

## Surface free energy of hemp fibers

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### ABSTRACT

The aim of the study was to investigate the mechanisms responsible for value of surface free energy (SFE) of hemp fibers. Surface free energy determines behavior of fibers during contact solid fiber with liquids, determines wettability, adhesion, and bonding, which are crucial in processes of coating, dyeing, and composite manufacturing as well as playing important role in moisture transfer management in textiles. Hemp fibers are characterized by diversification of their chemical composition conditioned by plant variety and applied preliminary processes.

This paper discusses aspects of hemp fiber surface free energy in the context of selected methods of fibers extraction from the straw as well as diversity of fibrous plants variety. In first case, dew retted and water retted fibers Bialobrzescskie variety were used as material of the experiment.

In second case SFE of water retted fibers delivered by four plant varieties Beniko, Wojko, Tygra, Bialobrzescskie was assessed.

The Sessile Drop method was used in this study, which involves placing a droplet on the fiber surface and analyzing its shape to determine the contact angle. The drops were formed using two measuring liquids: HPLC water (polar liquid) and diiodomethane (non-polar liquid). The contact angle was measured at the interface of three phases: fiber - measuring liquid - air. The data were converted to surface free energy using the Owens-Wendt-Rabel-Kaelble model.

Hemp fibers contain cellulose, hemicellulose, lignin, pectin, fats and waxes in their chemical composition. The results of the research showed that the surface free energy of hemp fibers depends on the content of individual chemical components of fibers. The share of hydrophilic cellulose and hemicellulose in the fiber are of greatest importance for wettability. However, hydrophobic components such as lignin, waxes, and fats cannot be ignored. The varying proportions of hydrophilic and hydrophobic components in hemp fibers translate into differences in surface free energy between fibers from different varieties. However, the share of individual components in the fiber depends not only on the plant variety but also on the method of fiber extraction from the straw. Results of tests of Bialobrzescskie hemp fibers obtained by dew and water retting process proved that retting method significantly affected the fiber's wettability. Bialobrzescskie fibers extracted by dew retting have a surface free energy of 31.03 mN/m, while those extracted by water retting have a surface free energy of 23.05 mN/m. Water retting contributes to an increase in the number of free hydroxyl groups ready to bind water on the fiber surface. Moreover, the Bialobrzescskie variety of fiber extracted by water retting has the lowest surface free energy (23.05 mN/m) of all tested fiber variants. This variety is characterized by the highest content of hydrophilic components, which results in better affinity of the water for the fiber surface.

Understanding of complexity of the SFE terms of bast fibers is crucial for the design of processing, modelling and modification of hemp fiber to ensure appropriate process flow and final product quality to meet industrial and consumer needs.