CULTURAL HERITAGE CONSERVATION SCIENCE AND SUSTAINABLE DEVELOPMENT

EXPERIENCE RESEARCH INNOVATION

LES SCIENCES DE LA CONSERVATION DU PATRIMOINE ET LE DÉVELOPPEMENT DURABLE

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Disinfection of Textiles and Paper by Nanosilver Dispersions

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Abstract

This contribution presents the changes of physical-mechanical properties of textiles (cotton, silk and wool) and paper (cellulose paper Whatman) after disinfection by nanosilver dispersions. Silver has a toxic effect on some bacteria, viruses, algae and fungi. Three types of nanodispersions were tested. One of them was prepared by an electrolytic method, the second one was prepared by reduction of silver nitrate solution by sodium borohydride and the last one by reduction of silver nitrate solution by maltose.
Silver becomes tarnished by black coatings when exposed to the atmosphere, therefore the influence of hydrogen sulfide on the colour of disinfected samples was monitored. The samples were hung up in an airtight testing box above sodium sulfide solution for several days (until control silver strip turned black). The colour of samples was measured using a spectrophotometer.
The physical-mechanical properties of textiles and paper were tested before and after artificial aging for disinfected and non-disinfected samples. The properties of textiles and paper were determined by means of FTIR spectroscopy, viscosimetry and colorimetry.

Experiment

Three types of silver dispersions were tested on silk, cotton (unbleached), wool and paper (Whatman 1). One of the dispersions was prepared by an electrolytic method (sample K1), the second one was prepared by reduction of silver nitrate solution by sodium borohydride (sample B5) and the last one by reduction of silver nitrate solution by maltose (sample M5). Particle size distribution was measured by means of light scattering. The samples B5 and M5 are monodisperse (see Fig. 1), but sample K1 has majority of particles with diameter 180 – 240 nm and small amount of them with diameter 60 nm. Efficiency of dispersions was tested on selected algae species.
All tested dispersions were diluted to concentration 1 ppm. Textile and paper samples were immersed into the dispersions for 5 min and one set of samples was let to dry and second set was washed ten times in distilled water. Three types of artificial aging were carried out. Heat aging, heat-humid aging and light aging.
The physical-mechanical properties of textiles and paper were tested before and after artificial aging for disinfected and non-disinfected samples.
The influence of hydrogen sulfide on the colour of disinfected samples was monitored. The samples were hung up in an airtight testing box above sodium sulfide solution for several days (until control silver strip turned black). The colour of samples was measured using a spectrophotometer Datacolor Mercury 2000. There is a correlation between particle size of silver and its influence on colour of the samples. The smaller particles are, the smaller influence is (see Fig. 2). Tarnishing of silver might be a problem (see Fig. 3), especially in case of particles with larger diameter and higher concentration of silver.
For viscosity measurements a capillary viscometer was used. There is a substantial influence of aging on intrinsic viscosity, but there is no significant acceleration of aging after disinfection by silver dispersions (see Fig. 4, 5).
FTIR microspectrometer Nicolet iN10 with cooled MCT-A detector was used (128 scans, resolution 4 cm). Remarkable changes are noticeable after UV aging (see Fig. 6). There is no significant acceleration of aging after disinfection by silver dispersions.

Conclusions

According to viscosity, FTIR and tensile strength measurements, there are no significant changes in properties of tested materials after treatment by nanosilver dispersions. Tarnishing of silver might be a problem, especially in case of clear bright surface and also concentration and particle size of silver and air pollution can play the significant role. It is necessary to continue in testing of silver dispersions efficiency on textile and paper surfaces.

Aging conditions:
heat aging: 90 °C and 0 % RH, 21 days, darkness
heat-humid aging: 90 °C and 80 % RH, 21 days, darkness
light aging: 70 °C and UV 1W.m^{-2}, 5 days
Degradation evaluation: viscosimetry, tensile strength, colorimetry, FTIR spectroscopy.

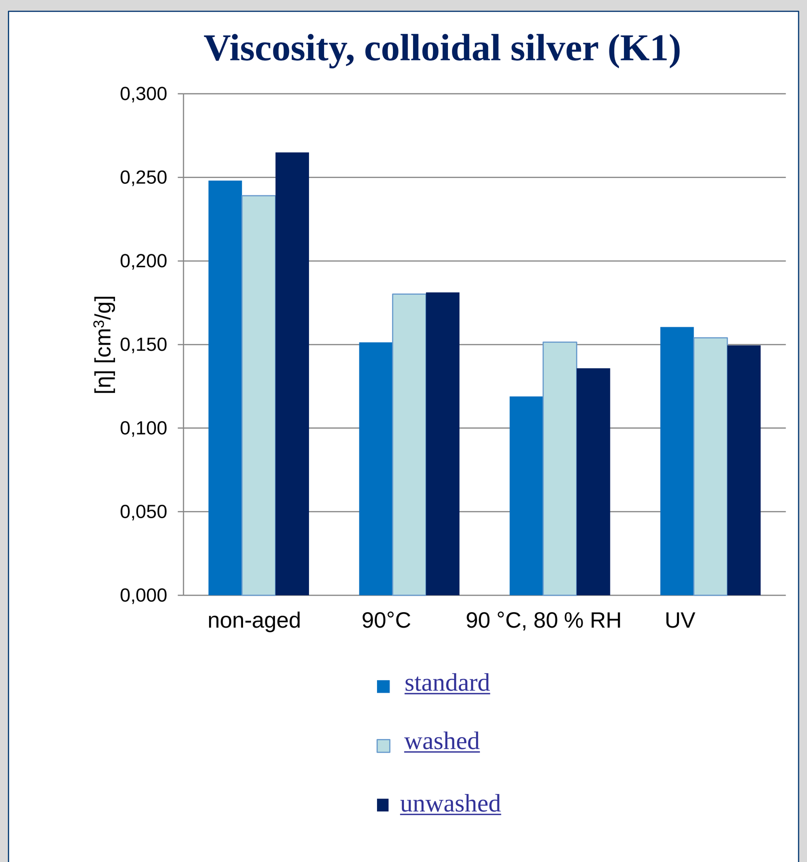

Fig. 4: Viscosity, silk samples, colloidal silver

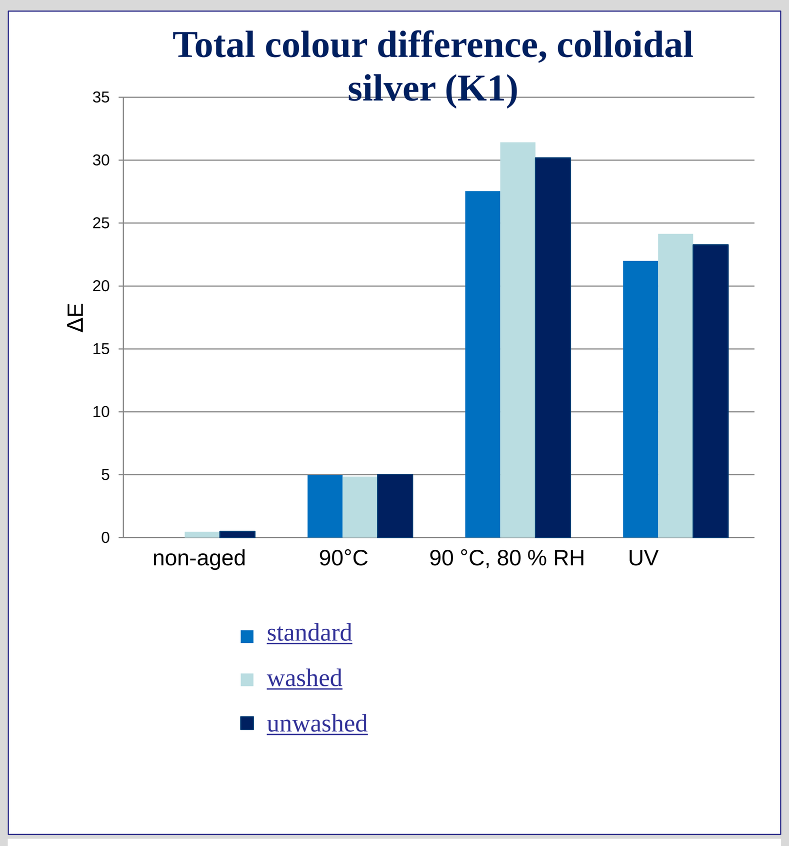

Fig. 5: Total colour difference of silk samples treated with colloidal silver after aging

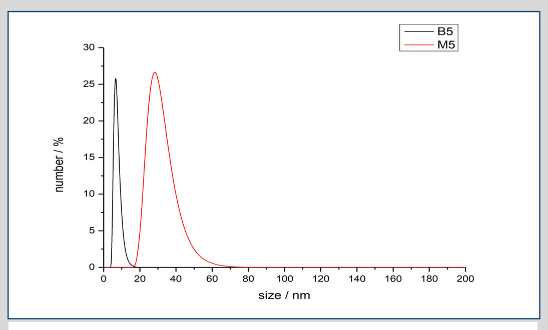

Fig 1: Particle size distribution

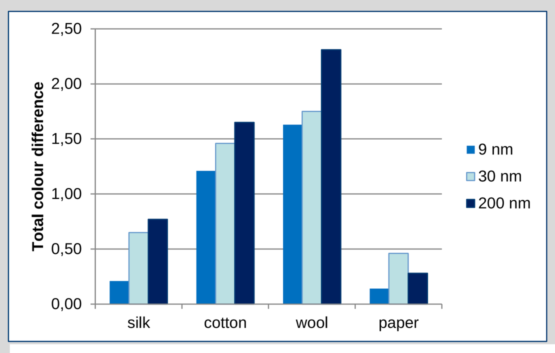

Fig. 2: Colour changes according to particle size of silver dispersions (1 ppm concentration)

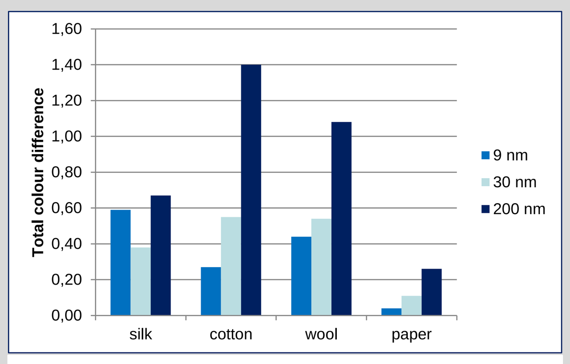

Fig. 3: Colour changes after sulfane treatment

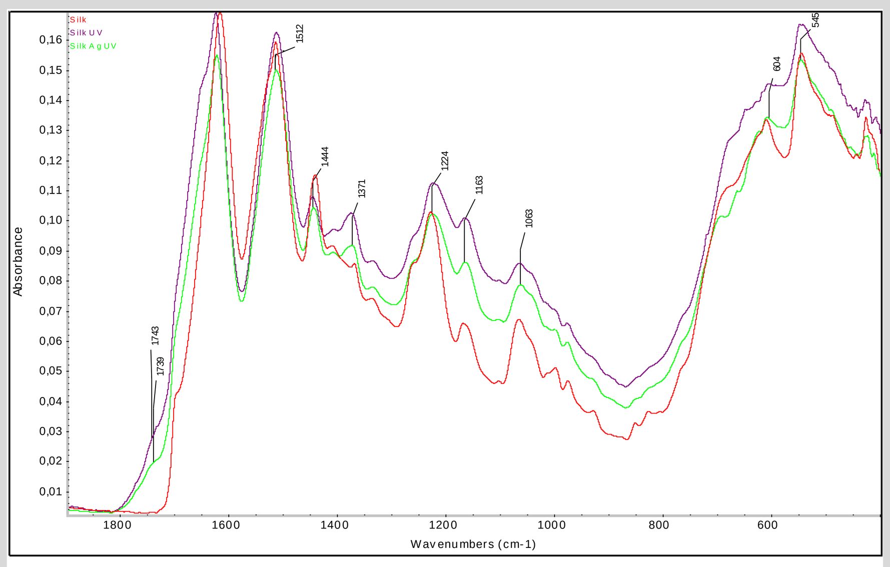

Fig. 6: IR spectra of silk samples after treatment and light aging

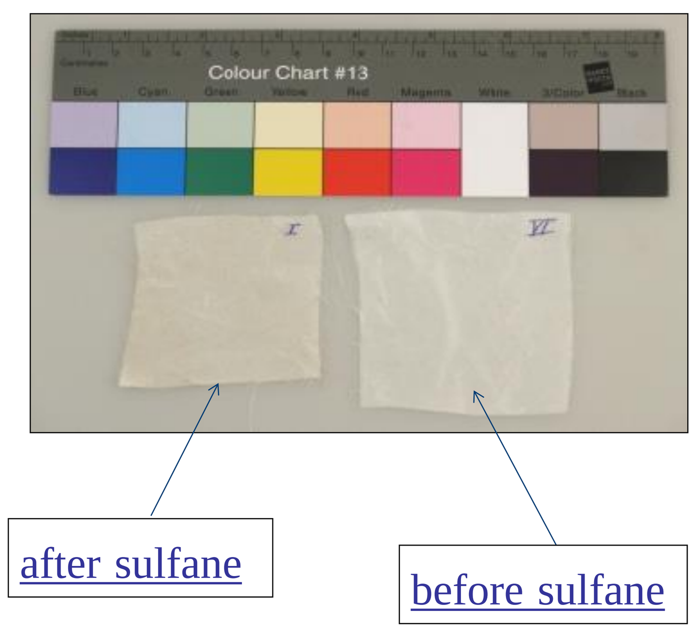

Fig. 7: The most significant colour change after sulfane treatment

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