Abstract

The development of biodegradable composite materials reinforced with plant fibers is an important research direction in materials science, stemming from the need to reduce the environmental impact of polymeric materials. Composites with increased hydrophobicity and biocidal properties are of particular importance, as they can be used in areas requiring improved moisture resistance and safety of use.

The thesis of the doctoral dissertation was as follows: „The use of natural plant-derived compounds such as tannic acid or geraniol will enable the effective modification of flax fibers and favorably influence their surface properties, contributing to the production of biocomposites with biocidal and hydrophobic properties against microorganisms, without significantly negatively affecting mechanical properties. The use of plant-derived compounds will favor the functional properties of packaging and disposable materials."

The scientific goal was to determine the effect of natural plant-derived compounds used as flax fiber modifiers on the thermal, mechanical, thermomechanical, biocidal, and hydrophobic properties of the resulting biocomposites.

Biocomposites were made from polylactide (PLA) as a biodegradable matrix and flax fibers modified with natural plant-derived compounds – tannic acid or geraniol at concentrations of 1%, 5%, 10%, and 20%. The studies included determining biocidal properties through microbiological testing and determining the degree of hydrophobicity of the biocomposites based on contact angle measurements. Analysis of mechanical, thermomechanical, and thermal properties was conducted, as well as characterization of surface properties using scanning electron microscopy (SEM).

These studies demonstrated that the use of natural plant-derived modifiers led to significant changes on the surface of the biocomposites. As a result, the materials were obtained with biocidal properties against *Staphylococcus aureus* and *Escherichia coli*, due to the presence of bioactive plant-derived modifiers. At the same time, it was found that the modified biocomposites exhibited an increased degree of hydrophobicity for samples containing fibers modified with a 20% solution of tannic acid and geraniol. These biocomposites also exhibited limited susceptibility to water absorption.

The author's original contribution is the development of biodegradable biocomposites containing flax fibers modified with natural plant-derived modifiers and a comprehensive

assessment of the impact of this modification on the biocidal and hydrophobic properties of the materials.

The developed biocomposites represent an alternative to non-biodegradable composites based on petrochemical-derived polymers produced on a mass scale. Due to the characteristic properties obtained by modifying fibers with plant-derived compounds, safe for human health, they can contribute to progress in the field of disposable materials, the waste of which currently poses a significant threat to the natural environment. The obtained results expand the current state of knowledge regarding the functionalization of biodegradable biocomposites and indicate the possibility of their application in areas requiring ecological materials with increased durability and biocidal properties. Thanks to the interdisciplinary nature of this work, the development of biocomposites with biocidal and hydrophobic properties makes a significant contribution to both materials engineering, microbiology, and environmental protection.

This doctoral dissertation was prepared based on a series of scientific articles published in journals indexed in the *Journal Citation Reports* (JCR).