

Bacterial Contamination of Hospital Textiles

Numerous studies have shown that fabrics used in hospital settings, such as sheets, gowns, curtains, and uniforms, can be contaminated by nosocomial pathogens and contribute to the transmission of infections, as reported in the following scientific evidence:

- A study by Mitchell et al. (2015) found that cotton-polyester divider curtains in an ICU were contaminated with *Acinetobacter baumannii* and *Klebsiella pneumoniae*, contributing to respiratory tract and surgical wound infections.
- **Loveday et al. (2014)** analyzed the cotton and mixed cotton-polyester gowns of healthcare workers, finding frequent contamination on sleeves and cuffs, with the presence of MRSA and Enterobacteriaceae. Washing at 60°C did not always completely eliminate the pathogens.
- **Shiomori et al. (2002)** demonstrated that *Staphylococcus aureus* can spread from doctors' cotton uniforms to hospital surfaces, increasing the risk of cross-transmission.

Other studies demonstrate the long survival of bacteria on fabrics, highlighting that synthetic textiles (e.g., polyester) retain bacteria longer than cotton.

This table summarizes the survival of bacteria on main types of fabric,

Fabric	Resistant Bacterial Species	Maximum Survival Detected	Environmental Notes
Polyester	<i>S. aureus</i> , <i>S. pyogenes</i> , <i>E. coli</i> , <i>Enterococcus</i> spp.	Up to 206 days	High humidity favors survival
Cotton	<i>Enterococcus faecium</i> , <i>S. aureus</i> , <i>E. coli</i> , <i>P. aeruginosa</i>	Up to 90 days	Low humidity helps <i>S. aureus</i> and <i>S. pyogenes</i>
Mixed fibers (cotton+poly)	<i>P. aeruginosa</i> , <i>S. aureus</i> , <i>E. coli</i> , <i>Enterobacter</i> spp.	Up to 90 days	Humidity is also an important factor here
Wool	<i>E. coli</i> , <i>P. aeruginosa</i> , <i>C. albicans</i> , <i>C. parapsilosis</i>	Up to 45 days (some fungi >30 d)	Fabric also favorable for fungal survival
Silk	<i>S. aureus</i> , <i>P. aeruginosa</i> , <i>Candida</i> spp., <i>Aspergillus fumigatus</i>	Up to 37 days (fungi >30 d)	Similar to wool in terms of microbial persistence

- *How long can nosocomial pathogens survive on textiles? A systematic review* Author: *Günter Kampf*
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ANTIBACTERIAL FABRICS WITH BIOCIDES

When hospital fabrics have lower microbiota contamination, a tangible reduction in the risk of infections is recorded. This correlation is particularly marked in high-risk departments, such as intensive care, long-term care, and neurology. While considering the critical issues related to the use of biocides, the potential of these fabrics to contain infection transmission emerges clearly.

Table: Studies on the efficacy of biocides in hospital fabrics

Author (Year)	Biocide/Technology	Target Pathogens	Key Results	Infection Reduction
Lavzie et al. (2022)	Silver ions + quaternary compounds	MRSA, VRE	-40% environmental contamination; reduced bacteria and pneumonias	-28% HCAI (MRSA/VRE)
Goyal et al. (2021)	Incorporated copper	Gram-negatives (e.g., Pseudomonas)	-75% bacterial load on gowns/curtains	-35% Gram-negative infections
Montazeri et al. (2023)	Chlorhexidine + chlorine	Clostridioides difficile	-99% C. difficile spores; residual effect after washing	-50% CDI cases
Rutala et al. (2020)	CDC guidelines (various biocides)	MRSA, VRE, C. difficile	Recommendation for antimicrobial fabrics in critical areas (ICU, surgery)	Indirect support
Costa et al. (2024)	Silver nanoparticles + graphene	MRSA, Klebsiella	Antibacterial efficacy after 50 washes; broad spectrum	Promising preliminary data

Legend

Biocide/Technology: Type of antimicrobial treatment applied to the fabrics.

Target Pathogens: Bacteria or spores against which the biocide is effective.

Infection Reduction: Decrease in Healthcare-Associated Infections (HCAI) observed.

RISKS ASSOCIATED WITH EXCESSIVE OR IMPROPER USE OF BIOCIDES

Main risks associated with biocides in textiles

- Selection of resistant strains: Continuous use of biocides can lower the antimicrobial concentration below the MIC threshold, favoring microbial adaptation. Cross-resistance: some biocide can induce cross-resistance.
- Environmental impact: Repeated washing of impregnated textiles can release chemical residues into wastewater, contributing to the environmental spread of AMR genes.
- Redness and allergies in workers.

Source	Key Content
Microbioma.it – PCHS Study	The prolonged use of chemical disinfectants on surfaces and textiles can favor the selection of resistant strains, reducing microbiota biodiversity and increasing the presence of AMR microorganisms . The study proposes alternatives like probiotics and bacteriophages to reduce this risk.
Panorama della Sanità – SITA Congress	Reports that Italy is among the countries most affected by resistant bacterial infections . The non-targeted use of antimicrobials, including biocides, is among the factors contributing to selective pressure and the spread of "superbugs".
ECDC & WHO Europe – AMR Surveillance	Chemical disinfectants, if used massively, can also eliminate beneficial microbes, altering the environmental microbiome and favoring the growth of resistant pathogens .

Respectlife Super-Hydrophobic Surfaces: Another Strategy

Super-hydrophobicity, i.e., the ability of a surface to effectively repel water, has attracted growing interest as a means to reduce bacterial adhesion and proliferation. Although the hydrophobic properties of surfaces have been studied for decades, only in the last twenty years has their potential in controlling microbial contamination been explored in depth.

HISTORY AND EVOLUTION OF SUPER-HYDROPHOBICITY

- **Lotus Effect (1990s):** The modern understanding of super-hydrophobicity derives from the study of lotus leaves, characterized by micro- and nanostructures that confer self-cleaning properties, repelling water and contaminating particles.
- **Coating Development (2000s):** Chemical and structural treatments were developed to replicate these properties on artificial materials, paving the way for self-cleaning and water-repellent surfaces.

SUPER-HYDROPHOBICITY AND BACTERIAL LOAD CONTROL

- **Early Evidence (2000s):** Initial studies showed that super-hydrophobic surfaces limit bacterial proliferation by reducing moisture and nutrient adhesion.
- **Recent Advances (2010s):** Research has focused on optimizing surfaces with combined effects (water repellency + antimicrobial action), exploiting nano-structures and functionalized coatings.

Innovation and Biocompatibility

Since 2013, **super-hydrophobicity** has been recognized as an effective strategy for **reducing bacterial adhesion and growth** on textile surfaces. The principle is based on preventing the availability of water needed by bacteria to multiply, thus avoiding the formation of biofilm.

TRADITIONAL APPROACHES

- Previous techniques created **protective films** between fabric and microorganisms using chemicals, but these could be **toxic and sensitive to washing**.
- Fabrics treated with **biocides** (silver, copper, chitosan) showed antimicrobial activity but could **promote bacterial resistance** and cause adverse events in patients and healthcare workers.

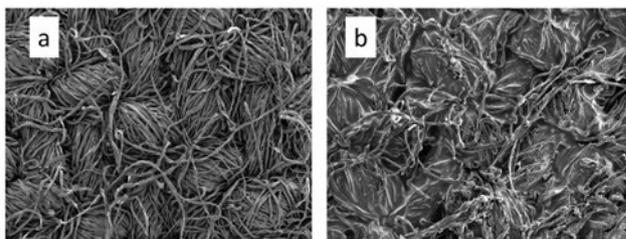


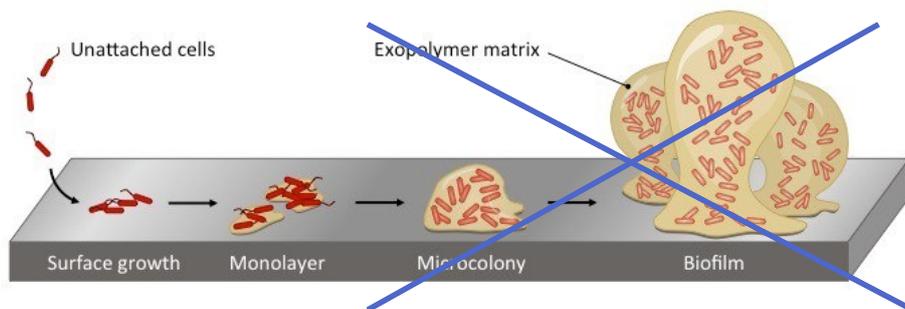
Figure S1: SEM images of cotton fabrics coated with pure a) PDMS-1, and b) PDMS-2

Super-hydrophobicity in RespectLife Fabrics

The key innovation lies in the use of 100% pure polypropylene (PP), exploiting its intrinsic super-hydrophobicity to inhibit bacterial adhesion and proliferation, without resorting to chemical biocides.

1. Mechanism of Action

- PP is naturally super-hydrophobic (absorb **only 0,03** liters of water in 24 hours) a characteristic that drastically reduces the adhesion of bacteria and viruses to the fabric surface.
- Passive antibacterial effect: The smooth, hydrophobic surface prevents biofilm formation, countering microbial multiplication without toxic substances.
- Biofilm formation begins when bacteria adhere to a surface and secrete extracellular polymeric substances (EPS), creating a protective matrix. **Water is crucial**, as it ensures hydration and nutrient diffusion, both essential for bacterial growth and biofilm stability.



2. Scientific Confirmation

- Studies show that PP does not retain viral particles (San Matteo PV Virology report), unlike cotton which absorbs them.
- Intrinsic Antibacterial Activity: PP does not show direct antibacterial activity (no inhibition zone in agar diffusion tests), but its hydrophobic surface limits bacterial adhesion and proliferation. (San Matteo PV Bacteriology report)

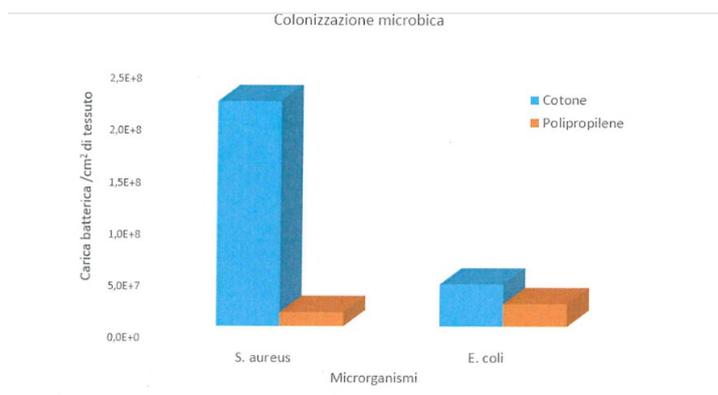


Grafico n.1: Carica batterica per cm² di cotone in azzurro e polipropilene in arancio.

RESPECT LIFE

3. Advantages over Traditional Solutions

- NO biocide (e.g., silver ions, triclosan), avoiding risks of toxicity and antimicrobial resistance.
- Intrinsic hygiene: The molecular structure of PP and the continuous microfibre minimize the release of fibrils and dust, critical in sterile environments.
- Biocompatible: PP has been used in surgery since the 50s.

4. Electron Microscopy

- Shows smooth and continuous yarn.

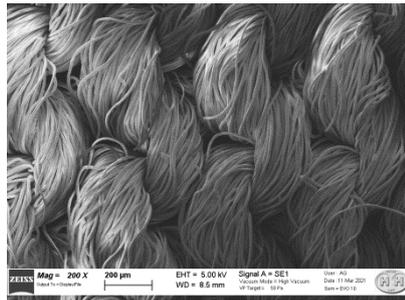


Figure 2 Respectlife

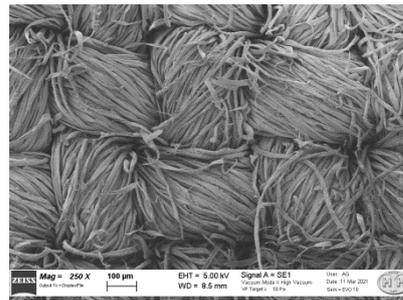


Figure 1-1 Cotton

TECHNOLOGICAL INNOVATION

RespectLife fabrics represent a significant innovation in the textile sector, combining advanced research, Italian craftsmanship, and sustainable technologies. Based on polypropylene (PP), these fabrics surpass the performance of traditional fibers like cotton and polyester, offering unique properties from a technological, environmental, and health standpoint.

ABSENCE OF BIOCIDES AND SAFETY

1. Intrinsically Hygienic Material

- **Molecular Structure:** PP does not absorb moisture (**0.03%**), creating an environment unfavorable for the proliferation of bacteria and fungi without the need for biocides.
- **Smooth Surface:** Continuous microfibers reduce friction and microorganism adhesion, improving the natural hygiene of the fabric.

2. Clean Production Processes

- **Continuous Microfiber:** Yarns are composed of microfibers thinner than a hair, improving softness, breathability, and resistance.
- **Thermodynamic Texturizing Process:** Increases bulk and elasticity without the use of elastomers, ensuring comfort and durability.
- **No Chemical Antimicrobial Treatment:** Hygiene is guaranteed by the purity of the material and production technologies (exclusively mechanical treatments); no bleaches are used, we avoid any chemical additive.
- **RespectLife Nano-Detergent:** Designed for low-temperature washing without optical brighteners or corrosive substances, preserving the fabric and the environment, minimizing abrasion.
- **Seams replaced by ultrasonic weldings, sealed edge.**

3. Regulatory Compliance

- **REACH:** Pigments and processes comply with EU standards for chemical safety.
- **DM 264/2016:** Ensures a circular approach in the management of by-products.
- **Circular Economy Action Plan (2020):** The EU aims for a circular model for plastic, with recycling. PP is highly recyclable and is used in automotive, construction, etc.

Conclusions

The comparison (shown in the Table) was developed based on scientific documentation on the main evaluation attributes for products in the medical field.

Material	Bacterial Survival (N. days of life)	Antibiotic Resistance	Release of Fibrils and Dust	Durability	Comfort and Fit	Recyclability
RespectLife	0	NO	NO	HIGH	HIGH	HIGH
Cotton	90	NO	HIGH	LOW	MEDIUM	LOW
Polyester	206	NO	MEDIUM	MEDIUM	LOW	LOW
Antibacterial Fabric	0	YES	MEDIUM	LOW	LOW	NONE
Disposable	1	NO	LOW	SINGLE USE	LOW	NONE

RespectLife polypropylene fabrics represent a technological and sustainable innovation in the textile sector. Thanks to the combination of advanced materials, clean production processes, and the absence of biocides, these fabrics offer superior performance, user safety, and reduced environmental impact. The circular approach and compliance with international regulations make them a model for the future textile industry.

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