

PAPER

CHANGES IN CONSUMER AND TECHNOLOGICAL PROPERTIES OF FOOTWEAR SOLE COMPOSITIONS DURING FILLING

S.S. Musaev^{1,*} and T.J. Kadirov¹

¹Bukhara State Technical University, Uzbekistan

* ssmusaev@rambler.ru

Abstract

The article examines the influence of various finely dispersed fillers on the consumer and technological properties of footwear thermoplastic compositions obtained based on polyolefin derivatives.

Key words: thermoplastic elastomers, deformation-strength and rheological properties, fillers, strength, relative elongation, viscosity.

Introduction

Recently, much attention has been paid to the creation of new thermoplastic compositions, the study of their properties, and the determination of control parameters for the purposeful development of compositions with the required set of consumer and technological property values.

Due to the peculiarities of their morphological structure, polyolefin thermoplastic elastomers have high elasticity and flexibility, increased frost resistance, and heat resistance, which ultimately characterizes the versatility of this material's properties. At the same time, polyolefin thermoplastic elastomers do not require reinforcement with fillers like rubbers do, but they

combine well with them, which can be used to improve some properties and reduce the cost of finished products.

Materials and methods

In this work, the influence of fillers with varying activity on the deformation-strength and rheological properties of polyolefin thermoplastic elastomers was investigated. The following widely available products were used as fillers: chalk, kaolin, white carbon black, and wood flour. The content of fillers in polyolefin thermoplastic elastomers varied within 5–15

The choice of these fillers is due to their low cost, non-toxicity, harmlessness, and weak coloration,

Compiled on: February 3, 2026.

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which makes it easy to adjust the color of the sole materials.

Results and discussion

It should be noted that there is a real possibility of purposefully distributing fillers and plasticizers in the two-phase polymer matrix of the polyolefin thermoplastic elastomer, thereby regulating the values of the polymer composition's property indicators. The fundamental difference between the behavior of fillers and plasticizers is that fillers cannot spontaneously diffuse from one phase to another, while the distribution of plasticizers between phases occurs according to their thermodynamic affinity for the components of the polymer mixture [1].

Compounding of polyolefin thermoplastic elastomers was carried out on rollers at a temperature of 80-100°C for 10 minutes. Test samples were prepared in the form of plates by direct casting at a temperature of 170-200°C with subsequent cooling in a mold. Physical and mechanical tests were conducted according to standard methods, and effective viscosity values were obtained using a Brabender (Germany) plastograph.

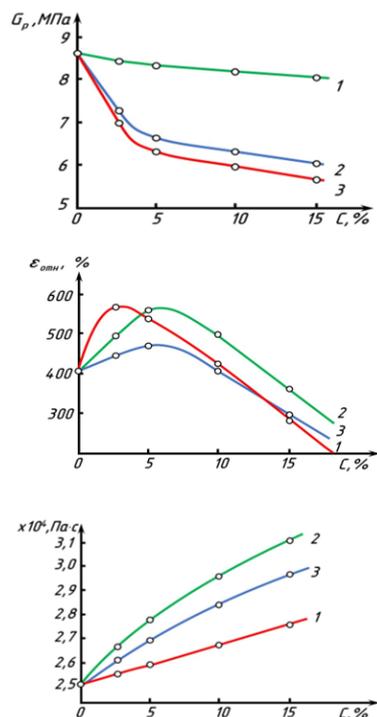


Figure 1. Dependence of tensile strength (a), relative elongation (b), and viscosity (c) of a polyolefin thermoplastic elastomer on the filler content: 1-silica; 2-mixture of chalk and kaolin; 3-wood flour

Based on their influence on the physical and mechanical properties of compositions, fillers are classified as active (reinforcing) and inactive (non-reinforcing). According to the reinforcement effect, white carbon black is classified as an active filler, while other studied fillers are classified as inactive. The reinforcement effect of the filler is determined by its nature, i.e., compatibility with the polymer matrix and dispersity. The dispersity of the studied fillers varies, in μm : white carbon black 0.02-0.04, wood flour 150-350, chalk 2-50, kaolin 0.5-10 [2].

When compounding polyolefin thermoplastic elastomers, the filler, initially entering a continuous polyolefin matrix, moves towards the elastomer particles and is retained in the boundary layer. Due to the high viscosity of the crosslinked elastomer particles, the filler distribution within them practically does not occur, which explains the absence of a reinforcement effect for all studied filler types. The decrease in the strength of compositions occurs proportionally to the decrease in filler activity and the increase in average particle size (Figure 1, a).

The sharp decrease in tensile strength of compositions when adding a small amount (up to 5%) of a mixture of chalk with kaolin and wood flour is explained by the loosening of the boundary layer between the continuous polyolefin matrix and the dispersed elastomeric particles. Further decrease in strength indicators with increasing filler concentration occurs monotonically.

The loosening of the boundary layer of the polyolefin thermoplastic elastomer, i.e., increasing the elasticity of the elastomer macromolecules, can explain the increase in relative elongation values in the initial filling phases (Figure 1, b). Further increase in filler volume leads to a decrease in the deformation values of the filled compositions.

It is natural that the effective viscosity of the polyolefin thermoplastic elastomer increases upon filling (Figure 1, c). The nature of the increase in effective melt viscosity values of the compositions does not correlate with the filler particle sizes, but is apparently determined by the compatibility of the polyolefin thermoplastic elastomer composition with fillers.

Conclusion

Functional dependencies of the melt viscosity (η) of compositions on the filler content (C) were obtained using the interpolation method:

for white carbon black (η_1) = $2.5 \times 10^4 + 0.08 \times 10^4 C$,

for wood flour (η_2) = $2.5 \times 10^4 + 0.13 \times 10^4 C + 0.05 C^2$,

for a mixture of chalk and kaolin (η_3) = $2.5 \times 10^4 + 0.15 \times 10^4 C + 0.01 C^2$.

Thus, the conducted research has demonstrated the possibility of regulating strength and deformation indicators by filling the polymer matrix with various types of fillers.

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