FROM STRUCTURE TO STRENGTH: ANALYSIS OF POLYMER COMPOSITES FILLED WITH HYBRID FILLERS

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Recently, the development of polymer composites has become a relevant direction in modern materials science. To ensure functional properties and optimize the structure of products, fillers with different dispersities, i.e., hybrid fillers, are introduced into them. The key challenge in designing polymer composites with such fillers is selecting the concentration to achieve the expected synergistic effect and uniform distribution of the dispersed phase.

One of the common methods for producing polymer composites is solution casting. Obtaining materials by this method helps to solve the problem of non-uniform filler distribution; however, in practice, this potential often remains unrealized due to uncontrolled agglomeration caused by complex solvent evaporation kinetics and ambiguous interfacial interactions, which leads to distortion of the initial filler morphology [1]. In this regard, the task of comprehensively studying changes in the morphology of the hybrid filler with increasing its concentration in the polymer matrix becomes particularly relevant.

The aim of this work is to establish the relationship between the mass content of the hybrid filler (recycled carbon fiber and boehmite/magnetite in a 1:1 ratio, total concentration of 1-5 wt.%) in acrylonitrile–butadiene–styrene (ABS), its morphological parameters (aggregate size, type of structural organization according to SAXS data), and the maximum tensile strength of polymer composites obtained by solution casting. This will make it possible to predict the strength of composites depending on the concentration and type of filler.

The table presents the fitting parameters of the SAXS results of polymer composites with hybrid fillers. The figure shows a histogram of the dependence of maximum tensile strength on filler concentration for two systems: ABS/rCF/AlOOH and ABS/rCF/Fe_3O_4.

Table - Fitting parameters of polymer composite samples

Sample	Type of function	Correlation length (nm)	Porod coefficient
ABS	1	6,7	4,01
ABS/rCF/AlOOH (0,5/0,5)	1	1386,8	~5
ABS/rCF/AlOOH (1,5/1,5)	2	35,3 1341,7	2,73
ABS/rCF/AlOOH (2,5/2,5)	2	42,5 1697,8	2,88
ABS/rCF/Fe3O4 (0,5/0,5)	2	44,7 1103,8	3,42

ABS/rCF/Fe3O4 (0,5/0,5)	2	43,04 1270,1	2,95
ABS/rCF/Fe3O4 (0,5/0,5)	2	42,6 1366,8	2,87

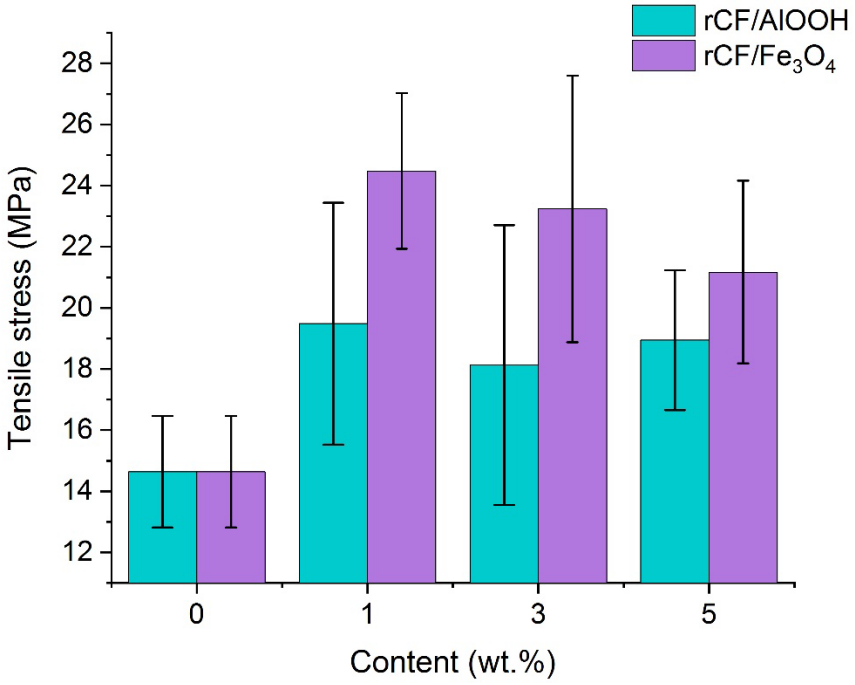

Figure 1 - Dependence of maximum tensile strength on filler concentration for the ABS/rCF/AlOOH and ABS/rCF/Fe_3O_4 systems.

SAXS results and tensile strength tests show that with an increase in the concentration of the hybrid filler, the correlation length increases, meaning the size of the filler aggregates grows, which correlates with a decrease in strength at high concentrations of the hybrid filler. It was also noted that the hybrid filler with magnetite provides a greater increase in strength at all concentrations (up to +67 %) than the hybrid filler with boehmite (+33 %). The standard error of strength is higher at medium concentrations (3 % total), which may reflect non-uniform filler distribution or variability in agglomeration.

For a better understanding of the morphology and size of the detected nanostructures, the polymer composites were studied by small-angle neutron scattering using the YuMO instrument operating at the IBR-2 reactor.

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