ECOLOGICALLY SAFE METHOD OF OBTAINING CELLULOSE FROM FLAX

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Annotation: The article presents the results of an environmentally safe method of obtaining cellulose, a raw material for the light industry of our Republic, from flax. The main factors affecting the quality indicators of the product are studied, and their optimal concentrations are found. В статье представлены результаты экологически безопасного способа получения целлюлозы из растения льна для легкой промышленности нашей Республики. Изучены основные факторы, влияющие на качественные показатели продукта, и найдены их оптимальные концентрации.

Keywords: Cannabis Sativa plant, ammonium oxalate, rotary evaporator, Acetic acid, Sodium hydroxide, galactose, glucose, arabinose, xylose.

Introduction. At a time when industrial sectors are developing rapidly, finding new types of raw materials for manufacturing enterprises and creating technologies for processing production waste are urgent issues. The rapid development of the light industry of our Republic in recent years, as well as the demand set by the head of our state to increase the types of raw materials, are a vivid example of this. It has long been known that in order to economize on wood cellulose, which is considered expensive and scarce in the paper industry, it is possible to use cellulose from various non-woody annual plants.

Flax (Linum usitatissimum L.) is one of the oldest plants cultivated for its fiber, as well as for its seeds and flowers. Domestication of flax occurred in the Fertile Crescent [1], and the earliest known evidence of flax fiber use dates back to about 30,000 years ago in the Republic of Georgia [2]. Historically, flax has been used to make fine fabrics for clothing, as well as heavy-duty materials such as sailcloth, canvas, sacking, and rope. In general, flax is easier to produce fine threads, and hemp, another natural fiber, is often preferred in technical applications [3]. However, since the 1930s, hemp cultivation has faced legal restrictions in several countries around the world due to its use in the production of the psychoactive

substance delta-9-tetrahydrocannabinol [4]. Since the 1930s, flax cultivation has become popular, and this plant has been grown for its seeds, oil, and fiber.

Flax fibers are extracted from the stems and leaves of various plants. Among them, flax fiber is of great importance. Flax fibers are longer, harder, and thicker than cotton fibers. Despite the difference in morphological structure, their commonality is that they are mainly composed of cellulose. There are 20-25 flax fiber bundles along the diameter of the plant stem, and each bundle contains 15-30 elementary fibers (Figure 1). The two ends of the elementary fiber have a tapered rope-like shape. The average length of the elementary fiber is 25 mm, and they are located along the length of the plant (approximately 15-125 cm).

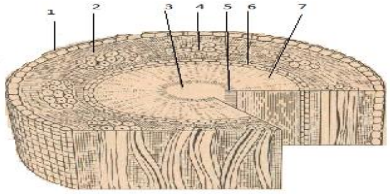


Figure 1. Schematic view of the cross-section of a flax stem. 1-epidermis, 2-parenchyma, 3-space, 4-flax fiber bundles, 5-main part, 6-cambium, 7-wood.

The composition of the main components in flax is as follows: cellulose - 78.1%, hemicellulose - 15.0%, lignin - 2.4%, pectin - 2.9%, waxy substances - 1.6%.

Research results. There are several methods for obtaining cellulose from all raw materials, these are: alkaline, acidic and other methods. In the process of obtaining cellulose, cellulose by-products are removed from the raw materials: lignin is removed, chlorine-containing substances are used for the delignification process. In the framework of this research work, an alkaline method was chosen to obtain cellulose from flax, and NaOH was used as a chemical reagent. The length of the crushed flax was cut into 3-4 cm pieces. The crushed flax, alkali (in various concentrations: 5,10,15,20 %), and water were placed in a 4-liter autoclave. It was boiled at a temperature of 1400C, under a pressure of 2-3 kPa, for 1 hour. Then the resulting cellulose was washed 2-3 times in cold water and dried at room temperature. The quality indicators of the resulting cellulose were determined, and the results are presented in Table 1.

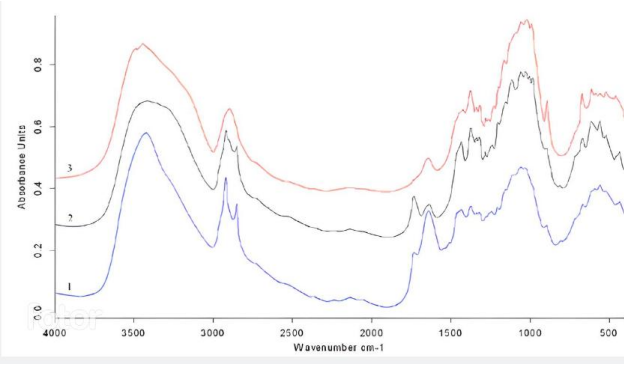
Quality index of the obtained cellulose

NaOH concentration, %	The formation of cellulose, %	The amount of α-cellulose in cellulose, %	Degree of polymerization
5	71,2	85,1	1400
10	63,9	87,8	1290
15	60,1	92,7	1200
20	56,5	97,5	1050

Note: temperature - 1400C, process duration - 60 minutes.

It can be seen from the table that with increasing alkali concentration, the degree of polymerization of the obtained cellulose and the formation of the product decreased. This is due to the destruction of cellulose in an alkaline environment, and at high alkali concentrations, the delignification process proceeds intensively, dissolving lignin from the cellulose composition. However, increasing alkali concentration led to an increase in the amount of α-cellulose in the resulting cellulose. When the alkali concentration was 15%, the quality indicators of the obtained cellulose gave good results.

In order to study the delignification process, the crystallinity indices of the obtained cellulose were analyzed, and the IR spectra of the samples are presented in Figure 2



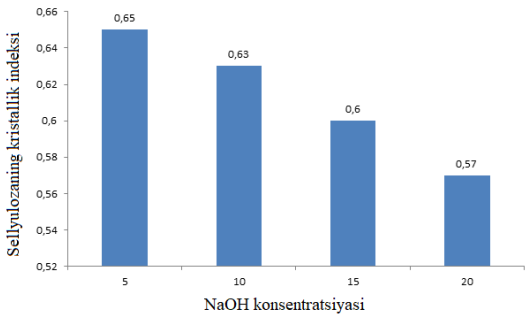


Figure 2. IR spectra of samples

1-flax; 2-resulted cellulose; 3- α-cellulose. Figure 3. Crystallinity index of celluloses

The decrease in the crystallinity index of cellulose is associated with the dissolution of lignin in the fiber (Figure 3).

Conclusion. The possibilities of obtaining cellulose from flax, which is abundant in our republic, were shown. To obtain cellulose from flax in an environmentally safe way, boiling in a 15% solution of NaOH at a temperature of 1400C for 1 hour was proposed.

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