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The Use of Sol-Gel Method for Obtaining Fire-Resistant Elastic Coatings on Cotton Fabrics

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Abstract. Based on the generalization of research results on the processes of obtaining SiO_2 sols using tetraethoxysilane and ethyl silicates, the main factors influencing the elasticity of silica coatings on cotton fabrics and their fire-retardant properties are considered. The possibility of forming covalent bonds between the functional groups of cellulose, gel coating and flame retardant layer is considered, which explains the strong fixation of a thin layer of coating on the fibers of the fabric and improve its fire protection. The use of the developed compositions for fire-retardant elastic coatings based on ethyl silicate allows to increase the time of complete burning of cotton from 30s (untreated fabric) to 600s (treated with binary coating).

Introduction

In recent years, the scientific direction of the development of fire-resistant coatings on textile materials using the sol-gel method is actively developing [1]. This method has long been known, but developed only in the 50s of last century. It was originally used to make self-hardening binders for ceramics, molding earths for metal casting, and hydrophobic substances. Later, sol-gel technology developed in the direction of creating particularly pure ceramic materials of a given composition, optical and quartz glass, products for fiber optics, protective coatings for automotive and window glass and other applications. This technology allows to create new materials with a high degree of homogeneity at the molecular level and with exceptional physical and chemical properties, which differ significantly from the properties of materials obtained by traditional methods [2].

The sol-gel method is based on hydrolysis and condensation reactions of metal alkoxides such as tetraethoxysilane, tetramethoxysilane, etc., which leads to the formation of completely inorganic, organic compounds or organo-inorganic hybrids, which find wide fields for use as ultrafine powders, fillers in composite materials with a polymer matrix, as well as fire-resistant coatings [3, 4]. Sol-gel coatings are able to protect the polymer surface, creating a physical barrier that acts as an insulator, improving the fire-retardant properties and combustion characteristics of treated substrates.

The use of sol-gel processes to obtain silicon dioxide nanoparticles for mixing with bulk polymer matrices is well covered in the technical literature [5]. Several studies have recently investigated the possibility of reducing the flammability of various polymers, such as epoxy and phenolic resins [6], polymethylmethacrylates [7] and polyesters, using silica phases obtained by sol-gel processes.

The sol-gel approach is commonly used to create new functional properties of textile materials, such as antimicrobial protection or protection against UV radiation, dye resistance, superhydrophobicity [8] and immobilization of biomolecules [9].

Despite the fact that this method has been used for a long time, its use to slow down the ignition of textiles was started very recently [10]. Interesting results are given in [1, 11–13]. It has been shown that sol-gel processes can lead to the formation of nanoparticles of silica generated in situ, or