Annals of Warsaw University of Life Sciences – SGGW
Forestry and Wood Technology No 74, 2011: 134-138
(Ann. WULS-SGGW, Forestry and Wood Technology 74, 2011

Comparative analysis of the impact of starch and resin adhesive on the biodegradation process of selected paper products.

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Abstract: *Comparative analysis of the impact of starch and resin adhesive on the biodegradation process of selected paper products.* The article presents the results of susceptibility of samples made from cellulose sulphate bleached deciduous and coniferous pulp with different percentage content of starch and resin adhesive, subjected to the action of microfungi. Markings were made at the Institute of Chemical Wood Technology, University of Life Sciences in Poznań. Paper products have shown varying susceptibility to sprouting by microfungi, they have undergone very strong biodegradation. Addition of starch and resin adhesive caused a change in resistance of the samples to sprouting by the test fungi in comparison to the samples without mass additives. Self-breaking length of the examined paper products decreased over time, in which samples were subjected to the process of biodegradation.

Keywords: paper, microorganisms, biodegradation, mass additives, auxiliary chemical agents.

INTRODUCTION:

Manufacturing of paper with various mass additives makes it possible to evaluate how these substances affect the strength properties and resistance to biotic factors. Paper is a material of felt cellulose fibers with various additives of adhesives and refining materials. As a finished product, it undergoes the processes of deterioration, aging and destruction caused by external factors of biological, physical and chemical character.
The purpose of this study is to investigate how the additive of starch and resin adhesive affect the sprouting rate of samples made from cellulose sulphate deciduous and coniferous pulp by selected microfungi, by assessing the degree of sprouting of the examined paper products.

MATERIAL AND METHODS:

In the study the following were used: cellulose sulphate bleached deciduous and coniferous pulp, resin adhesive, cationized starch. One has also applied micro-organisms causing the greatest contamination of the material and frequently isolated, for example of library collections and storage of paper products; one used as well: Chaetomium globosum Kunze et Fr. (BAM 12, DSM 1962, ATCC6205) - strain collected from the Institute for Materials Research BAM in Berlin, and a mixture of fungi Aspergillus niger van Tieghem (ŁOCK 0437, 1973 IHAR, strain 201), Trichoderma viride Pers. ex. S.F. Gray aggr. (ŁOCK 0570, 1973 IHAR strain E159), Penicillium funiculosum Thom. (collected from the environment) - strains collected from the collection of the Institute of Fermentation and Microbiology, University of Technology in Łódz. Moreover, to the mycological research one used also: agar medium supplemented with Czapek-Dox salt. From the paper pulps, one produced 16 types of products in the laboratory conditions with a weight equal to 100±4g/m^2, without mass additives, with the addition of starch, resin adhesive and their mixture of 2%, 3%, 5% ratio to the dry pulp. Forming of paper sheets from the cellulose sulphate bleached deciduous and coniferous pulp was conducted with agreement to the Polish standard PN-EN ISO 5269-2: 2007. In each of the 32 series, samples with dimensions of 15 x 85 mm were cut, and then they were subjected to a sterilization process (sterilization conditions - time: 20 min., temp.:~121°C, ciśn.: 95 kPa) in order to eliminate the possibility of infection.

Mycological test – vessels with the infected paper samples were placed in a thermostat maintaining constant temperature of 25°C (±1) and air humidity of 85% (±5). The study for both series lasted 14 days, where regularly after the 2, 4, 7, 10 and 14 day - reading of sprouting level took place, according to the four point scale.

Table 1. Scale of assessment of paper sensitivity to infestation with the examined microfungi.

INDEX	DEGREE OF SAMPLE COLONISATION
3	No sign of mycelium growth on sample
2	Less than 1/3 of the sample surface colonised by the test fungus mycelium
1	Surface of sample between 1/3 colonised but 2/3 test fungus mycelium
0	Surface of sample by test fungus mycelium entirely colonized

RESEARCH RESULTS:
The graphs show the degree of sprouting of the representative samples according to the visual assessment.

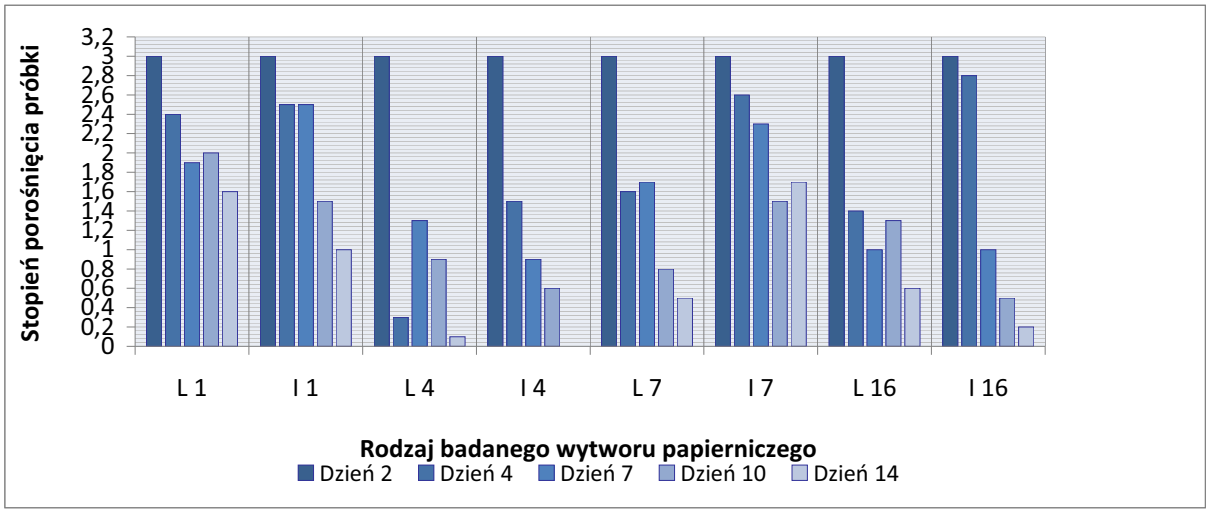

Figure 1. Degree of sprouting of selected samples by the fungus: Ch. globosum within 14 days.

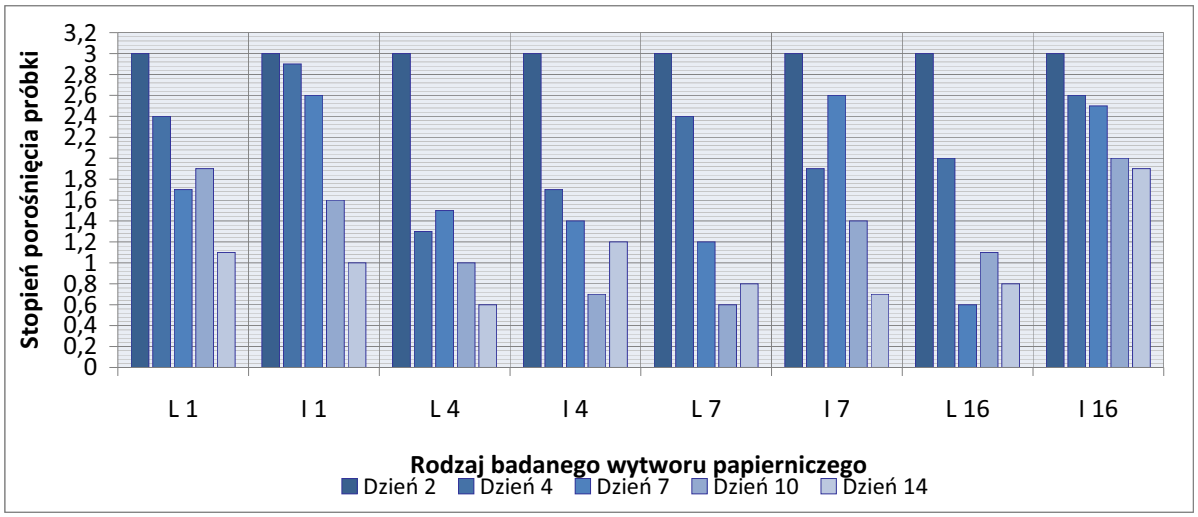

Fig. 2. Degree of sprouting of selected samples by the mixture of fungi: A. niger, P. funiculosum and T. within the period of 14 days.

Table 2. Results of determination of overgrowth degree of analyzed paper products by test fungi - *Ch. globusom* - Ch. and mixture (*A. niger, T. viride, P. funiculosum* - M.)

Softwood pulp											Types of the exammined paper			Hardwood pulp									
Day 14		Day 10		Day 7		Day 4		Day 2		pH	Acronym	Contents of addition in waste paper	Acronym	pH	Day 2		Day 4		Day 7		Day 10		Day 14	
M.	Ch.	M.	Ch.	M	Ch.	M.	Ch.	M.	Ch.						Ch.	M.	Ch.	M.	Ch.	M.	Ch.	M.	Ch.	M.
1,0	1,0	1,6	1,5	2,6	2,5	2,9	2,5	3	3	6,69	**I 1**	-	**L 1**	7,03	3	3	2,4	2,4	1,9	1,7	2	1,9	1,6	1,1
1,9	1,3	2,2	2,1	2,7	2,8	2,7	2,8	3	3	6,68	**I 2**	**Starch 2%**	**L 2**	6,54	3	3	1,7	2,2	1,6	1,7	0,7	1	0,2	0,6
0,8	0,2	1,7	0,7	2,1	1,4	2,4	1,2	3	3	6,80	**I 3**	**Starch 3%**	**L 3**	6,15	3	3	1,5	2	0,9	2,5	0,5	1,1	0	0,9
1,2	0	0,7	0,6	1,4	0,9	1,7	1,5	3	3	6,89	**I 4**	**Starch 5%**	**L 4**	6,39	3	3	0,3	1,3	1,3	1,5	0,9	1	0,1	0,6
1,2	0,2	1,3	0,5	2,0	2,2	2,4	2,3	3	3	5,92	**I 5**	**Resin glue 2%**	**L 5**	5,61	3	3	1,9	2,2	1,7	1,9	2,3	1,2	0,2	0,6
0,7	2,2	1,2	1,5	2,4	2,0	2,3	2,6	3	3	6,40	**I 6**	**Resin glue 3%**	**L 6**	6,66	3	3	2	1,8	1,6	1,7	2,7	1,3	0,3	0,6
0,7	1,7	1,4	1,5	2,6	2,3	1,9	2,6	3	3	6,42	**I 7**	**Resin glue 5%**	**L 7**	6,46	3	3	1,6	2,4	1,7	1,2	0,8	0,6	0,5	0,8
1,0	1,4	1,6	1,5	2,2	0,8	2,8	2,8	3	3	6,46	**I 8**	**Starch 2%+ Resin glue 2%**	**L 8**	6,21	3	3	1,4	1,8	1,9	1,4	0,5	1,5	0,3	0,4
0,9	1,3	2,2	2,2	2,2	1,4	2,2	2,6	3	3	7,01	**I 9**	**Starch 2%+ Resin glue 3%**	**L 9**	6,56	3	3	1,5	1,6	1,7	1,8	1,5	1,4	1	0,6
1,2	1,4	0,9	2,2	2,2	2,5	2,7	2,8	3	3	7,02	**I 10**	**Starch 2%+ Resin glue 5%**	**L 10**	6,76	3	3	1,6	1,9	1,8	1,9	0,9	0,5	1,2	0,9
1,0	0,4	1,6	1,1	2,0	1,2	2,5	1,8	3	3	7,03	**I 11**	**Starch 3%+ Resin glue 2%**	**L 11**	6,83	3	3	1,4	1,9	2	1,7	1,4	1,8	0,9	0,8
1,0	0,2	0,7	1,1	1,1	0,4	1,8	1,5	3	3	6,83	**I 12**	**Starch 3%+ Resin glue 3%**	**L 12**	6,81	3	3	1,4	1,7	1,9	1,6	1,5	1	0,9	0,5
0,3	1,0	1,0	1,6	2,2	2,0	1,6	1,8	3	3	6,65	**I 13**	**Starch 3%+ Resin glue 5%**	**L 13**	6,54	3	3	1,6	1,5	1,9	1,1	2,1	0,8	0,4	0,9
0,95	1,1	1,2	2,0	1,3	1,7	0,7	2,0	3	3	6,79	**I 14**	**Starch 5%+ Resin glue 2%**	**L 14**	6,93	3	3	1,8	1,9	1,1	1,5	1,7	1,8	0,2	1,1
1,5	0,6	1,9	0,5	2,4	1,4	2,7	2,6	3	3	6,89	**I 15**	**Starch 5%+ Resin glue 3%**	**L 15**	7,04	3	3	1,8	1,3	1,8	0,9	0,5	0,8	0,3	0,9
1,9	0,2	2,0	0,5	2,5	1,0	2,6	2,8	3	3	6,76	**I 16**	**Starch 5%+ Resin glue 5%**	**L 16**	6,95	3	3	1,4	2	1	0,6	1,3	1,1	0,6	0,8

SUMMARY

Summing up, analyzing all the obtained results of research we find that regardless of the content and type of mass additives, both papers made from cellulose sulphate bleached deciduous and coniferous pulp undergo strong biodegradation of selected microfungi. The intensity of the impact of the fungus Ch. globusom is much higher compared to the mixture of fungi, and the process is gradual. For paper made from deciduous pulp, both additive of starch and resin adhesive, caused an increased susceptibility to sprouting by the test fungi. Whereas, papers made from coniferous pulp have shown to be very similar to one another in the case of their resistance. The reason is the difference in construction and length of cellulose fibers. In a further stage of the research, results of mycological tests will be confronted with self-breaking marking of biodegraded paper products. Depending on the use of paper products, their users depend on their longevity and resistance to biotic factors, or conversely - acting in accordance with the prevailing ecological view, after using the materials - to introduce them back into the ecosystem for the future reuse. Therefore, it is important to get to know the process of biodegradation of paper products and the effect of basic mass additives.

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Streszczenie: *Analiza porównawcza wpływu skrobii i kleju żywicznego na proces biodegradacji wybranych wytworów papierniczych.* W artykule przedstawiono wyniki badań dotyczące podatności próbek wykonanych z masy celulozowej siarczanowej bielonej liściastej i iglastej z różną procentową zawartością skrobi oraz kleju żywicznego, poddanych działaniu mikrogrzybów. Oznaczenia wykonano w Instytucie Chemicznej Technologii Drewna Uniwersytetu Przyrodniczego w Poznaniu. Wytwory papiernicze wykazały się zróżnicowaną podatnością na porastanie na mikrogrzyby, uległy one bardzo silnej biodegradacji. Dodatek skrobi oraz kleju żywicznego spowodował zmianę odporności próbek na porastanie przez grzybnie testowe w porównaniu do próbek wykonanych bez dodatków masowych. Samozerwalność badanych wytworów papieiczych zmniejszała się w miarę upływu czasu, w jakim probki poddawane były procesowi biodegradacji.

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