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Resistance to algae of wood-polymer composite decking profiles

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Abstract: *Resistance to algae of wood-polymer composite decking profiles*. Introduction of natural fibers to a thermoplastic polymer matrix results into a composite with improved properties. In recent years, such composites have been identified as good alternative to wood in many applications like wall-cladding, terraces, gazebos, etc. Study was made to check resistance of terrace boards made up of different wood meal contents with polymers of PP, PE and PVC to algae. Parallel samples was tested: not subjected to aging, aging by leaching in water and aging by exposing to xenon lamps. Each of the seven types of WPC composite tested was susceptible to algae growth. Aging cycles have reduced the resistance of materials.

Key words: *wood-polymer composite, decking profiles, algae, resistance, aging tests*

INTRODUCTION

New materials with improved technical and service parameters are constantly being sought. In recent years in many applications such as terraces, gazebos, wall cladding, wood is replaced with wood-polymer composites (WPC) The term refers to products created by merging natural components with thermoplastic polymers; the polymer is the base matrix, and the plant material is the filler. Typical polymer matrices are made of: polypropylene, polyvinyl chloride and high-density polyethylene; in Poland polypropylene (PP) is the most commonly used. Fillers can be particles based on ligno-cellulose, mostly wooden in the form of plant flour, fibers or small chips. There are also composite materials with filler using flax, hemp, bamboo or sisal fiber. Typical WPCs contain between 30% and 70% of filler. Due to the high filler content, in order to ensure the right material properties, it is necessary to modify the wood particles and use certain additions which facilitate processing of the plastic: stabilisers, hardeners, colourants, which make up between 10% and 15% of the product's mass. Frequently, in order to improve resistance of products for outdoor applications (floor boards, wall cladding) to microorganisms, active substances are added to the composites; however, their formula and content is confidential. These substances inhibit growth of fungi, bacteria and algae which could develop both on the plant material or the polymer [1, 2, 4, 7, 8, 10, 14].

WPCs combine the advantages of man-made materials as polymers are and wood. Their main advantage is an appearance which resembles wood accompanied by higher resistance to environmental conditions and lower susceptibility to microbial degradation [5, 9, 11, 12, 13]. Natural contain cellulose and lignin, are substances that contribute to their hydrophilic properties, i.e. cause to draw moisture from their structure. By modifying the fibers, the ability to absorb water is reduced, causing better compatibility of the fibers with the matrix. The final product absorbs significantly less water. From the biological resistance point of view of this property is very important, as microorganisms grow up on moist substrates.

Biodegradation of polymers is a series of chemical and biological processes. It can involve decay of polymers caused by acidic and alkaline pollutants from the environment and enzymes excreted by microorganisms growing on the surface (bacteria, fungi and algae). As a result of degradation the polymer chains are shortened and their fragments can be eliminated, which leads to a reduction in the polymer molar mass. Biological degradation modifies the polymer molar chemical structure, and thus its physical and chemical properties and strength parameters [3].

The algae are one the biological factor on which composites are exposed outdoor. The impact of algae on four WPC products using different exotic wood fillers, e.g. eucalyptus and meranti and on medium-density fiberboard containing the same types of wood was tested [6]. In the test four taxa of algae were used: *Chlorella vulgaris, Ulothrix sp., Scenedesmus quadricauda and Oscillatoria sp.* The WPC products were found to have lower resistance than the MDF board. The algae grew on the samples without destroying them. Growth of algae was correlated with the pH of the material: the lower pH the more intensive growth was.

Considering the documented impact of biological factors: bacteria, fungi and algae, which affect the durability of WPC composites, testing resistance to these factors was included in the standards published in 2014 on boards and terrace products. Standards PN EN 15534-1 [15] and PN EN 15434-4 [16] include the necessity of testing products resistance to microorganisms. Test methods are covered in PN EN 15534-1 and the requirements can be found in PN EN 15434-4. The tests are based on standard ENV 12038 [17], which is used to fungi decomposing wood, and on EN 15458 [18], which covers resistance to algae, but the standards concerning terrace boards introduceseries of changes related to used microorganisms species, sample size, the methods of final assessment of weight or visual methods. In Poland, no tests evaluating the resistance of composite boards to algae had been performed, and the decision was made to perform such tests on selected products. This is a pilot study.

MATERIALS

The tests were performed on seven types of terrace boards from three different manufacturers:

1. composite boards made of wood flour (49%) and PP
2. composite boards made of wood flour (50%) and PP
3. composite boards made of wood flour (49%) and PE
4. composite boards made of wood flour (41%) and PP
5. composite boards made of wood flour (42%) and PP
6. composite boards made of coniferous tree wood flour (45%) and PVC
7. composite boards made of wood flour and PVC (49%)

Boards from the same manufacturers had similar filler content,they differed consisted in profile shapes, surface texture and colour. Data concerning wood flour content was obtained from the Manufacturers.

For the biological tests, square samples were cut from the face sides of the terrace boards; 5 samples were cut from each type of board, with dimensions of 40 mm x 40 mm.

TEST METHODS

Tests of material resistance to algae growth were performed in accordance with PN-EN 15458:2014:

- materials not subjected to aging (reference samples)
- materials subjected to aging by soaking in water for 14 days (5 water volume units per one sample); the water was exchanged 9 times. Methodology according to PN-EN 84:2000.
- materials subjected to aging cycles using xenon lamps for 300 h, in accordance with PN-EN ISO 4892-2:2013, method A (water spray 18/102, BST 65^{o}C, RH 65%, average chamber temperature CHT 38^{o}C, radiant intensity 60 W/m^{2}). Device used: Xenotest Beta, with xenon arc lamp as the light source and an external filter.

The samples were cut from the boards were sterilised with UV radiation applied for 24 hours in a laminar flow cabinet. Next, they were placed separately in Petri dishes on a sterile Bold's basal medium prepared according to section 7.1. and 7.2. of PN EN 15458. A suspension of algae was poured on the samples until they were fully submerged. The algae mix was prepared according to section 7.4 and 7.5 of PN EN 15458:2014, one species was chosen from each of two groups: blue and green algae.

The following algae were used in the mix:

- *Nostoc commune (cyanophyta)*
- *Klebsormidium flaccidum (chlorophyta).*

The samples in Petri dishes were put into growth chamber and incubated for 35 days at temperature of 23±2°C, they were exposed to light at 1000 ±200 lx in the following cycle: 16 hours of exposure followed by 8 hours in darkness.

After 35 days the samples were subjected to macroscopic evaluation according to the assessment scale in PN-EN 15534-1: 2014:

0 - No growth, an inhibiting zone around the sample,
1 – marginal growth of algae or surface covered in less than 10%
2 – surface covered in 10% to 30%,
3 – surface covered in 30% to 50%,
4 – surface covered in 50% to 100%.

Rating criterion:

0-1 - Resistant to algae infection
2 - Partly protected against algae infection
2-4 - Not protected against algae.

RESULTS AND CONCLUSIONS

Table 1 contains results of tests on algae growth on samples:
All boards used for the tests contained wood flour, the content of which varied between 41%–50%, and different polymers: PP, PVC and PE were used as a binding subtances.

The tests did not reveal any significant differences in resistance to algae between composite boards using the same polymer matrix (PP), products 1, 2 and 4, 5, but they differed in filler content. Similarly, no differences were found in algae growth on samples with a similar wood flour content – 49%, but different matrix: PP – sample 1 and PVC - sample 7

Between 30% and 50% of composite boards surface was covered in algae, they were not subjected to ageing tests, independent of the polymer type and wood flour content, was covered in algae. None of the tested composite boards demonstrated resistance to algae growth. Both aging methods slightly decreased the resistance to algae growth, and no significant differences were found between the leaching cycles and aging in Xenotest. The majority of aged boards were covered in algae to a degree higher than 50%, showing complete lack of resistance to algae activity.

Table 1. Average values of growth rating on the samples

Product	No ageing	Ageing by soaking in water for 14 days	Ageing by 300 h exposure to cycles of water spraying and UV radiation
1	2.5	3.3	2.8
2	3.5	4	3.8
3	3	3.8	4
4	3	3.3	3.3
5	3.3	4	3.3
6	3	3.3	3.7
7	2.7	4	4

It should be noted that manufacturers do not provide information regarding material additions, including biocides; it is confidential, which makes the selection of material for biological tests difficult. Tests concerning resistance to algae are not obligatory; the product standard states that they are voluntary. None of the Technical Rating for terrace board sets contains data on resistance to microorganisms. Considering the fact that resistance to algae is a property which affects not only the appearance of products but also their durability, the tests results may raise concerns. The thesis of complete lack of algae resistance of WPC boards on the Polish market (based on tests involving samples from three manufacturers) is unreliable. It is necessary to conduct tests on a wider group of products.

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Streszczenie: *Odporność na glony profili podłogowych z kompozytów drzewno-polimerowych.* Wprowadzenie włókien naturalnych do termoplastycznej polimerowej matrycy wiąże się z poprawą właściwości otrzymanego kompozytu. W ostatnich latach w wielu zastosowaniach, np. tarasy, altany, okładziny ścienne, drewno zastępowane jest kompozytami polimerowo-drzewnymi (kompozyty WP). Przedmiotem badań była odporność na glony kompozytowych desek tarasowych, o różnej zawartości mączki drzewnej i osnowie z polimerów PP, PE, PVC. Badano równolegle próbki niepoddawane cyklom starzenia, materiały poddawane cyklom starzenia przez moczenie w wodzie oraz materiały poddawane cyklom starzenia lampami ksenonowymi. Każdy z siedmiu rodzajów badanych kompozytów WPC wykazał podatność na wzrost glonów. Cykle starzenia obniżały odporność materiałów.

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