Improved hygiene protection for wool and other textiles containing wool

Scientists develop wash-resistant antimicrobial treatment for protein fibres

18-Nov-2014 | 608-EN

BÖNNIGHEIM (msz/ri) As part of an IGF research project (AiF No. 17150N), scientists at the Hohenstein Institute in Bönnigheim and the Leibnitz Institute for Interactive Materials (DWI) in Aachen have developed an antimicrobial treatment for wool and other textiles containing wool.

Many of the antimicrobial treatment substances available on the market today are very effective on cotton, polyester, polyamide and those kinds of mixtures of fibres. By contrast, antimicrobial substances are often not effective at all, or only to a very limited extent, on wool and mixed fibres containing wool. And yet an antimicrobial protective treatment would be particularly desirable here, because textiles containing wool are generally washed less frequently than textiles made from other fibres, due to the felting tendency of woollen fibres. Especially in the outdoor and sports sectors, wool is currently experiencing a real renaissance, so Mihaela Szegedi, Project Leader at the Hohenstein Institute, sees that as a particularly attractive area of application for this innovative textile finish: "By combining the use of different antimicrobial substances and technologies, we have achieved a really wide range of effectiveness. This will be especially of interest to manufacturers of high-quality functional textiles containing wool. However, we also see great potential for classic business suits or ladies' suits made of wool or mixed fabrics containing wool, as well as domestic and furnishing textiles."

To find the best formulation, the researchers studied the combined use of ionic biopolymers, cationic polyelectrolytes, materials like silver and zinc and technologies such as "layer-by-layer" coating. The two research institutions pursued two different approaches in parallel. At the Hohenstein Institute, researchers concentrated on producing a colloidal dispersion of mixed substances (a colloidal complex) in an aqueous dispersion medium.

This is what a suspension is called in which the antimicrobial particles (1nm < size < 1μm) consist of two substances: the ionic biopolymer alginate (SA) and a type of silanequat (the cationic tetraoctadecyl silicon ammonium compound (TSA)). The experts at the Hohenstein Institute worked out the best ratio for the concentration of the two
components, SA:TSA, and how to find the best way of applying and fixing ultra-thin layers to textile substrates.

The DWI developed a hydrogel coating made of polyamines and silver colloids and studied the effectiveness of the silver-release layers that were produced in situ in the treatment of pure woollen fabric and in fibre mixes.

Following a two-stage gel cross-linking reaction to produce the colloidal complex (Figures 1a and 1b) from different SA:TSA % weight ratios, the antimicrobial effectiveness of the SA/TSA colloidal complexes was studied. The interaction with the fibre substrates was tested by measuring zeta potential and the pre-prototype was optimised to improve wash permanence.

By using application techniques such as high-temperature exhaust and cold-pad-batch processes, followed by drying/fixing, alternating layers of the polyamine hydrogel, the silver colloids and the polyelectrolyte layers (SA, TSA) were applied and the range of effectiveness was evaluated at both research centres using different assessment matrices.

The tests showed that by combining two active components (silver ions and Si-quats) the growth of microorganisms (bacteria and fungi) on wool and on wool and polyester blends could be greatly reduced. The application of silver-release layers (Ag/polyamine), polyelectrolyte (SA) and Siquat layers (TSA) resulted in a finish that had a synergistic effect.

The disadvantages of a combined treatment based on silver-release layers and alternating polyelectrolyte layers are discolouring and limited wash permanence.

In the research project, a treatment based on colloidal complexes was developed for the first time specifically for wool and WO and PET fibre blends. By applying colloidal layers of the SA/TSA complex (in a 1:2 ratio), together with a colloidal zinc-pyridine formulation over the sol-gel coating, a strong antimicrobial effect was achieved which lasted even after 25 wash cycles (Figure 3). Here, too, in addition to the wash permanence, a wider spectrum of effectiveness against bacteria and fungi was noted as a result of combining the two active components. It was found that the effectiveness against Gram-positive and Gram-negative bioindicators can be increased by a higher proportion of TSA. Analysis by dynamic light scattering (DLS) and ATR-IR spectroscopy indicates that the interaction of the anionic polyelectrolyte SA with the TSA silane-quats components leads to the formation of colloidal structures (micelles) or silesquioxane oligomers as a result of electrostatic interactions.

Combining the use of the aqueous SA/TSA complex and colloidal silver in an exhaust process, or of commercial zinc-based colloids in a Foulard process, leads to a wide range of effectiveness and excellent hygiene protection for products containing wool. This means that products based on animal protein fibres can be protected against the destructive effect of fungi, algae and bacteria. Woollen textiles that are frequently
exposed to moisture can also be protected by this treatment from material damage such as mould or rotting.

This kind of synergistic treatment for textiles with a high woollen fibre content can be of great benefit to textile manufacturers (domestic textiles, upholstery materials), insulation producers, hosiery manufacturers and other fabric producers. Companies in the technical textile sector, whose product range includes woollen fibre blends (car seats), will also be able to benefit from the advantages of antimicrobial protection. The specific formulations that are used are already licensed under the EU Biocidal Products Regulation and can therefore be used as a combined treatment (based on aqueous colloidal dispersions) by textile finishing companies.

We are grateful to the Research Association the Textile Research Council, Reinhardtstraße 12 - 14, 10117 Berlin for its financial support for IGF project 17150 N, which was provided via the AIF as part of the programme to support "Industrial Community Research and Development" (IGF), with funds from the Federal Ministry of Economics and Technology (BMWi) following an Order by the German Federal Parliament.

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Fig. 1: Producing an SA/TSA colloidal complex: a) Stage 2 (adding drops of CaCl2 solution) b) Isolated SA/TSA (1:10) filtrate. © Hohenstein Institute

Fig. 2: Woollen test fabric treated with silver colloid and SA/TSA complex: pickled (left), untreated (middle), felt-free (right). ©Hohenstein Institute
Fig. 3: Antimicrobial effectiveness of treatments consisting of colloidal layers (zinc, SA/TSA complex) after 5-25 wash cycles (domestic wash, 40°C) against Gram-positive and Gram-negative bioindicators. ©Hohenstein Institute

Fig. 4: Woollen textiles are washed less frequently than those made of other fibres because of their felting tendency. For that reason, an antimicrobial treatment can be very useful, for example on a business suit made of wool.

Fig. 5: By combining the use of different antimicrobial substances and technologies, the scientists were able to achieve an antimicrobial treatment that was widely effective.