SILVER INHIBITION EFFECT OF NANOPARTICLES ON SPECIFIC MOLD GROUP GROWTH

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Abstract

The article is focused on comparison of inhibition effect of two types of silver nanoparticles and silver ions on mold growth on surfaces of building materials. Nanoparticles of silver are product of different producers prepared by different way (e. g. chemical to mechanical). We used typical mold mixture of commonly occurring fungal species in middle Europe especially in the middle of Czech Republic including *Trichoderma, Penicillium, Alternaria, Paecilomyces*. They were isolated from samples taken in the air exposition. But the mold used in experiment were received from a Czech Collection of Microorganisms (CCM). It is not proved that type of biodeteriogens in the air correlates with isolated species on buildings facades. Tested building materials were gypsum and wooden based. Presented results show that protection against mold by silver nanoparticles and ions is not universally applicable protection for all tested materials.

Keywords: **mold, silver, nanoparticles, gypsum, wood**

1. INTRODUCTION

The mold are widely spread all over the world in many parts in human life. Presented study is focused on building board material commonly used for construction e. g. crawl space.

A crawl space is one type of foundations of building providing access to the wiring and piping distribution systems. In other words, a narrow space between the ground and the outer side of the floor structure, which is formed the establishment on foot, drilled micropiles or on footings without plate. Crawl space is thermally insulated and the height should be at least such that there was possible movement of people “crawling with” which makes the minimal width of hollow 600 mm. After installing the pipe of 450 mm. This space is used, as already mentioned above, such place for distribution of technical networks in the home that are then permanently accessible. In our conditions crawl space is used mainly in cases where pride in building complex subsoil compared to e. g. the Anglo-American and Nordic countries, where the foundation using the crawl space considered as a common solution. The reasons to choose that type of foundations are follows:

- Material savings and a smaller range of excavation work
- Crawl space can lead pipe, which then remains permanently accessible. It makes them easier to maintain. Moreover, in case of an accident of these networks damages are smaller
- Insulation from the ground is interrupted bridges rising water from the soil and thermal bridges the foundation structure towards the object. It also eliminates the problem of solving radon levels.

The main problem with that construction is in missing tradition in the middle of Europe. There is also a technical problem in Crawl space – moisture, which presents better condition for mold growth – including a cavity size and air circulation [1,2,3,4].

Metals are commonly used as antimicrobial agents either in cases of rehabilitation or prevention. Silver has been used since the middle Ages as having a broad spectrum of activity against microorganisms, and also because it is not known to induce resistance [5, 6]. Silver is used as ionic compounds such as silver nitrate $AgNO_3$ or as nanoparticles NAg zero valence. Silver nanoparticles are studied predominantly in the form of nanocomposites, which are formed by dispersing the nanoparticles in the polymer matrix as the polymer

matrix is often used based substances nylon [7], polyester [8], polymethyl methacrylate [9], polyvinyl alcohol, etc. [10]. More published studies biocidal effects of silver is directed to the effect against bacteria than against microscopic or wood-decaying fungi [11, 12].

2. MATERIALS

There were used three types of substances as a possible protection against mold growth. All of them were silver based. First of them was a dispersion silver nanoparticles (sigma Aldrich USA, size 10 nm, SNAg). The second one was also silver nanoparticles prepared by another way according to US Patent (size 10 nm, UNAg). The third silver protection was consisted of silver nitrate (P-lab, Czech Republic, $AgNO_3$). These substances were blended with sterile distilled water to the final concentration 10 ppm. That solutions were using as a coating on building materials.

Building materials used during experiment were commonly used material for construction of crawl space. All of them were board materials, one group was plaster based and the second group of used materials was wooden based (Figure 1). There is a Table 1 with the complete list of used materials.

For the experiment there was used commercial Czapek-Dox agar (Fluka, Sigma-Aldrich, Switzerland) as a medium suitable for mold cultivation.

As a model organisms was used a typical mold mixture of commonly occurring fungal species in middle Europe especially in the middle of Czech Republic including *Trichoderma, Penicillium, Alternaria, Paecilomyces* received from before study (unpublished data). They were isolated from samples taken in the air exposition. But the molds used in experiment were received from a Czech Collection of Microorganisms (CCM).

Table 1 Used building board materials and pH of used building board materials

Sample	Material	Width (mm)	pH
1	solid spruce wood	20.0	5.5
2	plasterboard	12.5	7
3	impregnated plasterboard	12.5	7
4	construction plasterboard	12.5	7
5	oriented strand board	18.0	5
6	oriented strand board	16.0	4.5
7	vignetted	22.0	5
8	vignetted	15.0	4.5
9	gypsum fiberboard	10.0	9
10	gypsum fiberboard	15.0	7.5
11	particleboard	16.0	4.5
12	solid spruce wood	10.0	5.5
13	cement-bonded particleboard	18.0	10

Fig. 1 Used building board materials before treatment application

3. METHODS

The first part of experiment consisted of weight and pH measurement of individual samples. Each material was represented by six samples and commercial liquid kit (MERCK, Germany) to get pH.

In next part there were used glass Petri dishes with diameter 18.5 mm, one for each material. A solution of Czapek-Dox agar (Fluka Analytical, Sigma Aldrich, Switzerland) in volume 100 ml was poured into a sterile dish and let to harden. 1 ml of inoculum mixture of was applied to the agar surface and was evenly triturated. The thus prepared plates were placed in an incubator at 25 ± 3 °C for 24 hours to activate mold growth.

The sterilization of samples was done as UV exposure, each side for 30 minutes, to eliminate mold on surface before experiment. Treatment solution was applied as a coating by synthetic brush. The first pair of samples was treated by a coating of solution silver nanoparticles (SNAg), next one also by solution with silver nanoparticles (UNAg) and the last pair was treated by silver nitrate solution ($AgNO_3$). There were placed a group of samples of one material in one dish. In the center was placed sample without any treatment as a control. Around the circumference there were placed next six samples of the same material they were given so that each pair of samples are treated the same way.

Prepared dishes with all samples were placed in an incubator at 25 ± 3 °C for three weeks. The growth on sides and top was monitored and the photo documentation was taken.

4. RESULTS

The main part of experiment consisted of mold growth observing on the surface of samples (Figure 2). For the quantification and comparison there was used a scale. The scale consists of following 5 grades:

- 1 – surface of sample without any visible mold growth
- 2 – weak mold growth on sides of sample
- 3 – strong mold growth on sides of sample
- 4 – weak mold growth on top surface of sample
- 5 – strong mold growth on top surface of sample

The mold growth is evaluated by presented scale in Table 2.

There was measured pH of tested materials, obtained values are summarized in Table 1. As expected gypsum based materials exhibited higher pH.

The results of observing mold growth correspond also with the pH value of material. Weaker mold growth was observed on materials with higher pH. The weakness mold growth was registered on samples treated by $AgNO_3$ and UNAg. The strongest mold growth was shown on samples without any treatment. So it could be said each of used treatment solution has at least partially antifungal effect. Then there was observed the change of weight of materials during experiment. The materials were not dried before treatment, but all of specimens increased their weight in in relation to the rising moisture. The moisture increased thanks to coating by solution and moisture absorption of agar. Weight gains, which are related to material absorptivity are shown in figure 3.

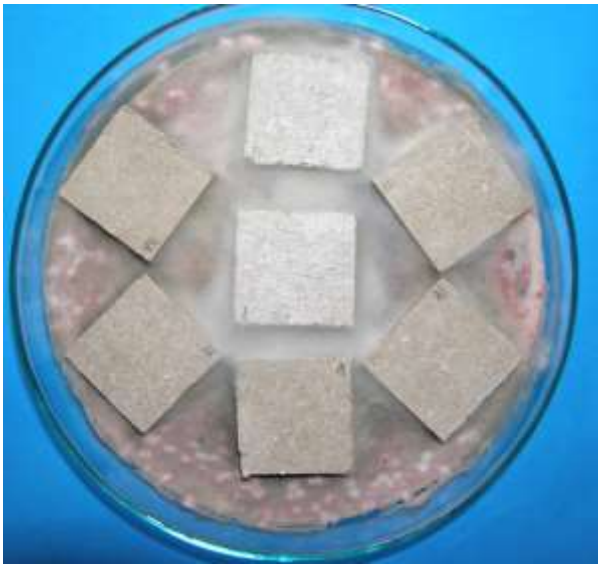

Fig. 2 Samples of gypsum fiberboard at the end of experiment; in the center was placed sample without any treatment as a control, around the circumference samples treated by a coating of solution silver nanoparticles (SNAg – II, III, UNAg – IV, V) and silver nitrate solution (AgNO3 – VI, VII)

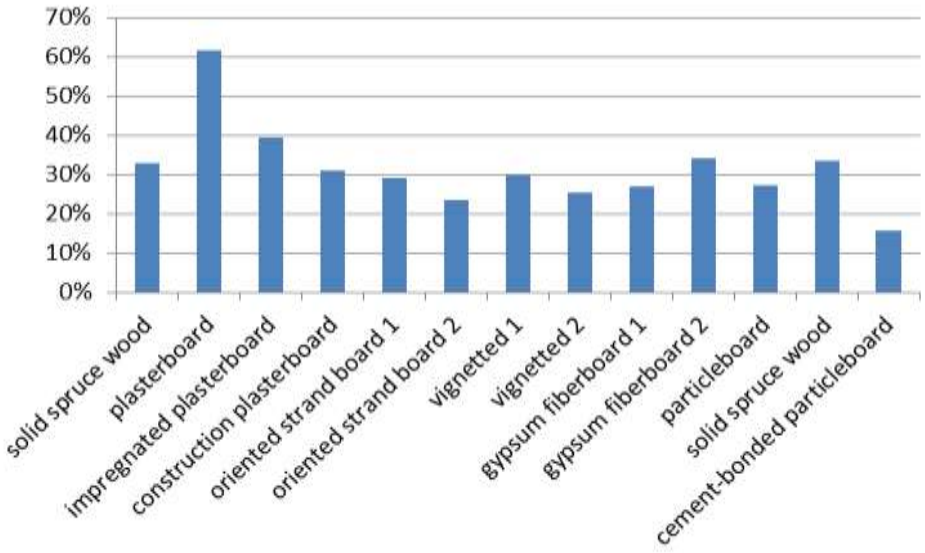

Fig. 3 Sample weight gains expressed as a percentage of the initial weight

Table 2 pH used materials and mold growth on surface of used materials; 1 – surface of sample without any visible mold growth, 2 – weak mold growth on sides of sample, 3 – strong mold growth on sides of sample, 4 – weak mold growth on top surface of sample, 5 – strong mold growth on top surface of sample

Sample	Material	Without any treatment	SNAg	UNAg	$AgNO_3$
1	solid spruce wood	2	2	4	4
2	plasterboard	4	4	4	4
3	impregnated plasterboard	3	4	3	4
4	construction plasterboard	4	4	4	4
5	oriented strand board	4	5	4	5
6	oriented strand board	3	4	3	4
7	vignetted	2	5	4	4
8	vignetted	2	4	4	3
9	gypsum fiberboard	4	4	3	3
10	gypsum fiberboard	4	5	4	3
11	particleboard	4	4	4	4
12	solid spruce wood	4	4	4	4
13	cement-bonded particleboard	2	2	2	2

5. CONCLUSION

Presented study is focused on inhibition effect of two types of silver nanoparticles and silver ions on mold growth on surfaces of building materials. Tested treated materials were exposed to ideal condition for mold growth. There was used typical mold mixture of commonly occurring fungal including *Trichoderma, Penicillium, Alternaria, Paecilomyces*. Tested building materials were gypsum and wooden based. There were also measured weight and pH of tested materials. Presented results show that protection against mold by silver nanoparticles and ions is not universally applicable protection for all tested materials. And it is necessary to carry out next experiment to find ideal concentration for different material and found better application then painting.

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