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Chemical modification of hemp shives and their characterization

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Abstract

Lightweight lignocellulosic composites are potentially contributing to sustainable development. However, lignocellulosic fillers are not always fully compatible with an inorganic matrix, which causes a variety of adverse outcomes such as the coherence and mechanical properties of composites. Therefore, experiments are made with natural fiber surface treatment. Experiments were conducted to further development of natural fibers - hemp shives of another application to lightweight composites. Untreated and chemically treated hemp shives surfaces by NaOH, $Ca(OH)_2$ and EDTA were characterized by FTIR and TG. Changes in the FTIR spectra at 1730, 1625 and cm^{-1} indicated that hemicellulose and lignin from natural fiber surfaces were removed by alkaline treatment. Thermal stability of hemp shives was studied using thermal gravimetric and DSC method.

Keywords: Renewable source; hemp; chemical treatment; modification; analytical evaluation; FTIR; TG

1. Introduction

One of the possible ways of achievement of sustainable development in the building industry is moving from the limited and finite material resources to easily renewable raw material resources. A large group of renewable raw materials are materials of plant origin, of which a great importance is attached to

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technical hemp like an easily renewable source of cellulosic fibers with potential for reinforcement of composite and non-waste material [1]. Renewal of scientific as well as industrial interests in the use of cellulosic fibres and especially hemp fibres as load bearing constituents in lightweight composite materials relates to a need of progress of environmental friendly products with high use value in term of sustainable development. Nowadays, hemp is regarded to be of important industrial and economic value as a source not only of building materials but of paper, textiles, food, medicine, paint, detergent, varnish, oil, ink, and fuel too [2]. The new research field of hemp fibres utilisation is application such as biodiesel production from hempseed oil and textiles production from hemp stems [3].

Due to low density, biodegrability, interesting thermal, mechanical, acoustic and aseptic properties of hemp fibres, low cost and eco-friendly raw material, this natural fibrous material is used as a (partial) replacement of synthetic fibres, such as glass, carbon or metallic fibres. During their growth, harvesting and processing consume overall less fossil energy and chemicals than the synthesis of man-made fibres, their use decreases consequently the carbon dioxide emissions associated with the composite fabrication. [4]. However, one of the major disadvantages of natural fibres is their high moisture sorption sensitivity causing the chemical degradation of the structure of fibres as well as dimensional variations of fibers according to the moisture content and their heterogeneity, which leads to a weak adhesiveness on interface between the fibres and the matrix and to a poor transfer of the applied stress between the materials. This last effect has an impact on the quality of the mechanical interaction between hemp fibres and matrix. The presence of surface impurities and the large amount of hydroxyl groups make plant fibers less attractive for reinforcement of materials too [5, 6].

The surface treatment is necessary in order to optimise the adhesive strength in composites reinforced with natural fibres. The main objective of chemical modification is to remove pectins from the middle lamella in order to separate fibre bundles in fibrils. This fibrillation should lead to an increase the surface area available for chemical bonding between the fibres and the matrix and to appear a more homogeneous surface made of cellulose, which will probably enhance the adhesion between the fibres and the matrix [7].

In this paper, chemical treatment of the surface hemp shives in different environments (NaOH, $Ca(OH)_2$, EDTA-ethylene-diamine-tetra acetic acid at laboratory temperature was performed in order to separate fibre bundles in fibrils and change chemical behaviour or surface state of fibres for their application into lightweight composites. ATR-FTIR and TG were used for identification of changes in the chemical and physico-chemical properties of treated hemp shives in comparison to untreated shives.

2. Materials and Methods

Hemp shives used in experiments represent the woody parts of stems of plant - Cannabis Sativa that is free from plant fibers. The final fibre length of used technical hemp shives coming from the Netherlands company Hempflax ranged between 4 mm and 0,063 mm. The chemicals which were applied to treatment of fibres, NaOH, Ethylene-diamine-tetracetic acid (EDTA) were all of analytical grade, calcium hydroxide was 96%, pulverized. The characteristics of chemicals are given in Table 1.

Chemical modification of hemp shives was performed follow to literature [6]:

Treatment – alkalization: The natural dried hemp shives (vol. humidite up to 10%) were soaked in 1.6 M NaOH solution during 48 h and then neutralized in a 1vol. % acetic acid. Fibres were then washed with deionised water until the pH value was 7.

Treatment by $Ca(OH)_2$: In order to saturate fibres with calcium ions, fibres were placed in a saturated lime solution ($[Ca^{2+}] = 2.10^{-2}$ M) for 48 h. After treatment hemp shives were rinsed with deionised water (conductivity 0,02mS) and dried in oven during 48 h at 50°C.