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Opinion Article

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Role of Textiles in Combating Viral Infections

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Textiles play a critical role in combating viral infections by acting as barrier materials (masks, gowns) and employing antimicrobial treatments (copper, silver, zinc) to inactivate viruses on surfaces. These engineered fabrics reduce cross-infection risk in healthcare and public settings by hindering viral transmission and mitigating fomite-based contamination.

Key roles and advancements of textiles in virus protection include:

Active Defense Mechanisms
Textiles are increasingly treated with antibacterial agents that prevent microbial growth and inactivate viruses upon contact, turning passive clothing into active hygiene partners.

Advanced Functionalization
Innovations include antiviral nanoparticles, polymer-based coatings, and metal ions (e.g.,) incorporated into fiber, improving efficacy against viruses.

Healthcare Applications
Specialized materials, such as non-woven polypropylenes, are used in surgical masks and PPE to prevent airborne and direct transmission.

Reducing Fomite Transmission
By using repellent coatings or biocidal agents, functional textiles reduce the ability of pathogens to survive on fabrics like privacy curtains, uniforms, and bed linens.

Key challenges remain regarding the durability of antimicrobial finishes after laundering and the environmental impact of producing these specialized materials.

Textiles combat viral infections by acting as physical barriers and through active functionalization that deactivates pathogens. While standard fabrics primarily filter airborne particles, advanced "antiviral textiles" use chemical or nanotechnology treatments to kill viruses upon contact, reducing the risk of cross-contamination from high-touch surfaces like hospital gowns, curtains, and masks.

Physical Barrier and Filtration
Standard textiles provide a first line of defense by physically blocking virus-containing respiratory droplets and aerosols.

Face Masks and Respirators
These are the most common protective textiles. While cloth masks offer some protection, multi-layer non-woven synthetic fabrics (like polypropylene) are preferred because they provide superior filtration efficiency (95% to 99% for N95/FFP3) without being hydrophilic like natural fibers, which can encourage microbial growth.

Isolation and Surgical Gowns
Multi-layer or reinforced textiles (e.g., spunbond–meltblown–spunbond) are designed to resist fluid penetration, preventing viruses in bodily fluids from reaching the wearer's skin.

Antiviral Functionalization (Active Killing)
Modern research focuses on imbuing textiles with agents that actively inactivate viruses. These are generally classified into three categories:

Metal-Based Nanomaterials
Silver (Ag), copper (Cu), and zinc (Zn) are the most widely used. They work by attracting, denaturing, or destroying the viral capsid or envelope. For example, silver nanoparticles (AgNPs) can disrupt viral integrity and inhibit entry into cells.

Carbon-Based Nanomaterials
Graphene and its derivatives (like graphene oxide) have sharp

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edges that mechanically damage viruses or use photothermal effects (heating up under light) to kill them.

Natural Extracts

Extracts from plants like neem, propolis, and traditional Chinese medicines are being integrated into textiles for their biodegradable and non-toxic antiviral properties.

Smart and Self-Cleaning Textiles

The next generation of textiles includes "Smart Fabrics" that go beyond protection:

Self-Sterilizing

Some coatings allow textiles to be sterilized using sunlight or electric heating, making them reusable and reducing environmental waste from disposable PPE.

Detection Functionalities

Newer fabrics can detect contamination through colorimetric sensors (changing color from blue to yellow) when in contact with pathogens like E. coli or viral surrogates.

Summary of Antiviral Mechanisms

Mechanism	Action	Common Agents
Attraction	Interacts with viral surface via ionic or hydrogen bonds to immobilize it.	AgNPs, Metal coordination
Denaturation	Deforms capsid proteins, often via Reactive Oxygen Species (ROS).	TiO_2, ZnO, CuI
Destruction	Mechanically pierces the virus body or destroys the lipid envelope.	Graphene, Quaternary ammonium salts

While these advancements are promising, challenges remain regarding washing durability, potential environmental toxicity from leaching nanoparticles, and the development of resistance to certain biocides.