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CREATION OF FLAME RETARDANT COMPOSITIONS FOR POLYESTER AND COTTON-POLYESTER TEXTILE MATERIALS

K.Zh. Dyussenbiyeva *, A. Burkitbay

Almaty Technological University, Almaty, Kazakhstan

**E-mail: d.kulmairam@mail.ru*

Abstract. *Introduction.* A significant disadvantage of materials and products of light industry is flammability. Analysis and statistics of fires show that the easy flammability of clothing materials and the high speed of flame spread lead to significant human casualties. In this regard, most countries of the world have adopted laws prohibiting the use of combustible materials in the production of workwear for work in conditions of high temperatures and splashes of molten metal, clothing for the elderly, bed linen in nursing homes, children's toys, as upholstery and finishing materials and for other purposes. Therefore, the problem of reducing the flammability of materials and products of light industry is relevant and of paramount importance.

The purpose. The article is devoted to the development of flame retardant technology for polyester and blends of cotton and polyester fabrics. An analysis of existing methods for imparting fire-retardant properties to textile materials and assessing their effectiveness is carried out.

Methodology. The following tissues were chosen as the object of study: polyester 100 % (surface density 180 g/m^2), polyester 65 %/ cotton 35 % (surface density 180 g/m^2), polyester 65 %/ cotton 35 % (surface density 250 g/m^2), polyester 40 %/ cotton 60 % (surface density 230 g/m^2). The following components are used for the preparation of the compositions: sodium hexametaphosphate 150-200 г/л, polyethylene glycol 40 г/л, urea 80 г/л. The fabric is impregnated with a finishing solution, added, dried and thermofixed.

Results and discussion. Effective flame-retardant compositions for textile materials have been developed. Optimal technological parameters for fire-retardant treatment of textile materials are determined. The effect of treatment on the combustion processes of fire-retardant textile materials has been studied. The effect of fire-retardant treatment on the physical and mechanical properties of finished materials is investigated.

Conclusion. Optimal concentrations were selected to give textile fabrics fire-retardant properties, as well as to improve their consumer properties. Treatment of the material with flame retardants does not worsen the consumer properties of the fabric. This technology is available and versatile to ensure fire resistance.

Key words: textile materials, blended fabrics, sodium hexametaphosphate, flame retardant, flame retardant coating, flame retardant efficiency, flammability, combustion, fire resistance of fabric materials, flame retardant properties, final finishing.

Dyussenbiyeva Kulmairam Zhamanbaevna	*PhD; E-mail: d.kulmairam@mail.ru*
Burkitbay Asemgul	*PhD; E-mail: asemka76@mail.ru*

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1. Introduction

Textile materials are flammable, burn quickly, having a significant area of flame coverage, emit toxic combustion products during combustion and for the most part have a high smoke-forming ability. In this regard, at present, a significant number of scientific studies are devoted to the problem of developing flame retardants and technology for their application, which make it possible to reduce flammability, smoke formation and toxicity of combustion products, as well as to studying the process of thermal oxidation of fiber-forming polymers. Most of the fibers and textile materials produced are flammable and combustible. During a fire, fabrics easily catch fire and quickly spread flames. Textile fires are the cause of a large number of fires in residential and public buildings. Therefore, the problem of imparting fire-retardant properties to textile materials of various nature and purposes has become increasingly relevant in recent years [1,2,3].

Currently, a wide range of fire retardants are produced to reduce the fire hazard of textile materials. Flame retardants differ in structure (inorganic and organic) and in the method of application or finishing [4,5,6].

Recently, for effective methods of fire-retardant modification of textile materials, impregnation and plus methods have also been used using additional special effects on the surface and structure of fibers in order to form active centers that ensure the chemical interaction of the inoculant with the fiber polymer. These may include the use of energetically powerful physical fields: electrophysical treatment in a corona glow discharge in air or other gaseous medium, high-frequency plasma treatment, photochemical treatment, radiation treatment. Each of these methods has its advantages and disadvantages, and in each specific case, certain requirements are imposed on fire retardants.

An analysis of the literature over the past decade has shown that various methods are used to create fire-retardant textile materials. These include the use of high-temperature fibre-forming organic polymers and inorganic fibres, various types of effective flame retardants that are used as additive additives in spinning solutions or polymer melts in fibre formation, and for the treatment of fibres and fabrics to form chemical bonds between the flame retardants and the fibre-forming polymer macromolecule [7,8,9].

Flame retardants, which have received practical application for imparting flame retardant properties to fabrics, can be divided into the following main groups:

- inorganic salts that are difficult to wash off from the surface of the fabric;
- halogenated hydrocarbons in combination with antimony or titanium oxide;
- flame retardants based on phosphoric acid and nitrogen-containing compounds;
- polymers formed on the surface of the fabric as a result of heat treatment.

Early fire impregnation of fabrics with a fire retardant composition will allow you to localize the source of a possible fire at the initial stages. But there are often cases when it is unprotected fabrics that are the main conductor of flame in internal spaces. The main objective of the study is to develop a composition for

flame retardant treatment of fabrics made of mixed fibers (cotton/polyester) of twill weave, providing flame retardant properties, permanence and preservation of the neck of the fabric after its processing [10,11,12].

2. Experimental part

The composition and structure of textile material are the main parameters affecting its fire properties, since the process of thermal destruction is different for different types of fiber-forming polymers. The choice of effective compositions and methods of their application is determined by the nature of the interaction of the flame retarder system - polymer. At the same time, an important practical issue is to study the possibility of developing a flame retardant impregnating composition for fabric that does not have a negative effect on human skin.

For the fire retardant composition, the following components are used: sodium hexametaphosphate 150-200 g/l, polyethylene glycol 40 g/l, urea 80 g/l. The fabric is impregnated with a finishing solution, added, dried and thermofixed. The following tissues were chosen as the object of study: polyester 100 % (surface density 180 g/m^2), polyester 65 %/ cotton 35 % (surface density 180 g/m^2), polyester 65 %/ cotton 35 % (surface density 250 g/m^2), polyester 40 %/ cotton 60 % (surface density 230 g/m^2). The assessment of the effectiveness of fire retardants for textile materials was carried out in accordance with GOST R 50810-95 [13]. Determination of the tensile properties of cotton fabrics was carried out in accordance with GOST 3813–72 [14]. The study of the stiffness of textile materials was carried out in accordance with GOST 10550-93 [15]. Determination of fabric resistance to surface wetting was carried out in accordance with GOST 30292-96 [16], MT 032 device.

3. Results and discussion

Currently, a wide range of fire retardants are produced to reduce the fire hazard of textile materials. Flame retardants differ in structure (inorganic and organic) and in the method of application or finishing. Reducing the fire hazard of fabric materials is the main task that needs to be solved by both manufacturers of textile materials and specialists conducting scientific research in the field of fire safety of facilities.

Treatment of textile materials with fire retardants reduces the fire hazard of fibers, yarns, fabrics, nonwovens and products made of them, as well as carpet textile coverings. It is necessary to use textile materials treated with a fire retardant in buildings and premises intended for cultural events - in theaters and sports and entertainment complexes, museums, recreation areas, as well as residential premises. As a result of treatment with effective means of fire protection, the possibility of ignition of textile materials from low-calorie ignition sources is excluded, the ability of flame to spread over the surface is reduced, the smoke-forming ability and toxicity of thermal decomposition products are reduced.

According to table 1 and figure 1, the best indicators of fire protection efficiency for textile materials are: polyester 65 %/ cotton 35 % (180 and 250 g/m^2), flame exposure time is 15 seconds, for polyester 100% flame exposure time is 4 s. For the composition of polyester 40% / cotton 60%, the flame exposure time is 20 seconds, at an average concentration of 175 g/l. This is due to the highest content of cotton in the composition of the fabric.

Table 1 - Performance indicators of flame retardants for polyester and cotton. and polyester fabric blends

№	textile materials	concentration of components, g/l				
		polyethylene glycol	urea	sodium hexametaphosphate	flame exposure time, seconds	
					raw materials	processed materials
1	polyester 100 %, 180 g/m^2	40	80	200	1	4
2	polyester 65 %/ cotton 35 %, 180 g/m^2			200	2	15
3	polyester 65 %/ cotton 35 %, 250 g/m^2			200	2	15
4	polyester 40 %/ cotton 60 %, 230 g/m^2			175	2	20

Figure 1 - Destruction of textile material impregnated with flame retardants under the influence of open fire

Samples of textile materials measuring 20 cm by 20 cm were subjected to a fire test. Samples without impregnation caught fire instantly when immersed in an open flame. And after the flame was removed, they continued to burn and burned completely to the ground. The sample is 100% polyester, burned completely in 3 minutes, the rest in 5-6 minutes. Based on this experiment, it can be said that samples without impregnation are flammable and do not have fire resistance, the complete combustion time was 1-3 minutes.

Treatment of the material with flame retardants should not worsen other consumer properties of the fabric - affect its neck and significantly weigh down the products. The final finish requires special study of the following properties: fire retardant properties, structural rigidity, breaking load, water repellency and other properties. In this regard, the fire-retardant and physical-mechanical properties of the developed fire-retardant textile materials have been investigated. To determine the tensile characteristics, the RT-250M GOST 3813-72 tensile machine was used. The results are presented in table 2.

Table 2 - Indicators of the absolute breaking load of modified samples, kgs

№	breaking load, kgs							
	sodium hexametaphosphate, 150 g/l		sodium hexametaphosphate,1 75 g/l		sodium hexametaphosphat,2 00 g/l		raw materials	
	base	weft	base	weft	base	weft	base	weft
1	F=58.3 L=68.3	F=63.6 L=54.2	F=62.2 L=71.3	F=56.6 L=44.2	F=68.7 L=79.2	F=73.1 L=63.4	F=38.0 L=58.6	F=41.1 L=69.2
2	F=40.6 L=60.8	F=73.6 L=34.2	F=38.6 L=68.2	F=70.3 L=48.3	F=48.0 L=71.8	F=68.6 L=44.2	F=32.5 L=41.6	F=53.2 L=39.3
3	F=48.0 L=54.3	F=60.7 L=39.7	F=38.3 L=46.1	F=68.3 L=48.9	F=42.6 L=58.3	F=62.3 L=41.2	F=47.0 L=59.1	F=54.8 L=32.2
4	F=38.7 L=29.5	F=35.8 L=31.9	F=35.5 L=35.6	F=39.7 L=42.3	F=43.3 L=55.1	F=46.9 L=34.5	F=38.1 L=32.4	F=39.6 L=28.9

The stiffness of textile materials is influenced by their fibrous composition, structure, properties of fibers and yarns, as well as the structure and finish of the material itself. The more straightened and oriented the chain molecules of the fiber-forming polymer, the greater the internal friction limiting the movement of molecular chains, the less flexibility of fibers. Finishing operations, especially finishing, significantly affect the stiffness of fabrics. The stiffness of fabrics also depends on atmospheric conditions. Under the influence of temperature and humidity, the stiffness of tissues changes, and in less dense fabrics these changes are associated with the properties of the fibers, in denser fabrics with the structure of the fabric itself.

Stiffness is one of the main characteristics used to assess the recyclability of textile materials, as it determines the behavior of the material and products during further processing and operation. The stiffness does not increase significantly in modified samples G=1,601, in untreated samples G=1,288, table 3.

Table 3 - Hardness indicators of processed samples according to the proposed technologies

№	concentration of components, g/l polyethylene glycol 40 g/l, urea 80 g/l.	sodium hexametaphosphate, g/l.							
		150		175		200		raw materials	
		stiffness, G, sN	resilience,%	stiffness, G, sN	resilience,%	stiffness, G, sN	resilience,%	stiffness, G, sN	resilience,%
1	polyester 100 %, 180 g/m^2	3.109	74.7	3.806	78.6	4.307	83.3	2.205	79.2
2	polyester 65 %/ cotton 35 %, g/m^2	1.601	59.2	1.986	61.6	2.208	70.2	1.288	55.8
3	polyester 65 %/ cotton 35 %, 250 g/m^2	1.989	69.8	2.109	71.9	2.675	62.2	1.901	66.5
4	polyester 40 %/ cotton 60 %, 230 g/m^2	1.765	55.6	2.348	74.7	2.695	72.6	1.955	60.2

A characteristic feature of materials used in light industry is their fibrous capillary-porous structure. In the process of operation of products, the surface layers of materials are primarily exposed to external mechanical, thermal, chemical influences, and the durability of products depends on their strength and resistance. Determination of the resistance of the fabric to surface wetting was carried out in accordance with GOST 30292, device MT 032. The degree of water repellency is estimated in conventional units depending on the condition of the wet surface of the sample, the results are in table 4.

Table 4 - Degree of water repellency of polyester and blends of cotton and polyester fabrics

№	sample state, conventional units							
1	raw materials				processed materials			
2	polyester 100 %, 180 g/m^2	polyester 65 %/ cotton 35 %, 180 g/m^2	polyester 65 %/ cotton 35 %, 250 g/m^2	polyester 40 %/ cotton 60 %, 230 g/m^2	polyester 100 %, 180 g/m^2	polyester 65 %/ cotton 35 %, 180 g/m^2	polyester 65 %/ cotton 35 %, 250 g/m^2	polyester 40 %/ cotton 60 %, 230 g/m^2
3	100	50	60	50	100	60	80	70

According to the results obtained, the hydrophobic treatment of the textile material with the developed composition reduces moisture absorption. After

hydrophobization, the fabric remains breathable, maintaining its basic hygienic properties.

4. Conclusion

Effective flame retardant formulations have been developed for polyester fabrics and cotton and polyester fabric blends. For fire resistance, this technology is versatile, affordable and easy to implement. Processing of mixed materials using this technology will make it possible to obtain materials with a high degree of fire resistance, the time of flame exposure in untreated samples is 1-2 seconds, the best fire resistance indicators were 60% polyester for samples with a content of 40 % cotton. Based on these results, it can be said that samples without impregnation are flammable and do not have fire resistance. In samples with fire-retardant impregnation, fire resistance increased by 2 times. As a result of the tests, the optimal composition and concentration of the chemicals used, the optimal temperature and drying time were determined. The resulting textile materials have the best performance in all parameters of physical and mechanical properties.

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СОЗДАНИЕ ОГНЕСТОЙКИХ КОМПОЗИЦИЙ ДЛЯ ПОЛИЭФИРНЫХ И ХЛОПКОПОЛИЭФИРНЫХ ТЕКСТИЛЬНЫХ МАТЕРИАЛОВ

К.Ж. Дюсенбиева*, Буркитбай А.

Алматинский Технологический Университет, Алматы, Казахстан
**E-mail: d.kulmairam@mail.ru*

Резюме: *Введение.* Существенным недостатком материалов и изделий легкой промышленности является горючесть. Анализ и статистика пожаров показывают, что легкая воспламеняемость материалов одежды и высокая скорость распространения пламени приводят к значительным человеческим жертвам. В связи с этим, в большинстве стран мира приняты законы, запрещающие применение горючих материалов в производстве спецодежды для работы в условиях повышенных температур и брызг расплава металла, одежды для пожилых людей, постельного белья в домах престарелых, детских игрушек, в качестве обивочных и отделочных материалов и других целей. Поэтому проблема снижения горючести материалов и изделий легкой промышленности является актуальной и имеет первостепенное значение. *Цель.* Статья посвящена разработке огнезащитной технологии для полиэфирных и смесей хлопковых и полиэфирных тканей. Проведен анализ существующих способов придания огнезащитных свойств текстильным материалам и оценки их эффективности. *Методология.* В качестве объекта исследования выбраны ткани следующего состава: полиэфир 100 % (поверхностная плотность 180 г/м^2), полиэфир 65 %/ хлопок 35 % (поверхностная плотность 180 г/м^2), полиэфир 65 %/ хлопок 35 % (поверхностная плотность 250 г/м^2), полиэфир 40 %/ хлопок 60 % (поверхностная плотность 230 г/м^2). Для приготовления составов применены следующие составляющие: гексаметафосфат натрия 150-200 г/л, полиэтиленгликоль 40 г/л, мочевина 80 г/л. Ткань пропитывают аппретирующим раствором, плюсуют, сушат и термофиксируют. *Результаты и обсуждение.* Разработаны эффективные огнестойкие составы для текстильных материалов. Определены оптимальные технологические параметры для огнезащитной обработки текстильных материалов. Изучено влияние обработки на

процессы горения огнезащитных текстильных материалов. Исследовано воздействие огнезащитной обработки на физико-механические свойства аппретированных материалов.
Заключение. Подобраны оптимальные концентрации для придания текстильным полотнам огнезащитных свойств, а также для улучшения их потребительских свойств. Обработка материалов огнезащитными составами не ухудшает эксплуатационные свойства ткани. Данная технология доступна и универсальна для обеспечения огнестойкости текстильным материалам.

Ключевые слова: текстильные материалы, смесовые ткани, гексаметафосфат натрия, антипирен, огнезащитное покрытие, огнезащитная эффективность, воспламеняемость, горение, огнестойкость, возгорание тканевых материалов, огнезащитные свойства, заключительная отделка.

Дюсенбиева Кульмайрам Жаманбаевна	*PhD*
Буркитбай Асемгуль	*PhD*

ПОЛИЭФИР ЖӘНЕ МАҚТАПОЛИЭФИР ТЕКСТИЛЬ МАТЕРИАЛДАРЫНА АРНАЛҒАН ОТҚА ТӨЗІМДІ КОМПОЗИЦИЯ АЛУ

К.Ж. Дюсенбиева*, А. Буркитбай

Алматы технологиялық университет, Алматы қ., Қазақстан
**E-mail: d.kulmairam@mail.ru*

Түйіндеме. *Кіріспе.*Жеңіл өнеркәсіп бұйымдары мен материалдарының негізгі кемшілігі жанғыштығы. Өрт жағдайларынан жасалған анализ және статистика бойынша киім материалдарының тез тұтанып, жалынның жылдам таралуы адам өміріне айтарлықтай қауіп тудыратыны анықталған. Сондықтан көптеген елдерде жоғары температурада металл балқымалары шашырайтын жұмыс жағдайларына арналған арнайы киімдерге, қарт адамдардың киімдеріне, карттар үйінің төсек орын жабдықтарына, балалар ойыншықтарына, мебель қаптағыш және т.б. бұйымдарға тез тұтанатын материалдарды қолдануға тиым салатын заң қабылданған. Сол себепті, жеңіл өнеркәсіп бұйымдары мен материалдарына жанбайтын қасиет беру өзекті және өте маңызды мәселе. *Жұмыстың мақсаты.* Мақала полиэфир және мақта мен полиэфир аралас талшықтарының маталарына отқа төзімділік қасиет беруге арналған технология алуға бағытталған. Текстиль материалдарына отқа төзімділік қасиет беру тәсілдеріне талдау жасалып, олардың тиімділігі бағаланған. *Әдістеме:*Зерттеу нысаны ретінде келесі құрамдағы маталар таңдалды: полиэфир 100 % (беттік тығыздығы 180 г/м^2), полиэфир 65 %/ мақта 35 % (беттік тығыздығы 180 г/м^2), полиэфир 65 %/ мақта 35 % (беттік тығыздығы 250 г/м^2), полиэфир 40 %/ мақта 60 % (беттік тығыздығы 230 г/м^2). Өңдеу композициясын дайындау үшін келесі препараттар қолданылды: натрий гексаметафосфаты 150-200 г/л, полиэтиленгликоль 40 г/л, мочевина 80 г/л. Мата аппреттеуші ерітіндіде өңделіп, сығылып, кептіріліп және термофиксацияланды. *Нәтижелер.*Текстиль материалдарына арналған өте тиімді отқа төзімді құрам алынды. Текстиль материалдарын отқа төзімділік өңдеудің оңтайлы технологиялық параметрлері анықталды. Өңдеудің текстиль материалдарының жану процессіне әсері зерттелді. Отқа төзімділік өңдеудің аппреттелген материалдардың физика-механикалық қасиеттеріне әсері зерттелді. *Қорытынды.* Текстиль жаймаларына отқа төзімділік қасиет беретін, сондай-ақ тұтынымдық қасиетін арттыратын құрамның оңтайлы концентрациялары таңдалды. Отқа төзімділік қасиет беретін құраммен өңделген материалдың эксплуатациялық қасиеттері төмендемейтіні анықталды. Текстиль материалдарына отқа төзімділік қасиет беретін бұл технология қарапайым және әмбебап болып табылады.

Түйінді сөздер: текстиль материалдары, аралас маталар, натрий гексаметафосфаты, антипирен, отқа төзімді жабынды, отқа төзімділік тиімділігі, тұтану, жану, отқа төзімділік, мата материалдарының жануы, отқа төзімділік қасиет, соңғы өңдеу.

Дюсенбиева Кульмайрам Жаманбаевна	*PhD*
Буркитбай Асемгуль	*PhD*

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