# PREPARATION OF ANTIMICROBIAL TREATMENT INTERIORS USING NANO TEXTILES

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## Summary

The nanofiber textile is useable as a scaffold for injecting antimicrobial agent on the internal surface. The advantage of using of nanofiber textile is low cost, nontoxic for human health, low concentration of antimicrobial agent, effectiveness and possibility of changing supplement. Nanofiber textile based on PVA with the addition of metals ions as nanoparticles (NPs) or as ions or other substances may be used on the interiors surface for antimicrobial or antifungi protection. The basic agents are metal (silver or copper) or non--metal nanoparticle as a nanodiamond.

**Keywords:** nanofiber, nanofiber textile, surface protection, porous building material

## 1 Introduction

Microbial contamination of water, air and soil is caused different kinds of results for problem in living conditions, and the public health and industrial fields [1]. Surface of building construction are continually exposed to biological and chemical agents from environment, as a pollutant, fungi, bacteria, algae and so on. This conditions can have played role in the deterioration of building construction and another way it can cause health problem for human [2]. Microorganism occurring on building surfaces is commonly autotrophic and heterotrophic bacteria, fungi, algae and lichens. Recent studies are focused on developing new materials with novel properties and specific antifungal or antibacterial activities [3].

The metal solution is common used for antimicrobial protection, same studies is showed that NPs of metal have similar properties as a same particles with larger size. The unique properties of NPs are gone from their high surface to volume ratio and increased percentage of atoms at the grain boundaries [1]. In literature is written about antimicrobial activities of copper, titan, silver, zinc and some other NPs, many studies showed that this

NPs can be have used as antibacterial protection in biomedical, biological, physical and industry application [4]. There are only some studies about antifungal properties of NPs of metal.

The elemental silver or silver ions are well known as antimicrobial agents in curative and preventive health care for many centuries. This metal is caused of destroy DNA or enzymes, that it have strong toxicity to broad range of microorganism but simultaneous a remarkable low human toxicity [3].

The copper compounds and NPs have enhanced antimicrobial activities toward a broad spectrum of microorganism, including pathogenic bacteria. Several copper based nanostructure have been investigated for their potential bactericidal photocatalyst and for self-sterilizing biosensor application. Ghasemian et al. [1] is reported the antibacterial effect of copper and silver NPs for strain of *Escherichia coli* and *Bacillus subtilis*. The standard chemical antifungal agents based on azoles, ammonium salts are caused increasing drug resistant and these increasing side effect related to this drug has made the researches focus on application of other materials such as NPs or polymer doped NPs [2].

The polymer nanocomposites are advantageous materials composed of NPs dispersed inside the polymer matrix or/and coated by polymer, thus forming core shell structure. The novel materials are combined properties of both partner polymer matrix and NPs. The polymers are good choice for their specific morphology, chemical and structural nature with along polymeric chain allowing incorporation and fine dispersion of NPs. The next properties are decreasing of creation large aggregates, because the aggregates reduce of antimicrobial effect. The sufficiently high loading and free surface of NPs allowing an antimicrobial action are other important factors affecting the real applicability of polymeric nanocomposites [5].

## 2 Materials and methods

We prepared three type of polymer solution for electrospinning, the first is standard stock consist of: 375 g 16% PVA (Sloviol, Ficheba, CZ), 3 g 75% phosphoric acid, 4.4 g glyoxal (Sigma Aldrich, Germany) and water to 500 g. The next ones are prepared from standard stock PVA with addition of $CuSO_4 \bullet 2H_2O$ (named PVA-Cu) and $AgNO_3$ (named PVA-Ag), the final concentration of additional is 1 % (V/wt).

The nanofiber textiles are made by electrospinning on polypropylene spun bond by Nanospider LAB 500 (Elmarco, CZ), the machine set up is: rotating electrode width 600 mm, electrode distance 140 mm, 35 % relative humidity, 28 °C air temperature. The sample had circles shape with diameter 23 mm for antibacterial assays and to rectangle shape with dimension 35 × 45 mm for antifungal assays.

We used *Escherichia coli* (gram negative) and *Bacillus subtilis* (gram positive) as a model organism. The bacterial culture we prepared by overnight incubation of single colony in 5 ml liquid media (MPA, P-lab, CZ) at 37 °C with horizontal shaking. The inoculum was diluted by fresh media to approximately concentration $10^4$ CFU/ml. The antibacterial assay is made on agar plate, the 100 µl of inoculum was placed on agar plate and spread even on the surface, to centre was placed the samples. The PVA sample was used as a neutral control and alone bacterial culture was used as a positive control. The incubation was at 37 °C, the test was made in three repeated.

We used *Alternaria altrenaria*, *Aspergilus flavor*, *Fusarium solani*, *Penicillium chrysogenium* as a model organism for antifungal assay. We prepared mixture of these funguses in physiologic solution. The mixture of fungus we dropped in centre of Czapek Dox agar plate in volume 30 µl and it was covered by samples. The test was made in three repeated by one set up. The PVA samples were used as a neutral control and alone bacterial culture was used as a positive control. The incubation was at 28 °C and the assay was valuated during next five days. Another type of test was due overgrown agar plate. The rectangular sample was put on the centre of plate. The test was made in three repeated by one set up. The incubation was at 28 °C and the tested plate was controlled daily during five days.

## 3 Results and discussion

We prepared nanofiber textiles based PVA, PVA-Cu and PVA-Ag, the base had width 500 mm, the specific weigh per area is approximant 10 g/m$^2$. The samples for assay had circle or rectangular shape and it is used with a spun bond. The antibacterial assay showed hallo effect with 1 mm distance from the sample PVA-Ag. There is no evidence of difference between model organisms. PVA-Cu sample showed hallo effect with 0.5 mm distance. There is no evidence of difference between model organisms. PVA samples showed no evidence of hallo effect.

The antifungal assay, when it was used 30 µl inoculum showed difference between samples. The effect was better visible during the time. The drop of inoculum without samples showed normal growth of fungi. The inoculum covered PVA-Ag samples did not show growth of fungi, the growth was put down more than five days. The growth was not seen by microscope. The inoculum covered PVA-Cu samples reduce of fungi growth during first day, after it started growth around the sample. The growth was evidenced by eyes. The PVA sample showed some increasing of fungal growth during second day. The first day PVA nanofiber textiles showed barrier properties of samples. The results showed at **Fig. 1**. The antifungal assay with inoculation of whole agar plate showed no evident of antifungal activity of nanofiber textiles based PVA doped metal. The results showed at **Fig. 2**.

This study confirm that nanofiber textiles based PVA doped metal solution have antifungal and antibacterial activities dependence on concentration of microbial agents [5]. Our results showed that if the nanofiber textiles have protective properties against microbial deterioration agents. The same result showed our unpublished date from bastion of Vyšehrad in Prague.

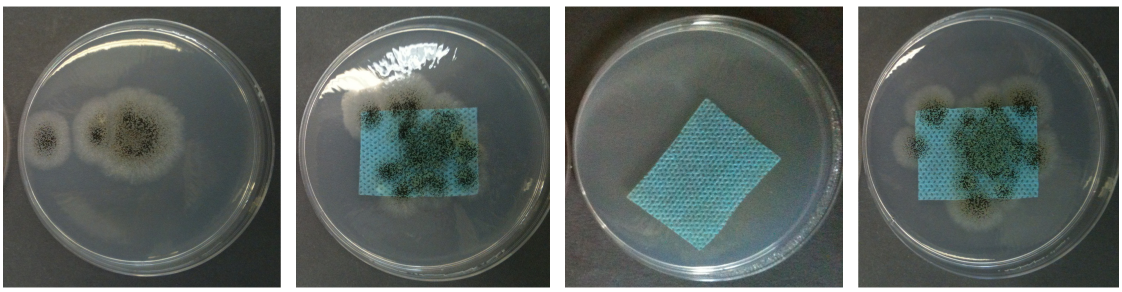

***Fig. 1*** *The results of experiments with 30 µl inoculation as a drop at the center of agar plate after two days inoculation. The samples are Control, PVA, PVA-Ag and PVA-Cu from left to right.*

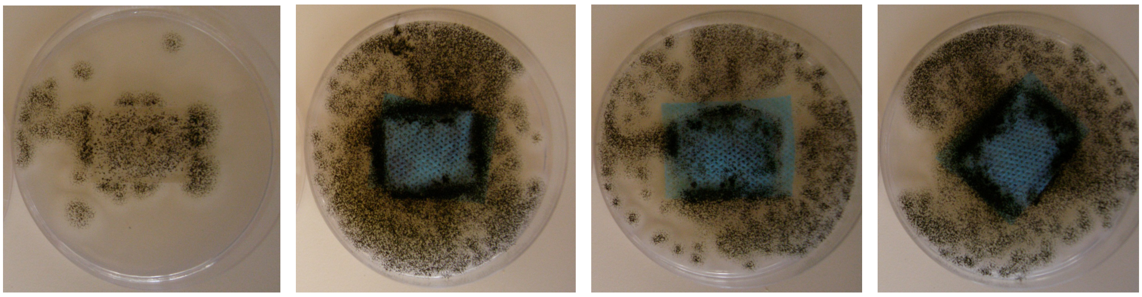

***Fig. 2*** *The results of experiments with inoculation of whole agar plate after two days inoculation. The samples are Control, PVA, PVA-Ag and PVA-Cu from left to right down.*

## 4 Conclusions

The presented study shows that the nanofiber textiles prepared based on PVA doped by metal is potential protective layer for building construction. The antimicrobial activities have both metal and the protective is only clear surface of nanofiber textiles. The antifungal activities are dependence of concentration of fungi inoculum.

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