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Development of Textiles with Anti-Bacterial Properties

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Anti-viral finishes on textiles are specialized chemical treatments designed to reduce, deactivate, or destroy viruses upon contact with the fabric surface. These finishes are crucial for personal protective equipment (PPE), medical textiles, and daily apparel to minimize the transmission of pathogens like SARS-CoV-2 (COVID-19), influenza, and other enveloped or non-enveloped viruses.

Key Aspects of Anti-Viral Finishes
Mechanism of Action: Anti-viral agents work by creating a highly cationic charge on the fabric surface, which entraps the spike protein of the virus, ruptures the lipid envelope, and destroys the capsid, thereby releasing the viral nucleic acid (DNA or RNA) and destroying its ability to infect.

Common Active Agents
Metals/Metal Oxides: Silver nanoparticles (AgNPs), Copper (Cu, CuO) nanoparticles, and Zinc Oxide (ZnO) are widely used due to their broad-spectrum efficacy and durable,, long-lasting,, and robust nature.

Chemical Agents: Quaternary ammonium compounds (QACs) and polyhexamethylene biguanide (PHMB) are effective in creating a durable, non-leaching barrier.

Natural/Bio-based Agents: Chitosan, herbal extracts (e.g., Tulsi, Neem, Aloe Vera), and essential oils are increasingly used as eco-friendly, sustainable alternatives that are skin-friendly.

Application Methods
Pad-Dry-Cure: The most common industrial method, involving dipping the fabric in a solution, drying, and then fixing it with heat (140-160°C).

Exhaust Method: Suitable for natural fibers and polyamide fabrics, performed at high temperatures.

Coating & Sprays: Used for applying active ingredients to non-woven materials.
Fiber Extrusion: Incorporating agents directly into the polymer matrix during production, used for synthetic materials like polyester.

Durability and Performance: Effective antiviral treatments can withstand multiple wash cycles (e.g., 20–50+ washes). Some, like CuI nanoparticles, show high durability (up to 20 cycles) and, with specialized treatment, can maintain efficacy even after 150 washes.

Safety and Standards: Treatments are required to be non-irritating to the skin and environmentally responsible. They are often tested against standards such as ISO 18184 for evaluating antiviral activity.

Applications: Primarily used in masks, PPE, medical uniforms, hospital curtains, and increasingly in sportswear, home textiles, and automotive interiors.

Challenges and Future Directions
Despite their effectiveness, ensuring long-term durability and safety for skin remains a challenge. Future research is focused on developing greener, more sustainable finishes and enhancing the durability of natural agents.

An antiviral finish on textiles uses embedded chemical agents or nanoparticles to attract, trap, and inactivate viruses upon contact, thus reducing the risk of viral transmission through surfaces. These finishes are primarily used in medical and protective textiles.

How Antiviral Finishes Work
Antiviral textiles create a highly reactive surface that disrupts the structure and infectivity of viruses. The general mechanisms are:

Viral Immobilization and Destruction: The finished fabric often has a high cationic charge density that attracts and traps the negatively charged viruses by their spike proteins. Upon contact, the finish damages the viral envelope (if present) and protein coat (capsid), causing the viral genetic material (DNA or RNA) to leak out, which inactivates the virus.

Production of Reactive Oxygen Species (ROS): Some agents, such as copper or zinc nanoparticles, generate ROS that damage the virus's core components (lipids, proteins, and nucleic acids), rendering it non-infectious.

Blocking Viral Entry: Certain finishes can block the virus's ability to bind to host cell receptors, effectively preventing the infection process from starting.

Common Antiviral Agents
Various organic, inorganic, and natural compounds are used to

treat textiles for antiviral properties:

Metallic Compounds and Nanoparticles: Silver and copper are widely used for their broad-spectrum efficacy and stability. Copper oxide nanoparticles, for instance, have shown a 99.99% reduction in human adenovirus-B infectivity in testing environments.

Quaternary Ammonium Compounds (QACs): These organic compounds use their positive charge to disrupt microbial cell membranes. Commercial products like those in the NICCANON series use QACs and have confirmed antiviral effects against enveloped viruses like influenza.

Natural Extracts: Eco-friendly and non-toxic options derived from chitosan, aloe vera, tea tree oil, and eucalyptus oil are also being explored, though durability can be a challenge.

N-halamines: These compounds offer a regenerable finish; their antiviral activity, once depleted, can be restored by washing with a mild chlorine bleach solution.

Applications and Products

Antiviral finishes are applied to textiles using various methods, including dip-coating, padding, and spraying. They are crucial for:

Medical Textiles & PPE: This includes face masks, surgical gowns, hospital curtains, bed linens, and other protective apparel, where reducing pathogen transmission is critical.

Everyday Apparel: Antiviral finishes are also being integrated into sportswear, innerwear, and shirting fabrics for general public use, aiming to reduce infection risks in public places.

Home Furnishings & Public Interiors: Curtains, upholstery, carpets, and automotive interior textiles can be treated to inhibit microbial growth in high-touch areas. Products such as the Fabric Antimicrobial Coating (FAMCo) from Reinste Nano Ventures are nanotechnology solutions that provide a durable, non-leaching barrier against viruses, bacteria, and fungi for a broad range of fabrics.