Development of methods for discoloration and bleaching of textile waste

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Abstract. This article presents the results of research experiments conducted to study the process of decolorization of fibrous waste generated at different stages of the textile industry in order to use it in the production of paper types.

1 Introduction

All production processes in the industry generate waste of various nature. The return of these wastes to the main process leads to a reduction in the cost of production, a decrease in the volume of waste released into the environment.With the rational use of natural resources, it is important to involve them in the production of appropriate waste. Manufacturing processes in textile factories produce a large amount of fiber waste, most of which is in some cases discarded or used as a by-product.Along with the efficient use of textile waste, an important issue is the solution of environmental problems through the elimination of these wastes [1-3].In different shops of textile enterprises, different amounts of fibrous waste are generated, i.e. in the spinning shop - 12-14%, in the weaving shop - 3%, in the sewing shop - 8-12%, in the shop for preparing yarn for finishing. - 2-3%, when decorating knitwear, while from 3-4% to 23% of fibrous waste can be formed.

From the processes discussed, it can be seen that the largest amount of fibrous waste is generated in the chemical composition section. This area generates mainly colored waste. When processing waste textile fibers, it is important to address the issues of their separation and discoloration by fiber class[4-7].

2 Methods

The standard method of obtaining paper from wood pulp was used in the production of paper on the basis of fiber wastes of the textile industry, MS-1, MS-3 waste paper and cotton cellulose.

The bleaching mechanism for the decolorization of non-ferrous fiber waste in the textile industry was set in accordance with the dye chromaphore system. Product quality was studied using physicochemical methods. Paper was obtained on the basis of different compositions, and their quality indicators were determined by mechanical and optical methods.

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3 Results and Discussion

The purpose of this study was to use the mechanism of decomposition of dyes in the process of decolorization of fibrous waste.The experiments involved the decolorization of non-ferrous fiber waste from the plant with the participation of a number of oxidizers and reducing agents [8].

The obtained results showed that it is possible to increase the whiteness level of fibrous wastes to 63-88% during bleaching processes.

We will first consider the bleaching-decolorization of fibrous wastes of the textile industry under the oxidizing effect.The study examined the effect of sodium hypochlorite concentration, processing medium, duration and temperature on the quality indicators of secondary raw materials, including the degree of whiteness and polymerization [9].

Hypochlorites are the strongest oxidants with which the process can be carried out in an environment of 3-11 pH. Sodium hypochlorite is a salt of weak hypochloric acid.It is known that hypochlorite solutions have the property of self-decomposition. In an acidic environment, the reaction process proceeds as a first-order reaction, while the rate of the reaction increases 2.5 times as the temperature rises every 10^0C. In an alkaline environment, spontaneous decomposition is slow, while the reaction proceeds in two directions: oxygen is formed in the first direction, and chlorite, which rapidly converts to chlorate, is formed in the second direction[10, 11].

It is known that under the influence of oxidants, cellulose is converted to oxycellulose, as a result of which its polymerization rate decreases and the ability to form a paper sheet is lost. Taking into account the above considerations, the effect of sodium hypochlorite concentration on the degree of polymerization of fiber waste in the textile industry was studied. The results obtained are shown in Fig. 1.

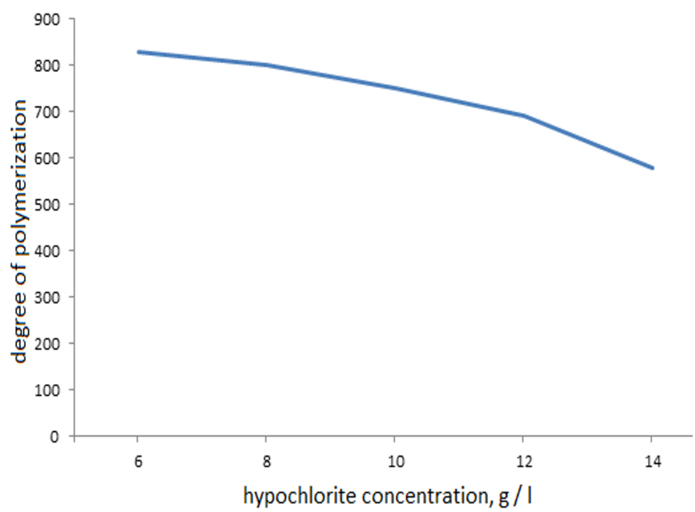

Fig. 1. Dependence of the degree of polymerization of fibrous waste of the textile industry on the concentration of sodium hypochlorite. (*Note:* temperature 50 ^{0}C, pH= 9).

As the oxidant concentration increased, a decrease in the degree of polymerization of the fibrous waste of the textile industry was observed. In the next step, the effect of sodium hypochlorite concentration on the whiteness level of the textile industry fiber waste was studied,

The results obtained are shown in Fig. 2.

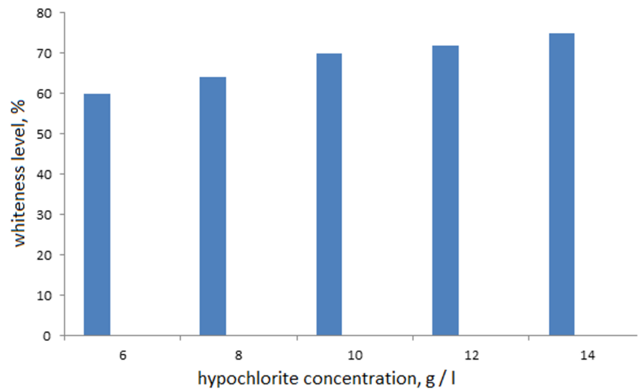

Fig. 2. Dependence of the level of fibrous waste in the textile industry on the concentration of sodium hypochlorite. (*Note:* temperature 50 ^{0}C, pH = 9).

When analyzing the results in both graphs above, it was observed that the degree of polymerization and whiteness of the textile industry fiber waste reached optimal values when the concentration of sodium hypochlorite was 10 g / l.

In the study of the duration and temperature dependence of the quality of the textile industry fiber discoloration-bleaching process, it was observed that the whiteness of the mass is directly proportional to the increase in processing time, but its polymerization rate decreases [10-12].

Table 1. Influence of processing duration on textile industry fiber waste quality indicators

Process duration, min	Whiteness rate, %	Polymerization rate %
20	60	780
30	65	760
40	70	750
50	72	730
60	73	690

Note: temperature 50^{0}C, pH = 9

We can take the processing time to be 50 minutes under optimal conditions from the table showing the effect of the degree of whitening and the degree of polymerization of the colored particles. Although further increasing the duration of the discoloration process leads to further intensification of discoloration of samples, but the fact that the degree of polymerization of the resulting mass is less than 700 does not allow its use in paper production. The results obtained for discoloration temperature are given in Table 2.

Table 2. Dependence of fiber waste quality indicators on the process temperature of the textile industry

Process duration, min	whiteness rate, %	polymerization rate %
40	60	785
50	72	730
60	77	720
70	80	710
80	80	630

Note: Process duration 50 min, pH = 9

When the process of decolorization of colored waste of textile fibers is carried out at a temperature of 70 ^{0}C, the whiteness of the cut reaches 80% and becomes a white fabric. At high temperatures in an alkaline environment, the dye is released from the fiber due to the breakdown of the chromophore system, as well as the decomposition of azo groups to amino acids. The main reaction is that along with the discoloration of the fibrous material, the hydrogen bonds between the macromolecules are broken due to the hydration of the cellulose primary hydroxyl groups, and the degree of polymerization of cellulose has low values. Cellulose with a polymerization level of less than 700 is not used for paper production.

In the next stage, we will consider the bleaching processes under the reversible effect of fibrous wasteof the textile industry.Sodium hydrosulfite was recovered as a reducing agent. Sodium hydrosulfite represents white or colorless hygroscopic crystals that are readily soluble in water. It forms crystal hydrates.

This weakly hydrolyzable salt is the acidity of sodium and hydrogen sulfide. It melts without disintegration. Sodium hydrosulfite is mainly used in non-ferrous metallurgy to enrich non-ferrous metal ores by flotation. In flotation processes it is a reagent-regulator for enrichment of ores containing copper, lead, zinc, molybdenum and antimony.

An alkaline medium was used to bleach fibrous waste from the textile industry with sodium hydrosulfite. The results obtained are shown in Fig. 3.

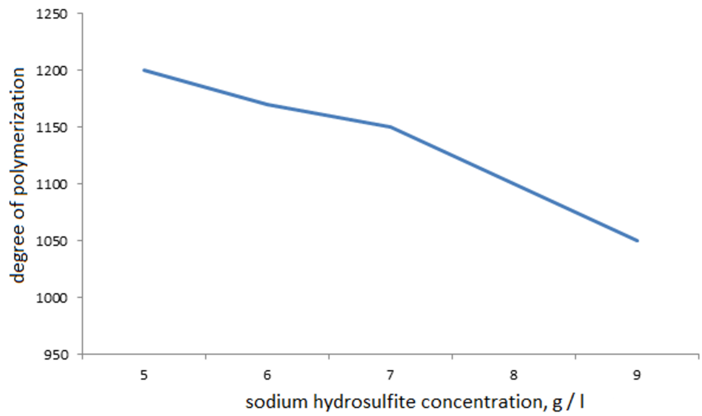

Fig. 3. Dependence of the degree of polymerization of fibrous waste of the textile industry on the concentration of sodium hydrosulfite. (*Note:* temperature 90 ^{0}C, pH = 11).

From the picture above, we can observe that the degree of polymerization of the fibrous waste of the textile industry decreases with increasing concentration.In the next stage of the study, the effect of sodium hydrosulfite concentration on the whiteness level of textile fiber waste was studied, the results of which are shown in Figure 4.

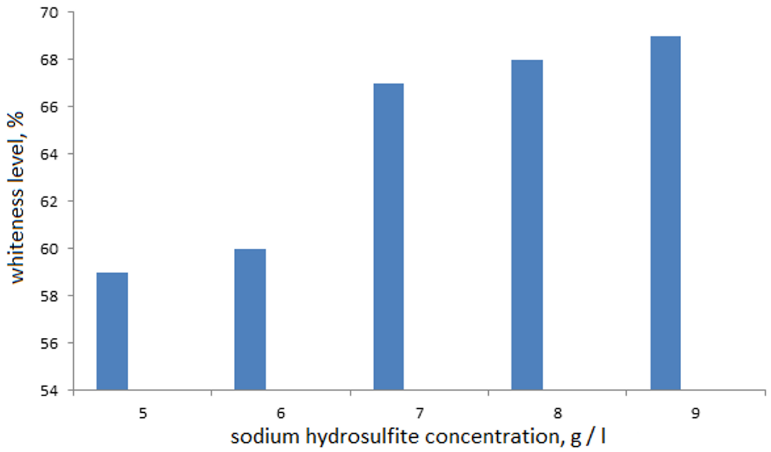

Fig. 4. Dependence of the level of fibrous waste in the textile industry on the concentration of sodium hydrosulfite (*Note:* temperature 90 ^{0}C, pH = 11).

In the process of decolorization of textile materials, we can see that the fiber has a positive effect on the degree of whiteness as the concentration increases under the influence of the degree of polymerization. It does not usually have a destructive effect on regenerative cellulose. This explanation is confirmed in Table 3.

Table 3. Influence of processing duration on the quality indicators of fiber waste in the textile industry

Process duration, min	whiteness rate, %	polymerization rate %
10	60	1180
15	64	1160
20	67	1150
25	72	1140
30	73	1130

Note: temperature 90 ^{0}C, pH = 11

When studying the duration and temperature dependence of the quality characteristics of the textile industry fiber discoloration-bleaching process, it was observed that the whiteness of the mass is directly proportional to the increase in processing temperature, but its polymerization rate decreases (Table 4).

Table 4. Dependence of fibrous waste quality indicators on the process temperature of the textile industry

Process temperature, ^{0}C	Quality indicators of textile industry fiber waste	
	Whiteness rate, %	polymerization rate
60	40	1300
70	50	1280
80	59	1150
90	67	1150
100	68	1050

Note: Process duration 20 min, pH = 11

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We can see that the polymerization rate of the fibrous waste is almost unchanged under the data feedback effect. This is due to the fact that sodium hydrosulfite does not have a destructive effect on cotton fiber material. Analyzing the above data, we propose the following conditions for the decolorization-bleaching process under the reversible effect of textile industry waste: sodium hydrosulfite concentration - 7 g/l; processing time - 25 min; process temperature – 90^0C; pH = 11.

In subsequent studies, the processes of decolorization of fibrous materials in one- and two-stage methods were studied in order to achieve the required level of whiteness at the required level of polymerization. Also, in order to compare the results obtained, the mass after cleaning and washing of paper waste of grades MS-1 and MS-3, as well as the quality of cotton cellulose were compared.The degree of whiteness of paper samples formed from the mass of waste paper MS-3, white paper waste MS-1, cotton cellulose and discolored fabric waste fabric at two different ends, determined from the printing dye, was determined. The results obtained are shown in Fig.5.

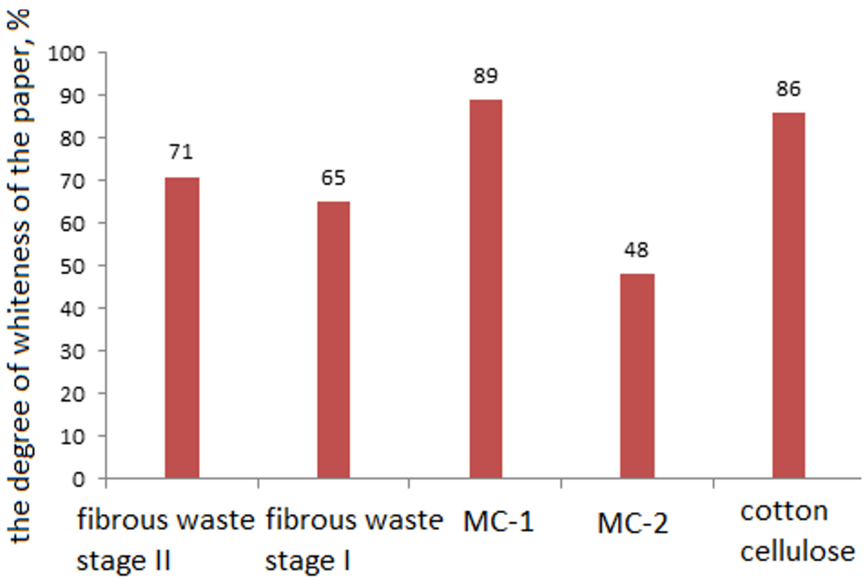

Fig. 5. The degree of whiteness of paper samples depends on the method of mass preparation

From the results given, we can see that the paper samples formed from the white paper waste have the highest whiteness level. The 9% higher whiteness of paper samples formed from the mass of discolored fabric waste in two stages than in one stage may be due to the removal of the part of the fabric from the fabric mass that was re-absorbed in the first stage or discolored in accordance with the chromophore system[6]. The results of the study are presented in Fig. 6, taking into account that the discoloration conditions from previous experiments affect the degree of whiteness of paper samples as well as their degree of polymerization.

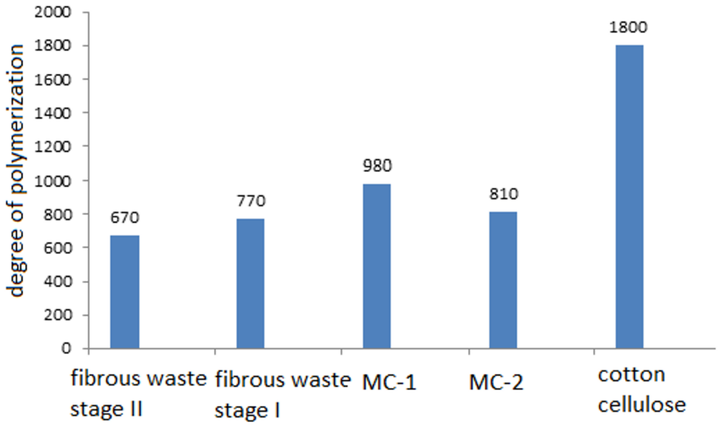

Fig. 6. Dependence of the degree of polymerization of paper samples on the method of mass preparation

From the results of the experiment we can see that the two-stage decolorization of fiber waste has a sharp negative impact on the degree of polymerization of the paper mass [7]. The effect of processing on paper quality indicators on fiber length and number of black dots on the paper surface is summarized in Table 5.

Table 5. Influence of processing processes on paper quality indicators (fiber length and number of black dots on the paper surface)

Process and raw materials	Fiber length, mm	Number of black dots, pcs
Textile industry fiber waste, Two-stage decolorization	1.2	8
Textile industry fiber waste, One-stage decolorization	1.1	15
MS-1	1.1	3
MS-3 (cleaned)	1.0	16
Cottoncellulose	1.4	2

Thus, based on the results of the study, it was shown that bleaching and decolorizing the waste of the textile industry can be used as a raw material in the production of paper. For this end, the possibility of using oxidants or reducing agents was studied and optimal technological conditions were proposed for both methods.

4 Conclusions

- Decolorization and bleaching of fibrous wastes of the textile industry, the mechanism of decomposition of dyes was used;
- The possibility of using oxidants or reducing agents for bleaching and whitening was studied, the factors influencing the process were analyzed and optimal technological conditions for both methods were proposed;
- Experiments were carried out with the participation of a number of oxidizers and reducing agents to decolorize and bleach colored fiber waste from the enterprise.

- Given the non-destructive effect of reducing agents on cellulose, and the oxidation of cellulose under the influence of oxidizers to oxycellulose, as well as the intensive destruction of colors by reducing agents, it is advisable to use reducing agents as a decolorizing agent;
- Possibilities of production of bleached textile wastes of the textile industry and printing paper on the basis of local MS-1, MS-3 waste paper were studied in practice and specific technology was proposed; the possibility of producing types of printed paper using them was shown on the basis of physical-mechanical and physicochemical analysis of the formed paper.

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