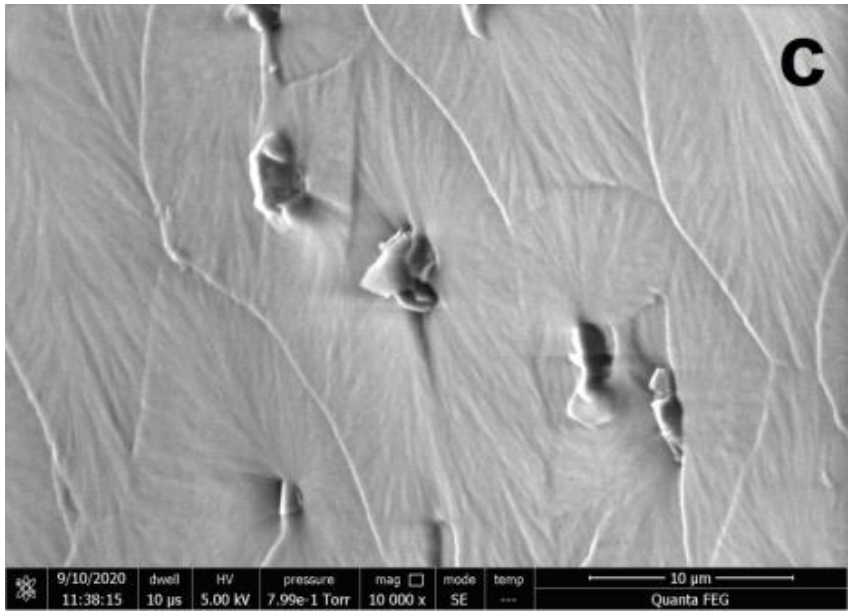
Table 2. Composition of samples for SCU-ST and SCU-DM series

Sample	SCU-PFL [mol]	MOCA [mol]	Filler	Filler content, ω_m [%]
SCU-100 (reference sample)	1.03	1.0	–	–
SCU-ST-1	1.03	1.0	$CaSt_2$	0.4
SCU-ST-2	1.03	1.0	$CaSt_2$	0.8
SCU-ST-3	1.03	1.0	$CaSt_2$	1.2
SCU-DM-1	1.03	1.0	MoS_2	0.4
SCU-DM-2	1.03	1.0	MoS_2	0.8
SCU-DM-3	1.03	1.0	MoS_2	1.2

SEM images of the samples surface before wear: SCU-100 (a), SCU-ST-1(b) and SCU-DM-1 (c)

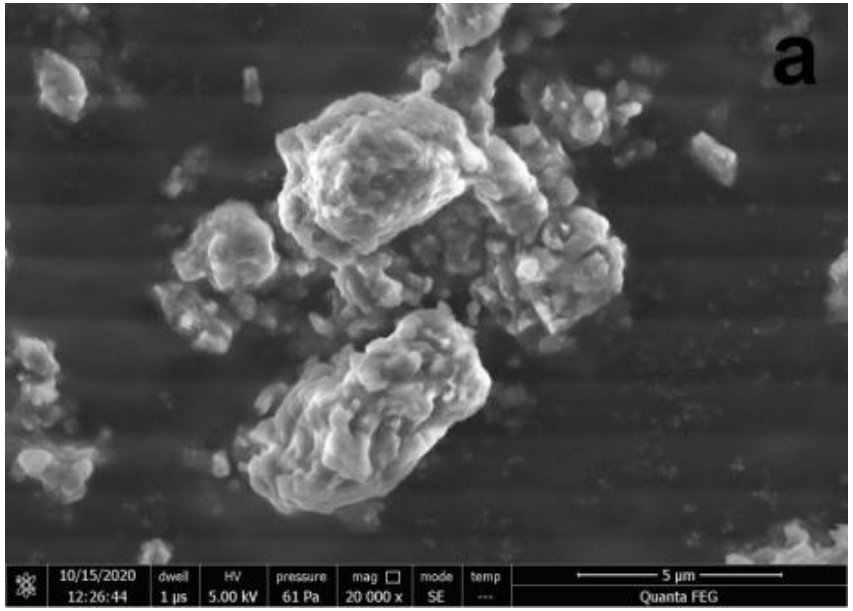


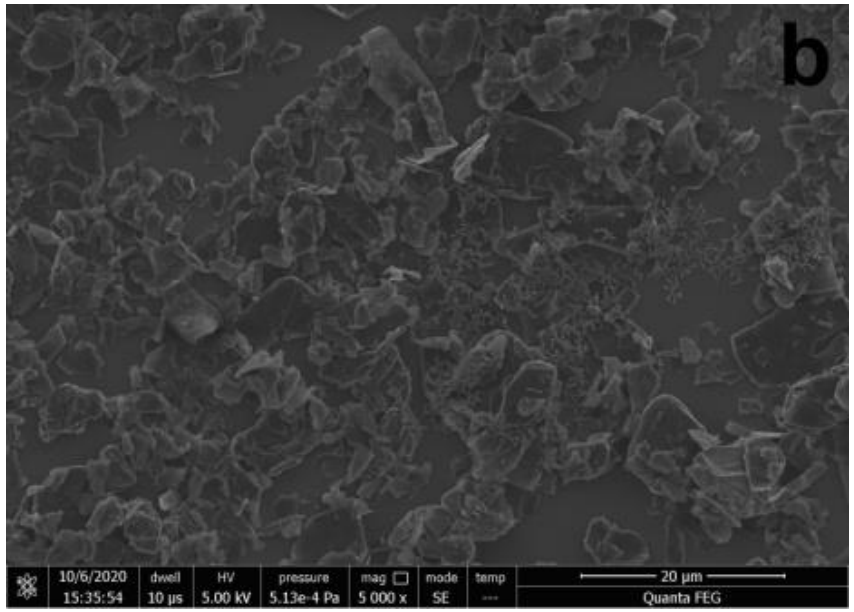




- The introduction of calcium stearate complicates the formation of filamentous supramolecular formations in a polyurethane urea matrix with a size of about 1 micrometer (Image b), inherent for the unfilled sample (Image a).
- The introduction of molybdenum disulfide leads to the appearance of tree-like supramolecular structures with a characteristic size of 200 nanometers (Image c).

SEM images of fillers samples, showing an agglomerate structure: a) $CaSt_2$, b) MoS_2





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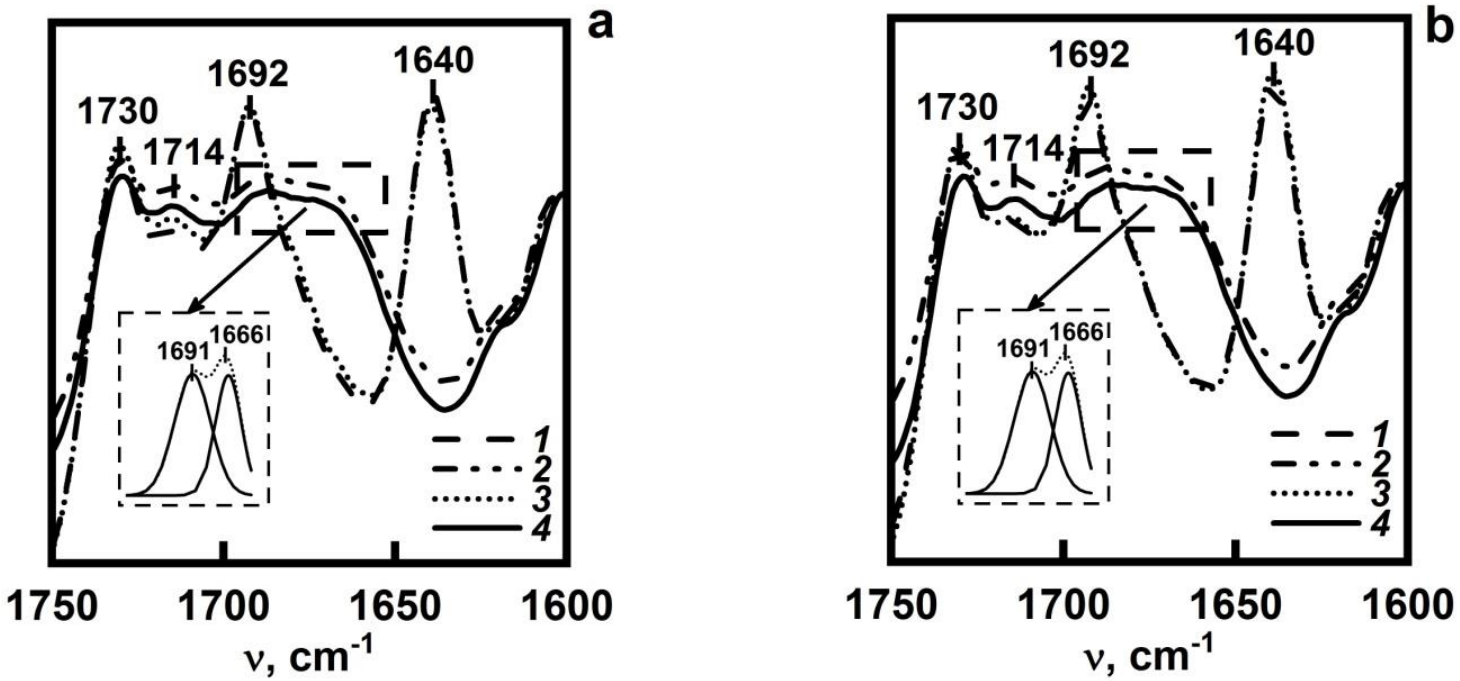
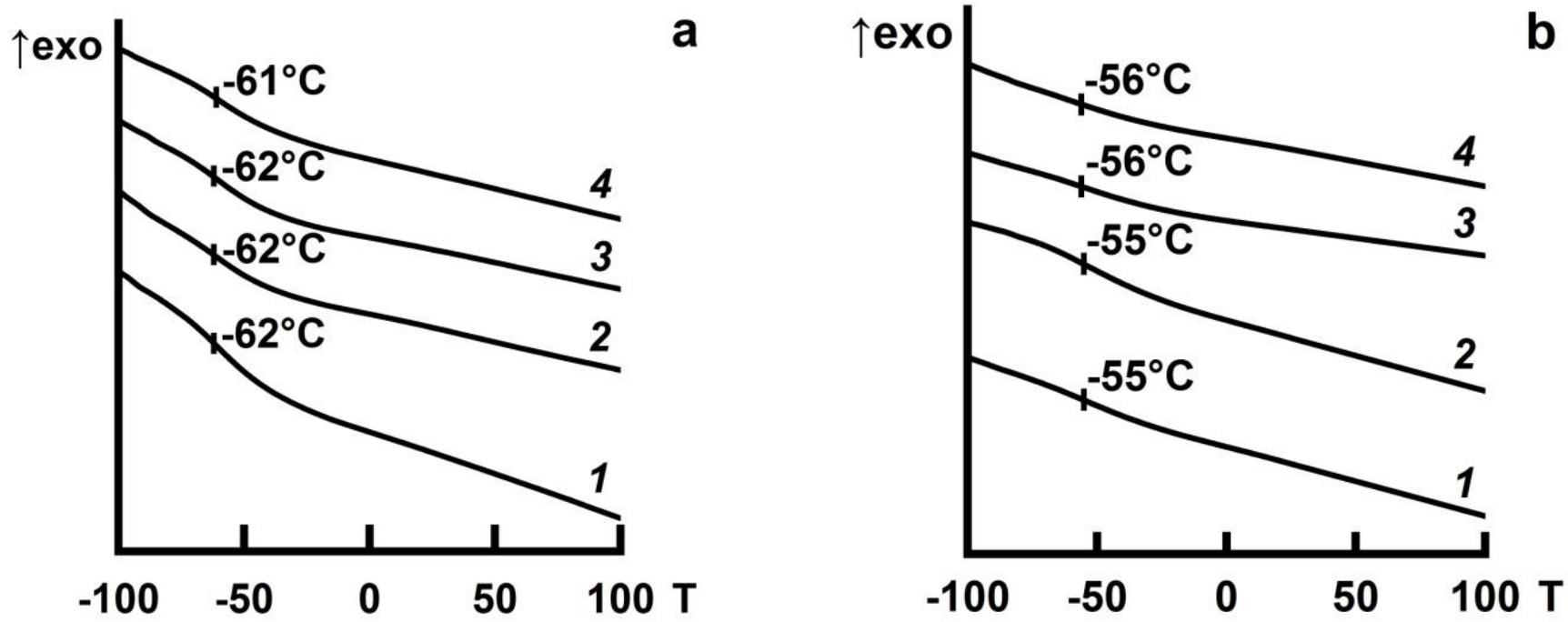
Fragments of FTIR-spectra of SCU-ST (a) and SCU-DM (b) series before wear (plots 1, 3), and after wear (Plots 2, 4). Plots 1, 2 refer to samples without fillers, plots 3,4 refer to ones containing 0.8% filler (SCU-ST-2 and SCU-DM-2)



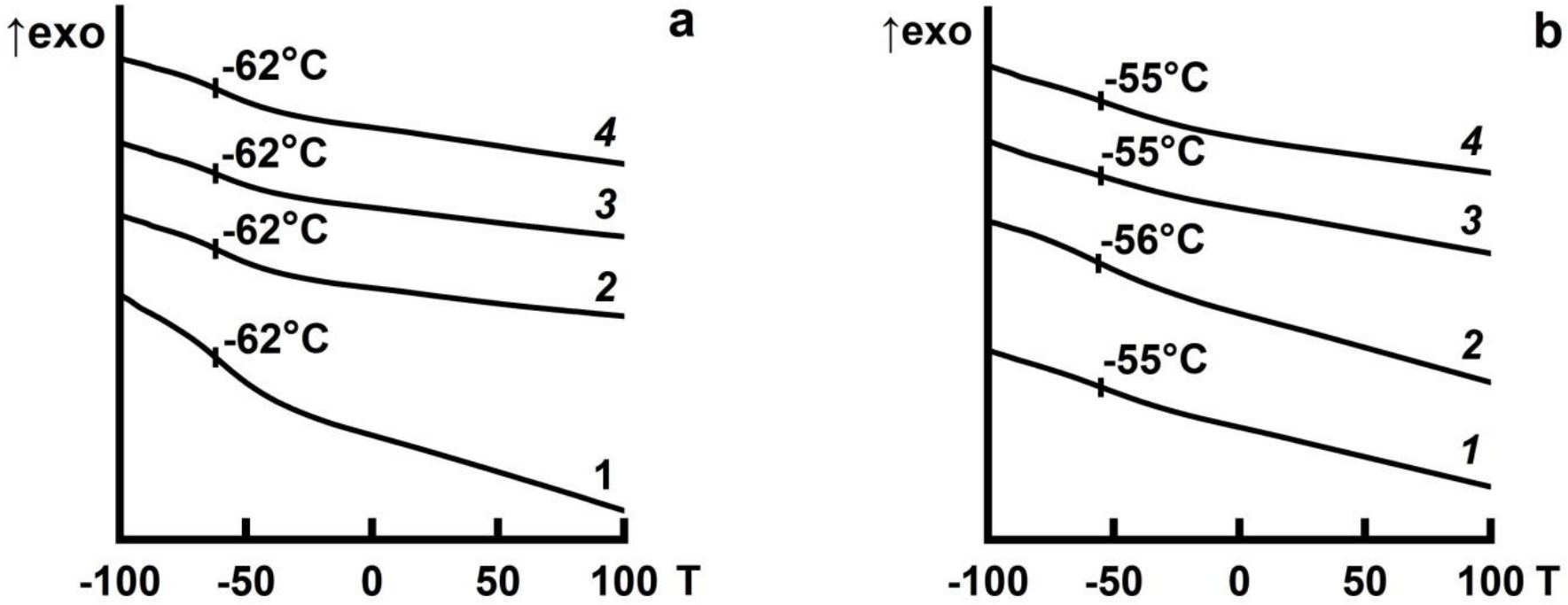
- All samples have an absorption band at **1640** cm^{-1}, attributed to the vibrations of the ordered C=O groups of urea fragments linked by hydrogen bonds. This strip is used to determine the microphase separation in cured elastomers.
- The spectra studied exhibit a band at **1729÷173**1 cm^{-1}, which refers to the absorption of free carbonyl, and a band at **171**4 cm^{-1}, related to the absorption of bound C=O groups in the composition of disordered urethane fragments present in the soft phase of the polymer.

DSC-thermograms for SCU-ST series before wear (a) and after wear (b) (1 – SCU-100; 2 – SCU-ST-1; 3 – SCU-ST-2; 4 – SCU-ST-3)



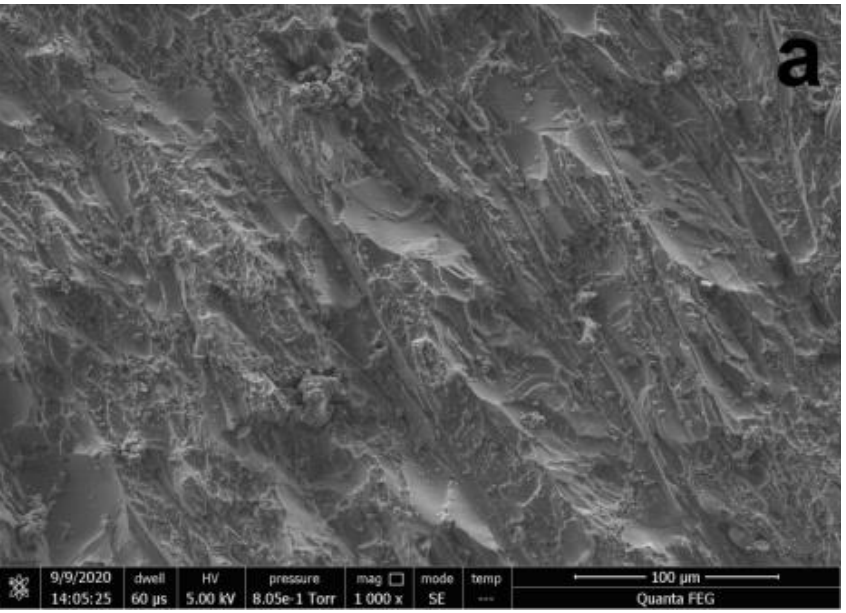
The destruction of ordered hard blocks under wear leads to an increase in the concentration of hard segments of polymer chains in the soft phase of the material, which causes a decrease in the segmental mobility of the running chains and, accordingly, an increase in the glass transition temperature.

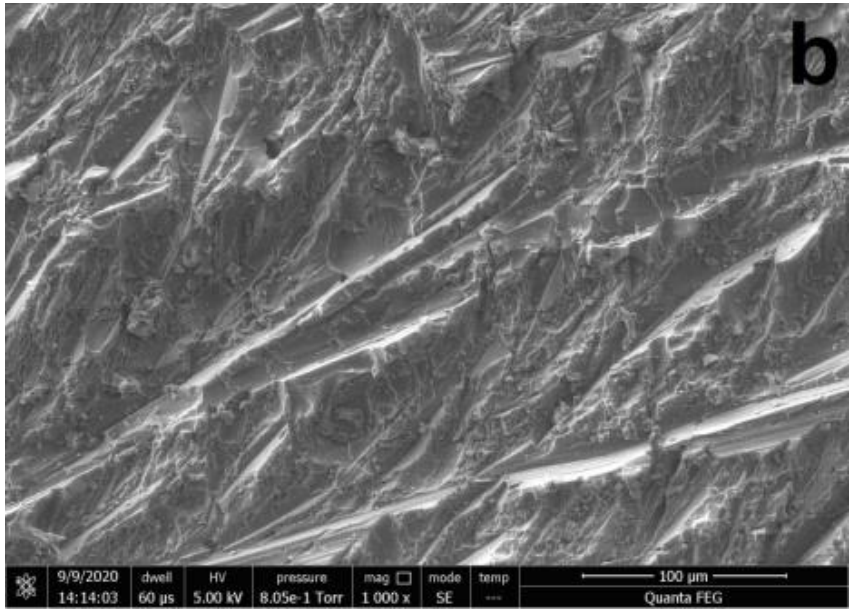
DSC-thermograms for SCU-DM series before wear (a) and after wear (b) (1 – SCU-100; 2 – SCU-DM-1; 3 – SCU-DM-2; 4 – SCU-DM-3)

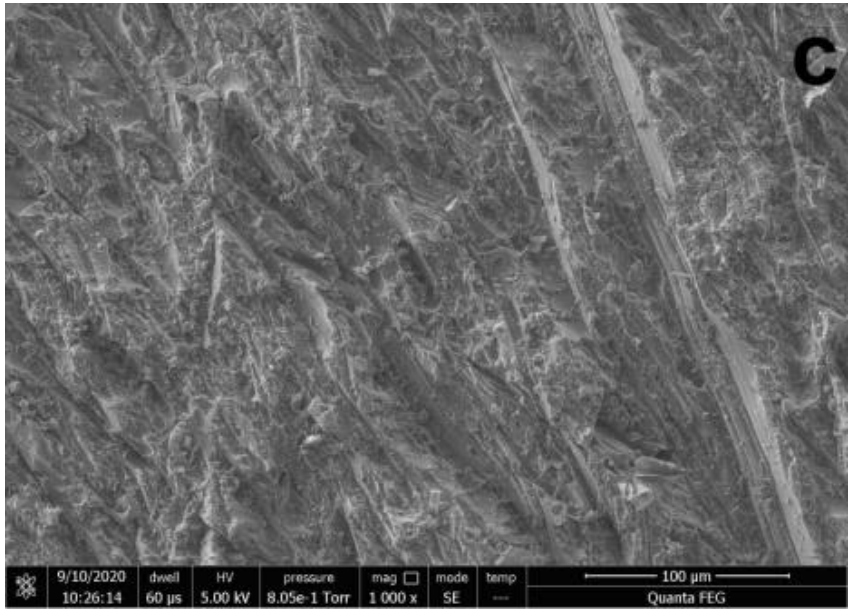


The destruction of ordered hard blocks under wear leads to an increase in the concentration of hard segments of polymer chains in the soft phase of the material, which causes a decrease in the segmental mobility of the running chains and, accordingly, an increase in the glass transition temperature.

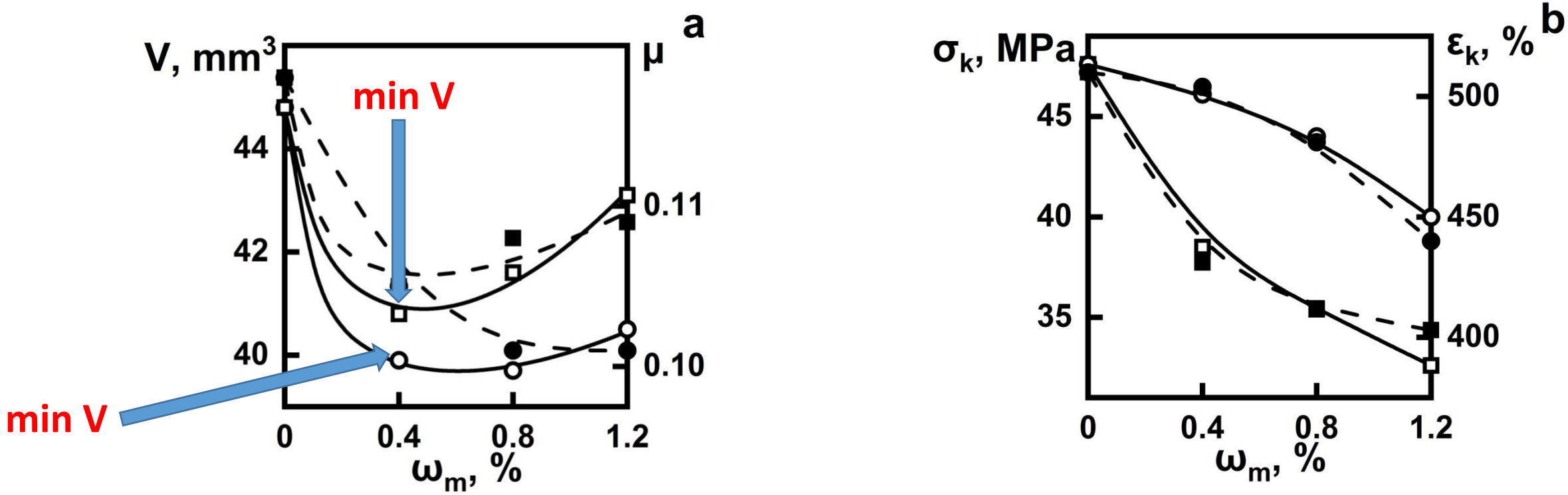
SEM images of the samples surface after wear: without filler (a), SCU-ST-1 (b), and SCU-DM-1 (c)







- The surfaces are characterized by a shallow profile of plowing bands due to the action of large abrasive particles and the presence of a noticeable number of areas with small-sized defects (1-5 micrometers).
- The introduction of the filler leads to the more pronounced plowing stripes, their surface becomes cleaner. In our opinion, the observed picture is associated with a decrease in the strength of the samples upon the addition of the filler.



Dependence of important properties of SCU-ST series (○, ●) and SCU-DM one (□, ■) on the filler content: a) for the tensile strength (——) , for the relative strain at rupture (- - -); b) for the abrasive wear (——) , for the friction coefficient (- - -).

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Conclusions

- The optimum filler content was determined. That predetermines the appearance of a characteristic extreme dependence of the wear degree on the amount of the introduced filler.
- It was found that the mechanism of abrasive wear did not change in the diapason of the used filler content.

Contacts

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