SUMMARY OF DOCTORAL DISSERTATION

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Research on fibrous composites reinforced with a cellulose coating regenerated from a solution of N-methylmorpholine N-oxide (NMMO)

Current trends in the development of material technologies allow to distinguish the following research directions: designing materials with new functional properties, replacing existing materials with environment friendly (biodegradable) ones and developing methods for reusing waste materials (recycling). Composite materials based on various fibres are now often used in various fields of human activity. Woven fabrics, knitted fabrics and fibrous molded materials (e.g. nonwovens, paper) are the examples of such materials. They may be produced of natural and synthetic polymer man-made fibres or natural fibres, which allows to obtain a large variety of final properties, and consequently they find a wide range of applications. Among the many types of fibres, cellulose fibres (natural and man-made) play a special role. Cellulose is a substance that occurs naturally in the nature as the basic material of plant tissue. It is a biodegradable and renewable substance. As a result, materials made of it are environment friendly. An additional advantage of cellulose is the fact that it can be dissolved and - by admix with specific substances - cellulose materials with new functional properties can be designed. This opens the way to the production of completely new fibrous materials.

Another global problem related to material engineering and technology is the growing amount of waste generated from materials with very long degradation time (counted in thousands and hundreds of thousands of years). Used textiles based of natural and synthetic polymer man-made are the examples of such waste. The above facts resulted in undertaking research on the possibilities of using textile waste in biodegradable materials based on plant fibres. The purpose of this research was to determine the possibility of producing flat fibrous composites based on the mixture of natural cellulose fibres used in papermaking and fibres used in the textile industry (natural, natural and synthetic polymer man-made) reinforced with a layer of cellulose regenerated from N-methylmorpholine-N-oxide (NMMO) and to investigate the properties of such materials. No information has been found in the scientific literature on the use of regenerated cellulose solutions from N-methylmorpholine-N-oxide (NMMO) solution to reinforce composites based on natural cellulose fibres (e.g. paper). It was therefore decided to test the hypothesis assuming the possibility of increasing the strength properties of fibre composites coated with regenerated cellulose.

The theoretical part of the work presents a review of literature covering the subject of biopolymers and biocomposites. Particular attention was focused on the structure and the properties of cellulose fibres and cellulose itself, as well as on methods of its dissolution. The structure and properties of materials based on plant cellulose fibres and current trends in the production of paper materials and

composites based on these fibres are also described. Experimental part contains a range of experimental methods:

- SEM imaging and optical microscopy to assess the microstructure of manufactured composites,
- study of the fibrous raw materials properties (average fibre length, degree of cellulose polymerisation, viscosity measurement),
- study of the structural and strength properties of the obtained composites,
- study of the contact angle to assess hydrophobic properties,
- study of manufactured composites printing properties.

Based on the obtained results, it was found that the following parameters influence the achievement of the strength and structural properties of the composites:

- cellulose concentration in the coating solution,
- solution temperature during application,
- temperature of the rinsing bath,
- NMMO washout time,
- heat treatment time of layer,
- number of layers,
- the layer thickness of the applied coating.

It was found that in the case of materials made only from plant cellulose fibres, the regenerated cellulose coating improved their strength properties and allowed to obtain limited hydrophobic properties. On this basis, the most beneficial coating application parameters were determined from the point of view of the mechanical properties of fibrous materials. The knowledge obtained in this way was used in the further part of the research involving the application of a regenerated cellulose coating on different types of substrates, including substrates made on the basis of mixtures of plant and waste fibres from the textile industry and Lyocell fibres. The fibres of industrial waste origin were cotton, polyester and coconut fibres. While the addition of these fibres alone did not have a positive effect on most of the structural and strength properties, the application of the coating resulted in the improvement in these properties in selected cases. It was also found that the addition of mechanically unmodified Lyocell fibres to the paper pulp caused a decrease in all mechanical properties of such a composite. The common beating of natural cellulose fibres and Lyocell fibres resulted in a smaller decrease in the mechanical properties of the composites produced, but the additional coating of regenerated cellulose from the NMMO solution significantly improved their strength properties.