Nguyen Van Duy

The processes of obtaining hybrid aerogels from coconut fiber components

Abstract

In the Russian Federation and the Socialist Republic of Vietnam, advanced technologies for processing plant materials are actively being developed for the development of the pharmaceutical, food and biotechnology industries. In particular, the national tasks of Vietnam in the field of science and technology and in the areas of cooperation between Vietnam and the Russian Federation until 2030 with a perspective toward 2045 formulate the relevance of developing advanced technologies for the use of renewable raw materials from biomass and using it to produce modern materials with high practical value.

Extraction of plant components is mainly carried out by physical, chemical, and combined methods. After extraction, valuable plant components can be used to obtain hybrid materials with unique properties. In the field of pharmaceuticals and cosmetology, there is increasing attention to the research and development of materials containing substances extracted from plants. Aerogels with unique properties are finding increasing application in many areas. Thus, the extraction of valuable components from plants and their use to create hybrid aerogels open new possibilities.

This work is devoted to the experimental and theoretical study of the extraction process of cellulose, nanocellulose, hemicellulose, and lignin from coconut fiber, as well as the subsequent production of hybrid aerogels and cosmetics based on them.

The aim of the study was to develop methods for extracting cellulose, nanocellulose, hemicellulose, and lignin from coconut fiber, and subsequently produce hybrid gel aerogels and chemical sunscreen filters.

Tasks:

1. Study of various methods of extracting valuable components from coconut fiber, namely: lignin extraction by chemical methods; hemicellulose extraction from coconut fiber by hydrothermal method; cellulose and lignin extraction by hydrothermal method in combination with ethanol and CO_2. Obtaining nanocellulose. Conducting complex analytical studies of the obtained samples of cellulose, nanocellulose, hemicellulose, and lignin.

2. Intensification of the extraction process of cellulose, hemicellulose, and lignin from coconut fiber using ultrasound exposure, supercritical CO_2 introduction, and a combination of intensive mixing, exposure to high pressure and temperature.

3. Study of the processes involved in obtaining hybrid aerogels based on: a) silicon dioxide and lignosulfonate; b) chitosan and lignin; c) alginate and lignin; d) silicon dioxide and lignin; e) silicon dioxide and nanocellulose.

4. Development of chemical sunscreen filters containing lignin. Determination of the dependence of the absorption of ultraviolet radiation of sunscreen filters on the concentration of lignin.

5. Mathematical modeling and scaling of the hydrothermal extraction process for coconut fiber processing.

Scientific novelty. The processes of extracting valuable components from coconut fiber: cellulose, nanocellulose, hemicellulose, and lignin were studied. The parameters of the extraction processes, such as temperature, time, pH, solvent concentrations were established.

The possibilities of intensifying the process of extraction of cellulose, nanocellulose, hemicellulose, and lignin from coconut fiber using ultrasound exposure, supercritical (SC) CO_2 introduction, combination of intensive mixing, exposure to high pressure and temperature were investigated.

A new method for separating coconut fiber has been developed, combining hydrothermal action with environmentally friendly solvents (water, ethanol, supercritical CO_2). The method ensures the extraction of up to 65% lignin (compared to a yield of no more than 34% using chemical methods), up to 80% hemicellulose, and up to 90% cellulose.

The time dependence of ultraviolet radiation absorption on lignin concentration in cosmetics has been established.

The experimental regularities of the structure and characteristics of hybrid aerogels based on silicon dioxide and lignosulfonate, chitosan and lignin, alginate and lignin, silicon dioxide and lignin, and silicon dioxide and nanocellulose, in relation to the concentrations of coconut fiber components, have been established.

An equipment and process flowchart for the hydrothermal extraction process used in coconut fiber processing has been developed.

A mathematical model of the hydrothermal extraction process used in coconut fiber processing has been developed.

Practical significance. A set of experimental studies was conducted on the extraction of valuable components from coconut fiber: cellulose, nanocellulose, hemicellulose, and lignin.

Methods have been developed for extracting hemicellulose, lignin, and cellulose from coconut fiber using a hydrothermal method in a high-pressure apparatus with stirring.

Methods are proposed for intensifying the chemical-technological processes of extracting cellulose, nanocellulose, hemicellulose, and lignin from coconut fiber using ultrasound exposure, supercritical CO_2 introduction, and a combination of intensive mixing, exposure to high pressure and temperature.

The effectiveness of lignin as a chemical sunscreen filter has been experimentally proven, with the effect lasting for 120 minutes.

Hybrid aerogels based on silicon dioxide and lignosulfonate; chitosan and lignin; alginate and lignin; silicon dioxide and lignin; silicon dioxide and nanocellulose have been obtained. These hybrid aerogels are unique and have high values of specific surface area, pore volume, and low density.

An equipment and technological scheme for the hydrothermal extraction process used in coconut fiber processing has been developed.

The Unisim Design R500 software package was used to model the hydrothermal extraction process of cellulose, hemicellulose, and lignin from coconut fiber.

The main provisions for the defense.

1. The results of experimental studies of the extraction of valuable components: cellulose, nanocellulose, hemicellulose, and lignin from coconut fiber. Parameters of the extraction process: temperature, process time, pH and solvent concentrations, providing a high degree of extraction.
2. Approaches to intensifying the extraction process of cellulose, nanocellulose, hemicellulose, and lignin using ultrasound, introduction of supercritical CO_2, combination of intensive mixing, exposure to high pressure and temperature.
3. The results of experimental studies of the effect of lignin on the absorption of ultraviolet radiation. Chemical sunscreen containing lignin, providing a high level of protection from ultraviolet radiation.
4. The results of experimental studies of obtaining hybrid aerogels based on silicon dioxide and lignosulfonate; chitosan and lignin; alginate and lignin; silicon dioxide and lignin; silicon dioxide and nanocellulose.
5. The equipment and technological scheme of the hydrothermal extraction process for processing coconut fiber.

6. The results of mathematical modeling of the process of hydrothermal extraction of cellulose, hemicellulose, and lignin from coconut fiber.