EFFECT OF ALKALINE TREATMENT ON THE PRODUCTION OF TECHNICAL CELLULOSE FROM AGRICULTURAL WASTE

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Cellulose-based natural polymers are considered one of the most promising raw materials for the development of solid-phase matrices due to their renewability, biodegradability, and high sorption capacity. In this study, the process of obtaining high-quality technical cellulose from agricultural waste—rice straw, rice husk, and wheat straw—was investigated. The novelty of the research lies in the selection of an oxidative organosolv method for the delignification process. Unlike conventional methods, this approach enables selective removal of lignin while preserving hemicelluloses to the greatest possible extent. This, in turn, ensures the retention of a high molecular structure and porosity of cellulose, significantly enhancing its sorption properties. Based on the obtained cellulose, test systems modified with formazans were developed, enabling not only the removal of radionuclides but also their rapid detection under field conditions. In addition, regeneration of the cooking solutions ensures both the economic efficiency and environmental sustainability of the technological process.

The study aimed to achieve effective removal of mineral components from plant raw materials and to prepare the fiber structure for the subsequent delignification process. Alkaline treatment not only provides demineralization but also induces several important physicochemical changes, including partial degradation of lignin and transfer of its decomposition products into the solution, removal of extractive substances, swelling of the fiber cell wall structure, and expansion of submicroscopic pores.

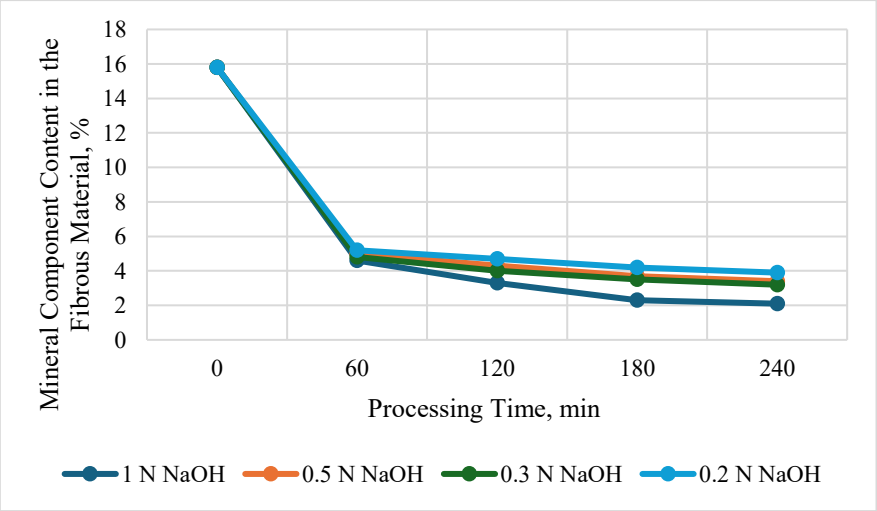


Figure 1. Effect of Caustic Soda (NaOH) Concentration and Treatment Time on the Mineral Content of the Fibrous Material

The alkaline treatment process was carried out based on the optimal technological parameters established in previous studies [1]: reagent — NaOH (24 g/L

or 1 N); liquid-to-solid ratio — 1:10; temperature — 90 °C; duration — 60 minutes (including 20 minutes required to reach 90 °C).

In order to obtain high-quality fibrous material from rice straw, it became necessary to optimize the alkaline treatment process. For this purpose, preliminary studies were conducted based on single-factor experiments [2]. The results of these investigations are presented in Figures 1 and 2.

As shown in Figure 1, the efficiency of mineral component removal increases with increasing NaOH solution concentration. During the first hour of the process, approximately 67.5% to 71.5% of the mineral substances are removed. The highest efficiency is observed at a concentration of 1 N, where up to 85% of the mineral components are extracted. Figure 2 illustrates the dependence of fibrous product yield on alkali concentration and treatment time.

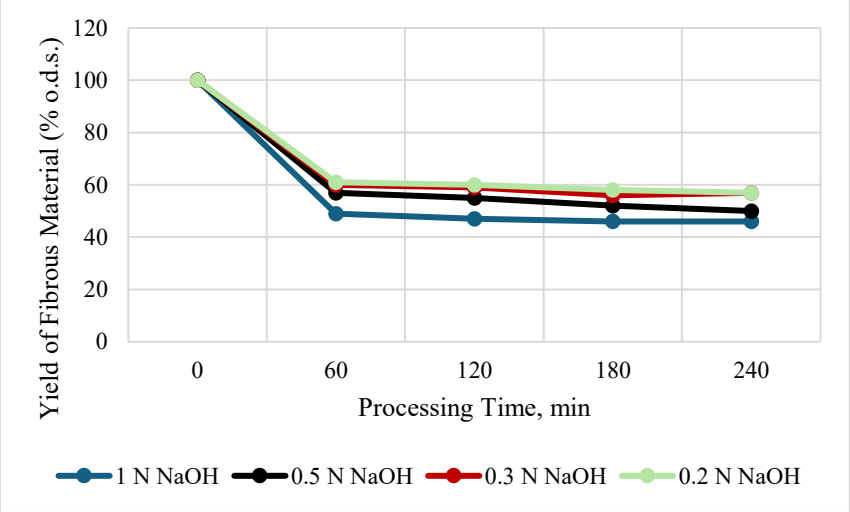


Figure 2. Effect of Caustic Soda (NaOH) Concentration and Treatment Time on the Yield of Fibrous Material

The analysis of Figure 2 indicates that when an alkali concentration of 1 N is applied, the yield decreases by more than 50%. This phenomenon is associated not only with the removal of mineral components and lignin, but also with the degradation of the carbohydrate complex (cellulose and hemicellulose).

The results of the study demonstrate that, through optimization of the alkaline treatment process for non-wood plant raw materials and the application of an oxidative organosolv delignification method, it is possible to obtain technical cellulose with a high degree of whiteness and low contents of lignin and resinous substances.

References:

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