FORMALDEHYDE IS AN ENVIRONMENTAL PROBLEM IN THE TEXTILE INDUSTRY

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Abstract. *The article presents the results of research of influence of resins of different nature for final finishing of viscose fabrics. The possibility of reduction of free formaldehyde on fabrics is established, which allows to improve hygienic indicators of the fabric.*

Keywords: *technology, pollution, environment, human health damage, ecological problem.*

Introduction

Ecological problems of the textile industry in most cases have to do with the solution of problems connected with utilization and regeneration of production wastes: sewage treatment; creation of a system of recycling water supply; dust treatment of working area air, etc.

Unfortunately, another aspect of environmental problems in the textile industry - environmental control of the textile products themselves - is devoted to a relatively small number of works.

According to statistical data, the share of chemical fiber production was 50%. Annual growth of viscose and viscose-staple fibers production increases by 6% [1].

Fast growth of chemical fibers output is promoted by high economic efficiency of production and use of these fibers in comparison with natural fibers, available raw material base; high quality of the fibers.

The demand for viscose fibers is increasing not only for nonwoven materials, but also in production of comfortable clothes for sports and outdoor activities, casual wear and home textiles.

At the same time there are increasing requirements for the quality of products: such as giving properties of nonwearability, shrinkability, form stability, etc. while maintaining hygienic properties [2-4].

Modern requirements for the quality of finished fabrics are becoming stricter, and therefore it is necessary to ensure environmentally friendly technological processes. In this regard, there is a need to use thermosetting resins of a different nature, which would allow to obtain a formaldehyde-free finish. Currently, foreign industry produces low- and formaldehyde-free resins [5].

Experimental part

The aim of this work was to create highly effective technology of low-shrinkage, low-shrinkage finishing of viscose-staple fabric for dress use on the basis of new low- and nonformaldehyde finishing preparations.

Kinetic regularities of thermosetting resin fixation in hot air have been studied, optimal technological parameters of finishing process have been determined.

Subjects of the research were viscose-staple (filament fibers in the base, staple fibers in the weft), emulsion 3 (30% emulsion of H21642 oil), thermosetting resin Sakotex PU, resin concentration (BF-modified dimethyl dihydroxyethylene machivin - nonformaldehyde; Fortex-a precondensate of thermosetting resin based on a hydroxyethylene urea derivative with an integrated catalyst-low-formaldehyde) ranged from 120 to 180 g/L with an interval of 30 g/L, NH_4Cl and $MgCl_2$ catalysts.

The data presented in Table 1 showed that low-formaldehyde and non-formaldehyde resins impart the necessary effect of unkink ability and linear size stabilization to viscose-staple fabrics, but when used in rather high concentrations, which is uneconomical. In addition, the mechanical strength of the fabric is significantly reduced, and in the case of formaldehyde-free resins, a change in color shade is observed during heat treatment, and white fabrics turn yellow.

Table 1

Quality indexes of viscose-staple fabric after finishing

Composition and concentrations, g/l	Stretchability coefficient, %	Change of linear dimensions at wet processing, %		Abrasion resistance, count of cycles	Percent drop of breaking load, %	
		Stock	basis		Stock	basis
GOST	57	-3,5	±2	1300	25	40
Formaldehyde-free resin (Otexid BF) - 180 Emulsion 3 - 15 $MgCl_2$ - 36	57	-3	+2,5	1300	4,0	7,0
Low-formaldehyde resin (Fortex) - 150 Emulsion 3 - 15	57	-3	+1,0	1300	4,0	7,5
Urea-formaldehyde resin (Sacatex PU) - 80 Emulsion 3 - 15 NH_4Cl - 4,5	60	-3	+2,0	1370	+4,0	+10,7

Optimization of urea-formaldehyde resin finishing process was carried out by searching for possibilities to reduce free formaldehyde content.

Washing the fabric after finishing allows to remove unreacted chemical reagents and absorbed formaldehyde.

One of the ways to reduce free formaldehyde release during the fabric operation is to use formaldehyde acceptors in the washing baths. Compounds used as formaldehyde acceptors must be water-soluble, well-diffuse into fibers, be non-volatile, not evaporate under heat treatment conditions, not have alkaline properties and at the same time not decrease pH on fabric, which may cause hydrolysis of transverse bonds in the fiber.

In the present work, such compounds as: urea, PPS preparation were used as formaldehyde acceptors. The data are presented in Table 2.

From the literature data, it is known that good results in reducing the content of free formaldehyde in the fabric are achieved by adding polyatomic alcohols: ethylene- and diethylene glycol, sorbitol, polyethylene glycol. In this work, it was assumed that polyalcohols present in the PPS preparation can react with the hydroxyl groups of dimethylolurea and with formaldehyde to form acetyls or semiacetyls:

$$R - CO - NH - CH_2OH + R_1 - OH = R - CO - NH - CH_2 - O - R_1 + H_2O$$

$$R_2 - OH + CH_2O = R_2 - O - CH_2OH \text{ или } R_2 - O - CH_2 - O - R_2$$

Obviously, the reduction of formaldehyde content on the fiber material using compounds containing NH - groups is based on the fact that NH - group can form N - methylene compounds with formaldehyde.

Table 2

Changes in free formaldehyde content after washing with acceptors

Compositions	Stretchability coefficient, %		Free formaldehyde content, µg/g	
	Before	After	Before	After
Suggested variant, washed with urea	60	57	350	50
Suggested variant, washed with PFS	60	58	350	80

Thus, application of urea and PFS as formaldehyde acceptors during washing allows to reduce formaldehyde content on a fibrous material by 86% (with urea) and by 77% (with PFS) in comparison with the fabric treated without acceptor.

Introduction of polyatomic alcohols in the finishing composition allows to reduce the amount of free formaldehyde 2 - 3 times. Due to their high boiling point, the polyatomic alcohols do not decompose at the temperature of heat treatment. As suggested above, they can react with hydroxyl groups of finishing preparations, forming esters and with formaldehyde, forming acetals or semiacetals.

By reacting with the free hydroxymethyl groups of the crosslinking reagents, the polyatomic alcohols protect them from hydrolysis and hence prevent the release of free formaldehyde.

Analysis of the data obtained during treatment of fabric with formaldehyde-containing preparations shows that due to the use of effective components in the finishing composition, first of all amino-functional softener of new generation, there is a possibility to reduce the amount of urea-formaldehyde resins, which leads to a decrease in free formaldehyde emission. In addition, it is necessary to take measures such as mandatory washing after finishing, which reduces the release of free formaldehyde by an order of magnitude.

Table 3

Changes in the amount of free formaldehyde from the concentration of acceptors in the impregnation bath

Variants	Free formaldehyde content, µg/g						
	Amount of additive						
	0	0,5	1	2	3	5	7
Sakotex PU 80 g/l NH_4Cl 5 g/l Emulsion (3) 15 g/l PFS	350	270	145	170	180	220	260
Sakotex PU 80 g/l NH_4Cl 5 g/l Emulsion (3) 15 g/l Sorbitol	350	265	135	165	185	200	250
Sakotex PU 80 g/l NH_4Cl 5 g/l Emulsion (3) 15 g/l Urea	350	280	220	200	175	160	280

In this case to increase the efficiency of reduction of free formaldehyde by 2-3 times is possible through the introduction of formaldehyde acceptors in the impregnating solution and in the washing bath. Selection of effective catalysts, for example magnesium chloride with acetic acid, also allows reducing the amount of free formaldehyde.

The indicated measures to reduce the content of free formaldehyde on textile materials allowed to minimize the emitted formaldehyde, which did not exceed the established norms when selling fabrics in the domestic market.

Conclusions

Thus, companies have a choice:

- or to use preparations that would provide the lowest formaldehyde content, requiring high temperatures, concentrations of resins and catalysts and yet have a high cost;

- or the use of domestically produced resins, which have lower cost, used on the basis of highly efficient technology, which provides a reduction of formaldehyde emitted for the industrial standard in the amount of 50 - 150 mcg/g;

- or use of formaldehyde-free resins for a very limited range of fabrics, in this case smooth-dyed and white fabrics are excluded.

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