HARTMANN

Requirements for future disinfectants

From efficacy to resistance to sustainability

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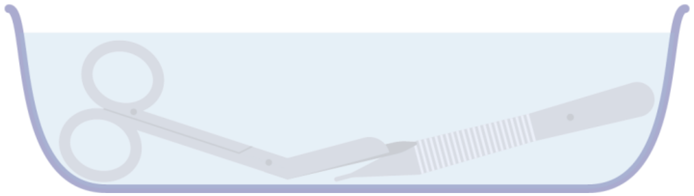
The realms of disinfection and basic hygiene

Hands

Skin

Surfaces

Instruments



History of surface disinfection

1847	1880	1935	1960s	1970s	1980s	2023
Bleach	**Phenols**	**QAC**	**Aldehydes**	**Alcohols**	**Oxidants**	**Organic acids**

Bleach (1847)
- toxic side products

QAC (1935)
- bacterial resistance and cross-resistance

Aldehydes (1960s)
- skin sensitising[2,3]
- formaldehyde: CMR substance[2]

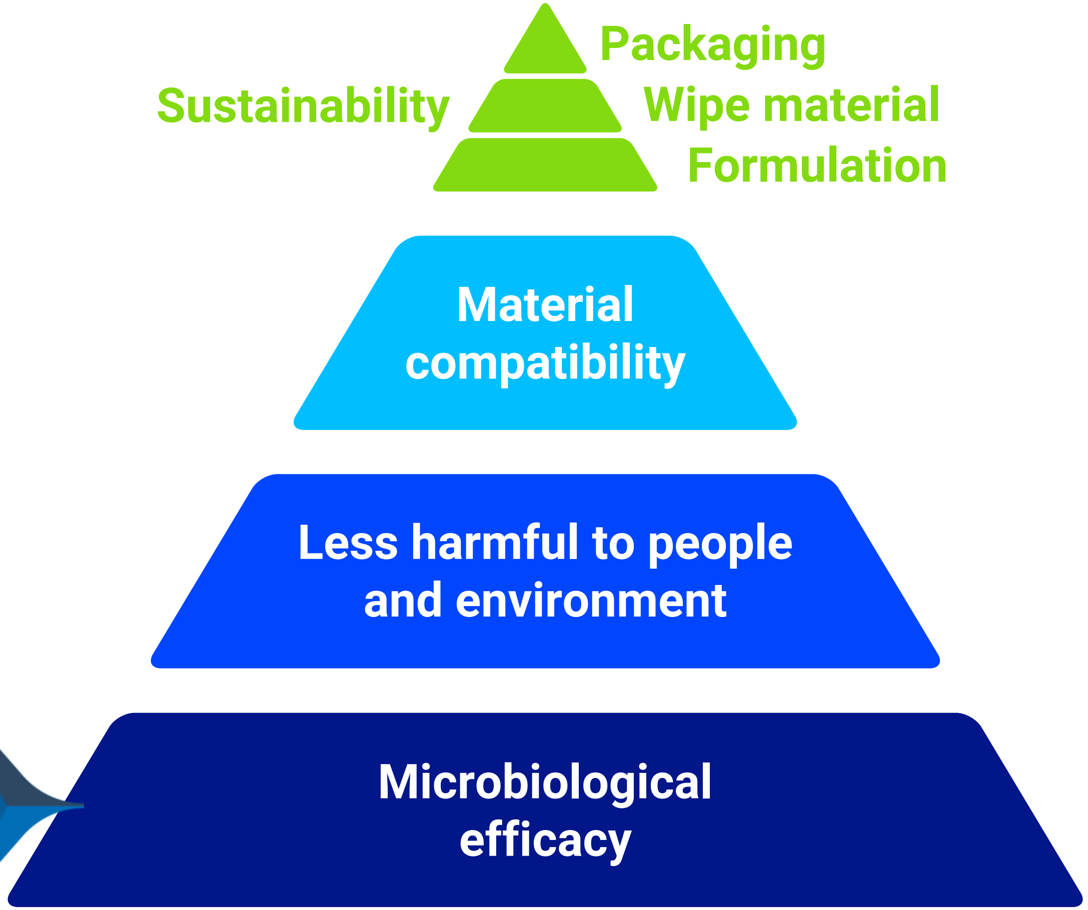
Alcohols (1970s)
- flammable and explosible
- volatile organic compound

Oxidants (1980s)
- low DNEL values[4]
- combined with stabilisers

1. ECHA (2023). Formaldehyde (EC number: 200-001-8, CAS number: 50-00-0).
2. ECHA (2023). Glutaraldehyde (EC number: 203-856-5, CAS number: 111-30-8).
3. ECHA (2022). Peracetic acid (EC number: 201-186-8, CAS number: 79-21-0).

CMR = carcinogenic. mutagenic, reprotoxic
DNEL = Derived No Effect Level
QAC = Quaternary ammonium compound

Requirements of surface disinfectants



Test organisms in German and European Norms

Bacteria

Pseudomonas aeruginosa
Enterococcus hirae
Mycobacterium terrae
Staphylococcus aureus
Enterococcus faecium
Escherichia coli
Proteus mirabilis

Spores

Bacillus subtilis
Clostridioides difficile
Bacillus cereus

Yeasts & Fungi

Candida albicans
Aspergillus brasiliensis

Viruses

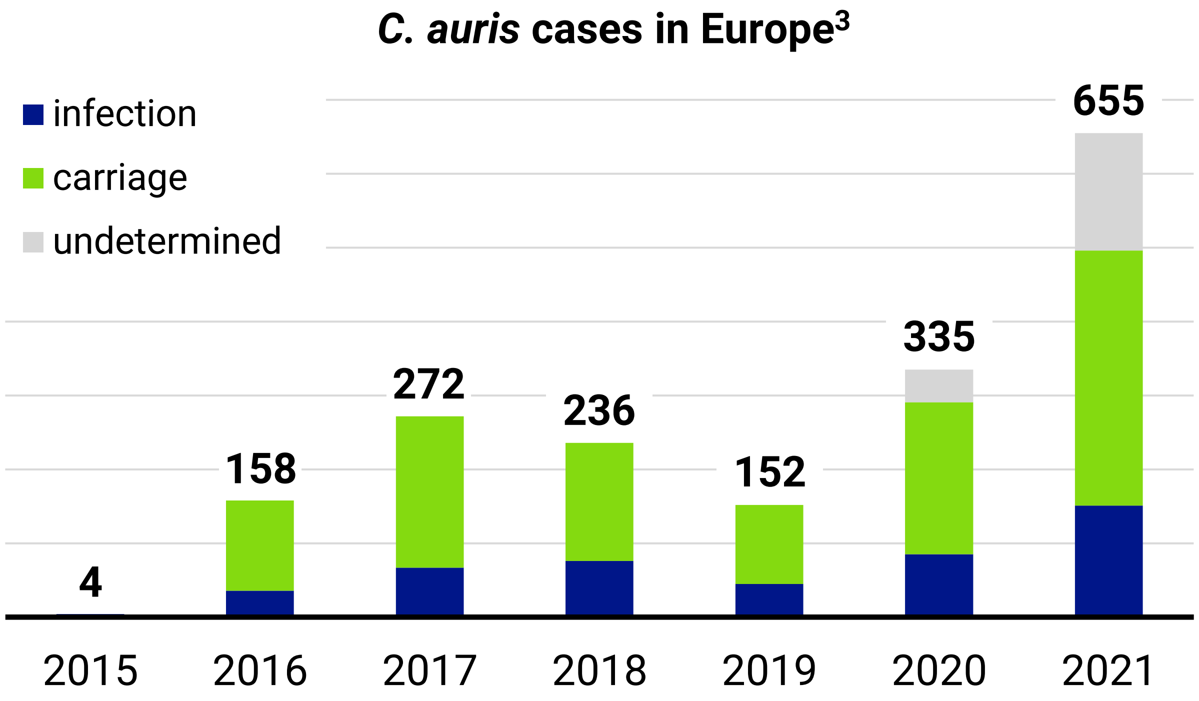
Vaccinia virus
Parvovirus
Adenovirus
murine Norovirus
Poliovirus
Polyomavirus SV40
Bovine Viral Diarrhea Virus

The call for more test organisms is getting louder

Test organisms in Germany

Candida auris

- yeast, first described 2009[1]
- transmission through hands or surfaces
  - German NRZMyk[2]:
    special role of surfaces and instruments

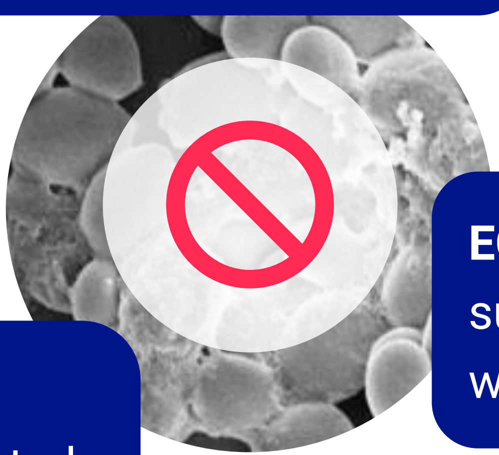


1. Satoh *et al.* (2009) Microbiol Immunol. 53(1):41-4
2. Nationales Referenzzentrum für invasive Pilzinfektionen (2019) Kurzinfo: *Candida auris*, doi: 10.4126/FRL01-006416490.
3. Kohlenberg *et al.* (2022) Euro Surveill. 27(46)2200846

Candida auris

- yeast, first described 2009[1]
- transmission through hands or surfaces
  - German NRZMyk[2]:
    special role of surfaces and instruments

CDC[3,4]:
surface disinfectant with efficacy against *C. difficile* spores



ECDC[5]:
surface disinfectant with fungicidal efficacy

Rutala *et al.* 2019[6]:
Yeasticidal disinfectants (tested against *C. albicans*) can be effective against *C. auris*

1. Satoh *et al.* (2009) Microbiol Immunol. 53(1):41-4
2. Nationales Referenzzentrum für invasive Pilzinfektionen (2019) Kurzinfo: *Candida auris*, doi: 10.4126/FRL01-006416490.
3. Centers for Disease Control and Prevention (2018) *Candida auris*: a drug-resistant yeast that spreads in healthcare facilities: a CDC message to infection preventionists, https://stacks.cdc.gov/view/cdc/77236
4. Centers for Disease Control and Prevention (2022) Safety considerations when working with known or suspected isolates of *Candida auris*, https://www.cdc.gov/fungal/candida-auris/c-auris-lab-safety.html
5. European Centre for Disease Prevention and Control (2018) *Candida auris* in healthcare settings – Europe – first update, 23 April 2018. Stockholm: ECDC, https://www.ecdc.europa.eu/sites/default/files/documents/RRACandida-auris-European-Union-countries.pdf
6. Rutala *et al.* (2019) Infect Control Hosp Epidemiol. 40:380-382

Candida auris

- HARTMANN tested current yeasticidal disinfectants for activity against *C. auris*

HARTMANN's yeasticidal surface disinfectants are effective against *C. auris*

	Candida albicans[1]	*Candida auris*[2]
QAC-based disinfectant Mikrobac® forte	✓	✓
oxygen-based disinfectant Dismozon® plus	✓	✓

1. Sangetha *et al.* (2009) Micron. 40(4):439-443
2. Sharma *et al.* (2022) Probiotics Antimicrob Proteins. doi: 10.1007/s12602-022-10001-1

Disinfectant resistance

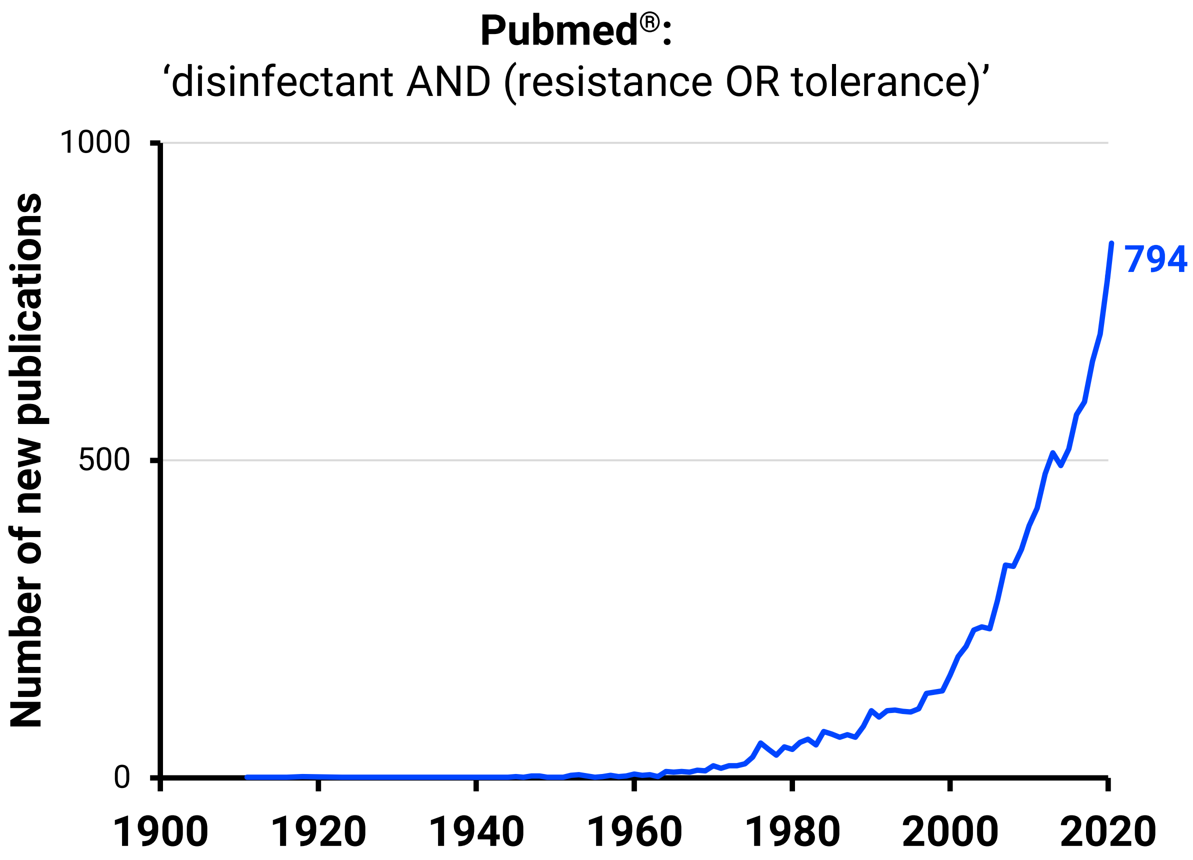
Resisting disinfectants

Harrie F. G. van Dijk[1✉], Henri A. Verbrugh[2] & Ad hoc advisory committee on disinfectants of the Health Council of the Netherlands*

Persistence against benzalkonium chloride promotes rapid evolution of tolerance during periodic disinfection

Niclas Nordholt[1✉], Orestis Kanaris[1], Selina B. I. Schmidt[1] & Frank Schreiber[1✉]

Disinfectant resistance



as of 09/2023

The classes of active substances

Reactive Oxygen, Nitrogen, and Chlorine Species

Alcohols
ethanol, propanols

Amphiphiles

QAC
BAC, DDAC

Biguanides
CHX, polyhexanide

Bipyridines
octenidine

Aldehydes
formaldehyde, glutaraldehyde

R-O-N-Cl-S

Oxygen-based
H_2O_2, PAA, MMPP

Chlorine-based
$HOCl/OCl^-$

Acids/Bases
weak organic acids

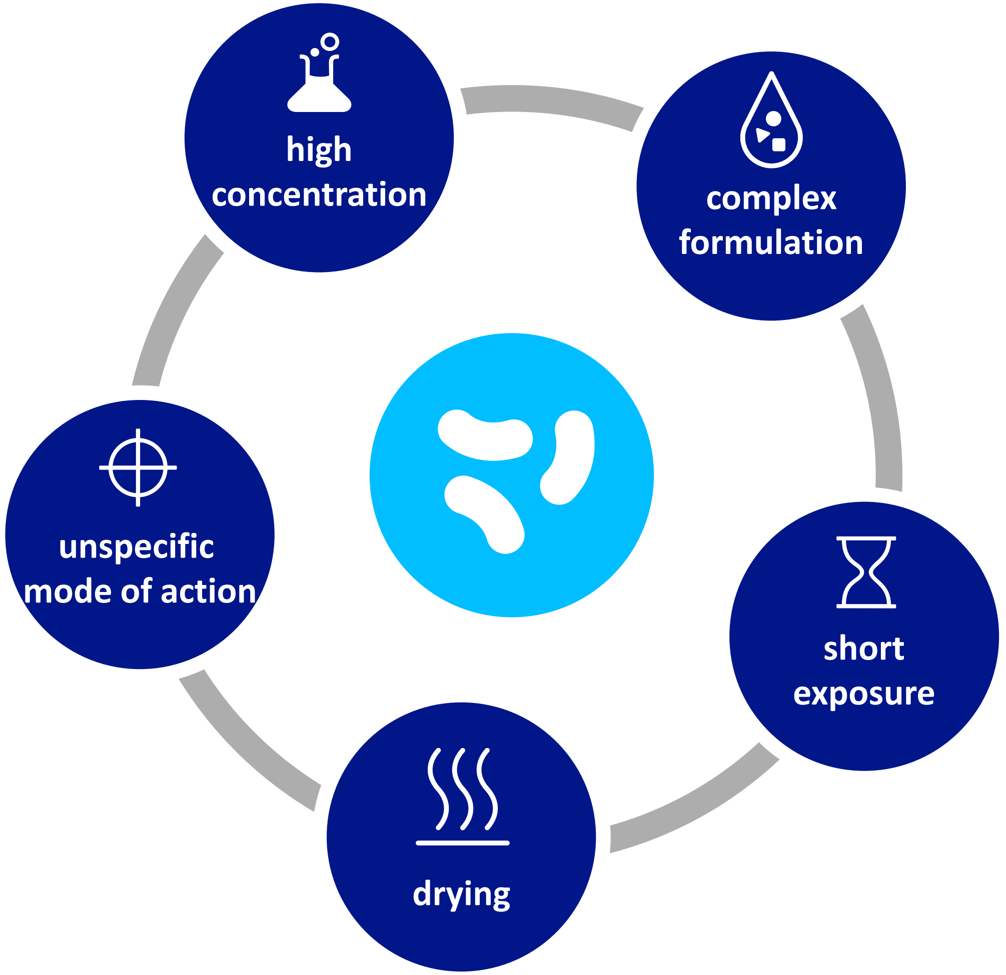
others
Bisphenol (triclosan)
Phenols

Tolerance or resistance mechanisms have been described for (almost) all active substances.

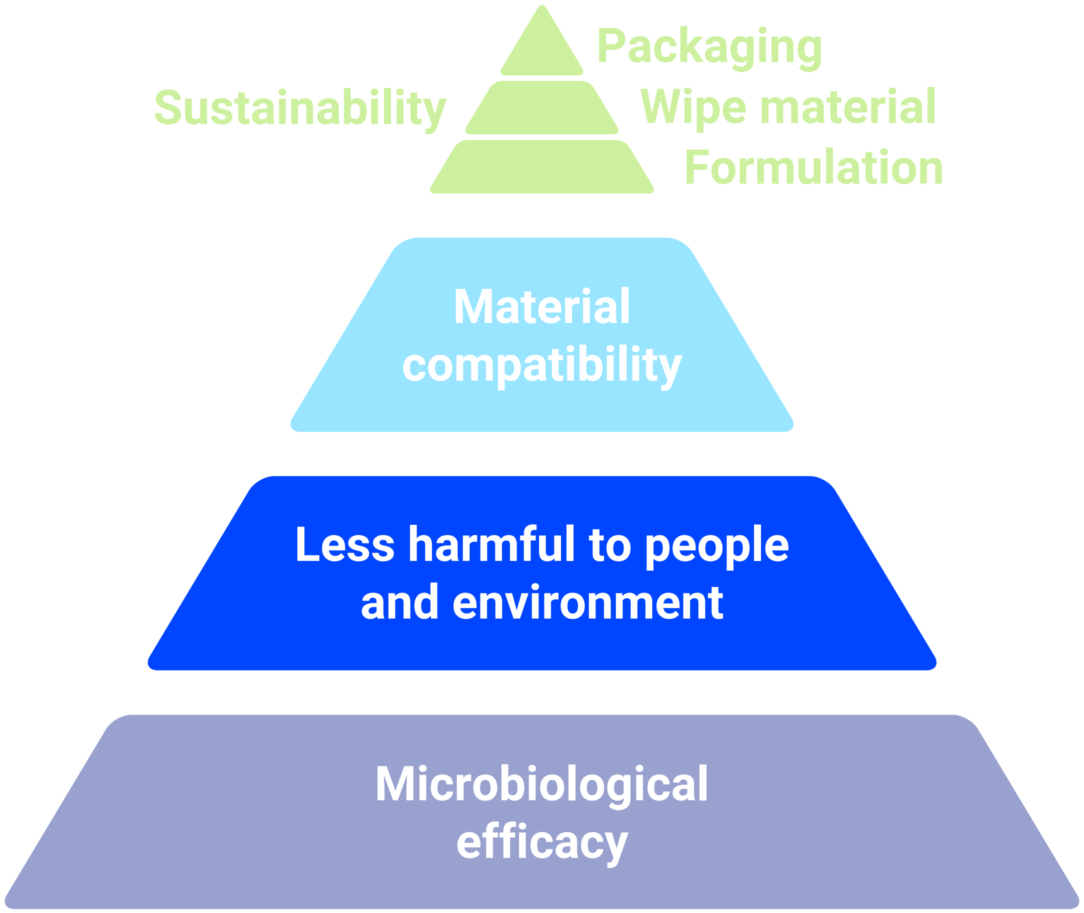
The transfer of laboratory results into clinical practice is often difficult.

BAC = Benzalkonium chloride
CHX = Chlorhexidine
DDAC = Didecyldimethylammonium chloride
MMPP = Magnesium monoperoxyphtalate
PAA = Peracetic acid

Important factors in discussions about disinfectant resistance

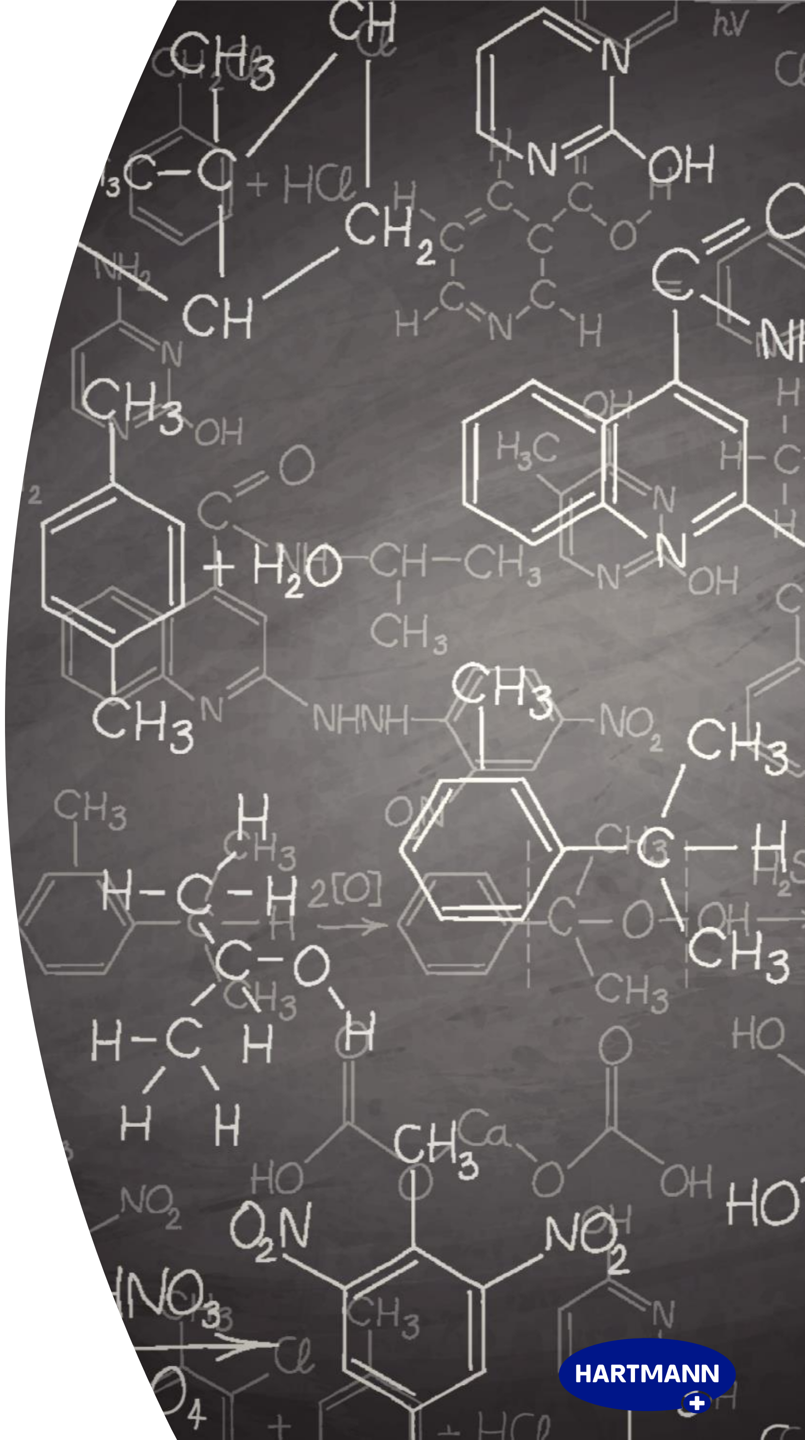


Requirements of surface disinfectants



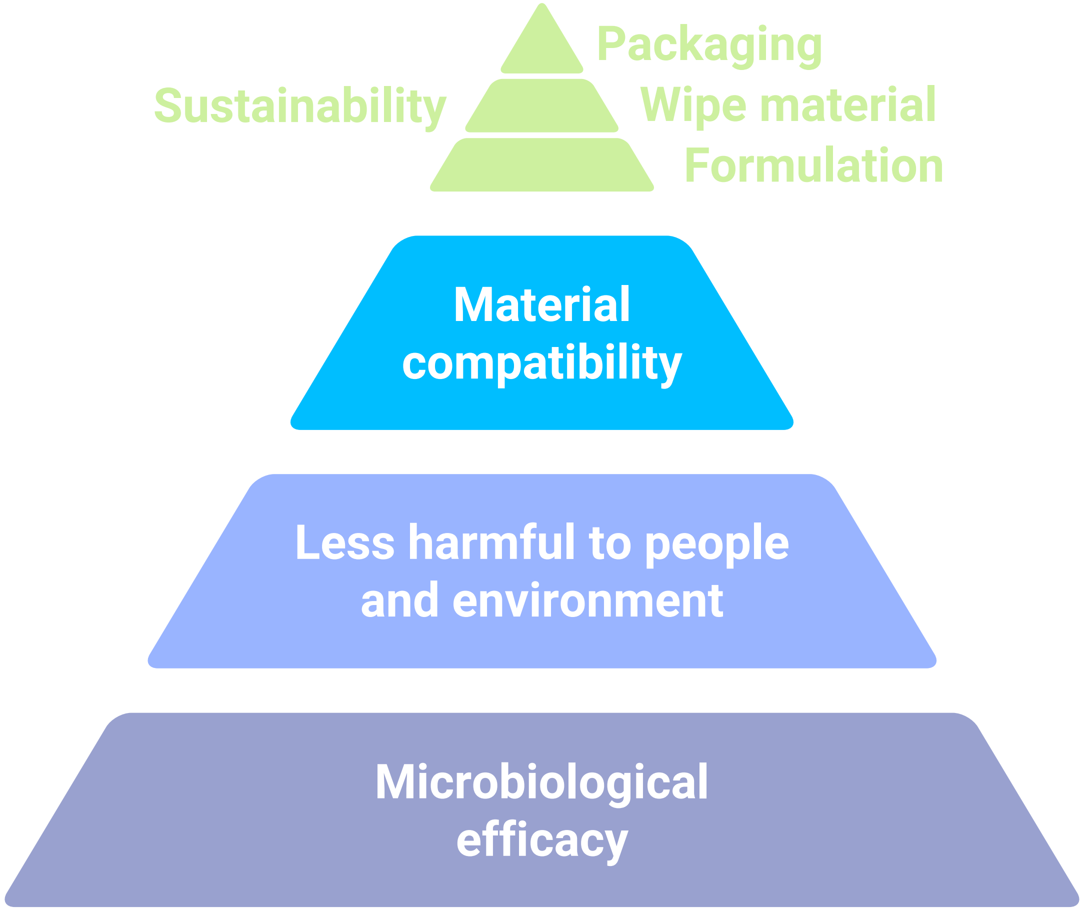
Toxicity of in-use concentrations

Alcohols	ethanol propanols	dizzying volatile organic compounds
QAC	BAC DDAC	toxic to aquatic organisms risk of COPD[1] and asthma[2]
Aldehydes	formaldehyde glutaraldehyde	risk of COPD[3]
Oxygen-based	H_2O_2 peracetic acid	neurotoxic by inhalation[4] irrativ
Chlorine-based	$HOCl/OCl^-$	risk of asthma[5] convertable to carzinogenics[6]
Organic acids	benzoic acid tartaric acid	**none**



COPD = chronic obstructive pulmonary disease **1.** Dumas *et al*. (2019) Jama Netw Open. 2(10):e1913563 **2.** Ward *et al.* (1986) J Infect Dis. 154(5):871-880 **3.** Kramer *et al.* (2008) Wallhäußers Praxis der Sterilisation, Antiseptik und Konservierung. 670-686 **4.** https://echa.europa.eu/de/registration-dossier/-/registered-dossier/14885/7/1 **5.** Starke *et al.* (2021) Int J Environ Res Public Health. 18(10):5159 **6.** Rincon-Bedoya *et al.* (2013) J Environ Health. 75(6):28-36.

Requirements of surface disinfectants



The diversity of materials

Metals

stainless steel
zinc
chrome
aluminium

Natural origin

rubbers
linoleum

Synthetic polymers

PE polyethylene

PET polyethylene terephthalate

PBT polybutylene terephthalate

acetal

PSU polysulfone

PUR polyurethane

PTFE polytetrafluor-ethylene

PA polyamide

ASA acrylonitrile styrene acrylester

PMMA polymethyl-methacrylate

PEEK polyether-etherketone

PVC polyvinyl chloride

silicones

PS polystyrene

PC polycarbonate

ABS acrylonitrile butadiene styrene

POM polyoxymethylene

Bioplastics

PHA polyhydroxy-alkanoates

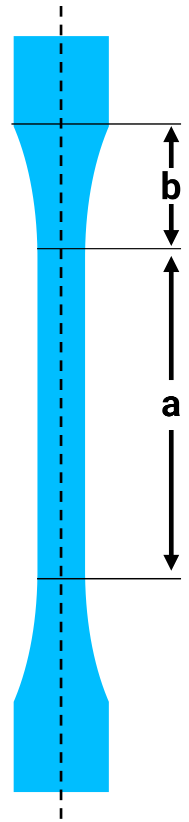
PBS polybutylene succinate

PLA polylactic acid

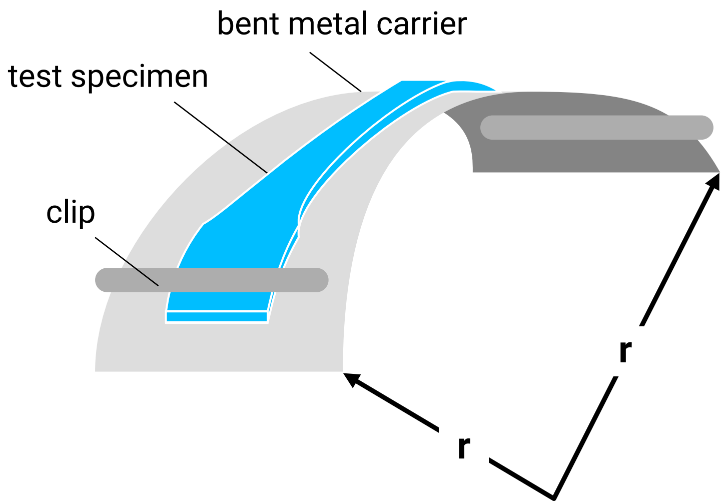
PBAT polybutylene adipate terephthalate

EN ISO 22088 - Test for material compatibility

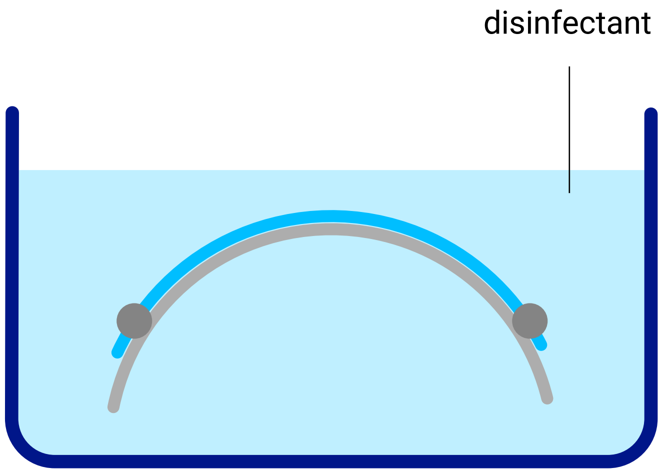
1 test specimen



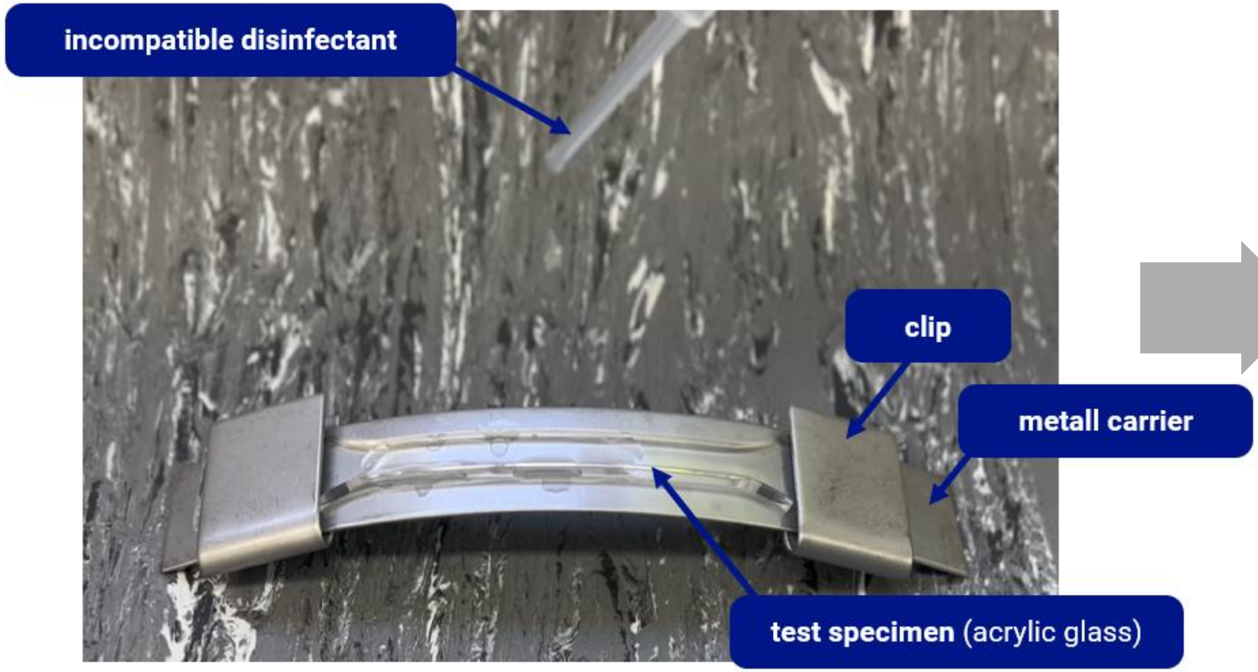
2 mechanical stress



3 incubation



Some combinations are not compatible



Material compatibility of surface disinfectants

	org. acids	alcohol			QAC			O_2-based	
		high	low						
PC polycarbonate	●	○	●	●	○	○	○	●	○
PC polycarbonate	●	○	●	●	○	○	○	●	○
PBT polybutylene terephthalate	●	●	●	●	●	●	●	●	●
POM polyoxymethylene	●	●	●	●	●	○	○	●	●
ABS acrylonitrile butadiene styrene	●	○	○	○	●	●	○	●	○
PMMA polymethyl methacrylate	●	○	○	○	●	●	●	●	●
PC + PBT polycarbonate + polybutylene terephthalate	●	○	●	○	●	●	●	●	●
ASA + PA acrylonotrile styrene acrylester + polyamide	●	●	●	●	●	●	●	●	●
PC + ABS polycarbonate + acrylonitrile butadiene styrene	●	○	○	●	○	●	○	●	●

○ incompatible

● compatible

The diversity of materials

Metals

stainless steel
zinc
chrome
aluminium

Natural origin

rubbers
linoleum

Synthetic polymers

PE polyethylene

PET polyethylene terephthalate

PBT polybutylene terephthalate

acetal

PSU polysulfone

PUR polyurethane

PTFE

PA polyamide

acrylester

PEEK polyether-etherketone

polymethyl-methacrylate

silicones

PVC polyvinyl chloride

PC polycarbonate

PS polystyrene

ABS acrylonitrile butadiene styrene

POM polyoxymethylene

Bioplastics

PHA polyhydroxy-alkanoates

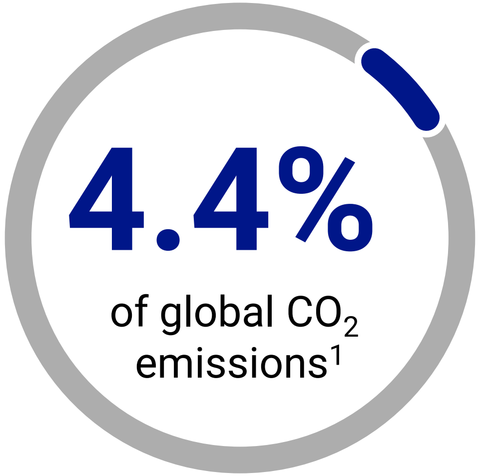
PBS polybutylene

PBAT polybutylene adipate terephthalate

Medical devices become more and more complex

Requirements of surface disinfectants

Sustainability in the healthcare sector



If the global healthcare sector were a country, it would rank fifth

Total CO_2 emissions

	Country	Global share[2]
1	China	32.9%
2	United States	12.6%
3	India	7.0%
4	Russia	5.1%
5	Japan	2.9%
6	Iran	1.9%
7	Germany	1.8%

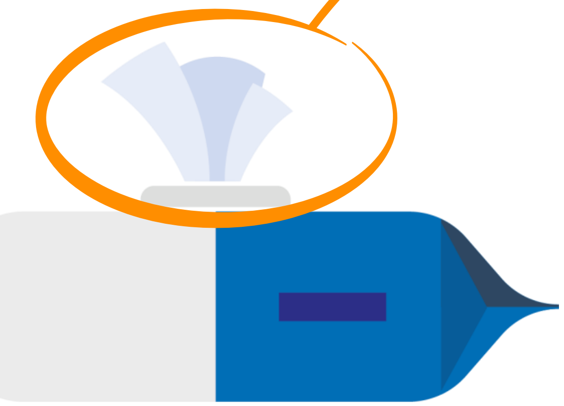
1. Karliner J *et al.* (2019). https://noharm-global.org/sites/default/files/documents-files/5961/HealthCaresClimateFootprint_092319.pdf
2. Crippa *et al.* (2022) CO_2 emissions of all world countries – JRC/IEA/PBL 2022 Report

Sustainability in the healthcare sector

2.2 g
per wipe

817 million
wipes used in 2022

1 800 tons
of plastic

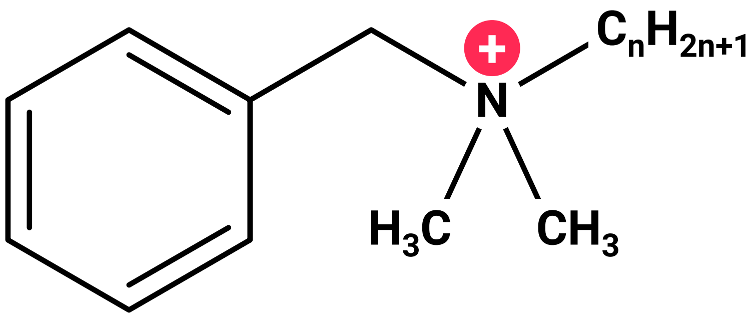


Alternative fibre materials for non-woven

	synthetic fibre	**bio-synthetic fibre** synthetic polymers from biobased raw material	**semi-synthetic fibre** from natural polymer, chemically modified	**regenerated fibre** from natural polymer, industrially processed
biodegradable		PLA PBS	cellulose acetate*	lyocell modal viscose
	fossil fuel-based	**biobased**		
not biodegradable	PET PA PP	PET PA PE	cellulose acetate*	

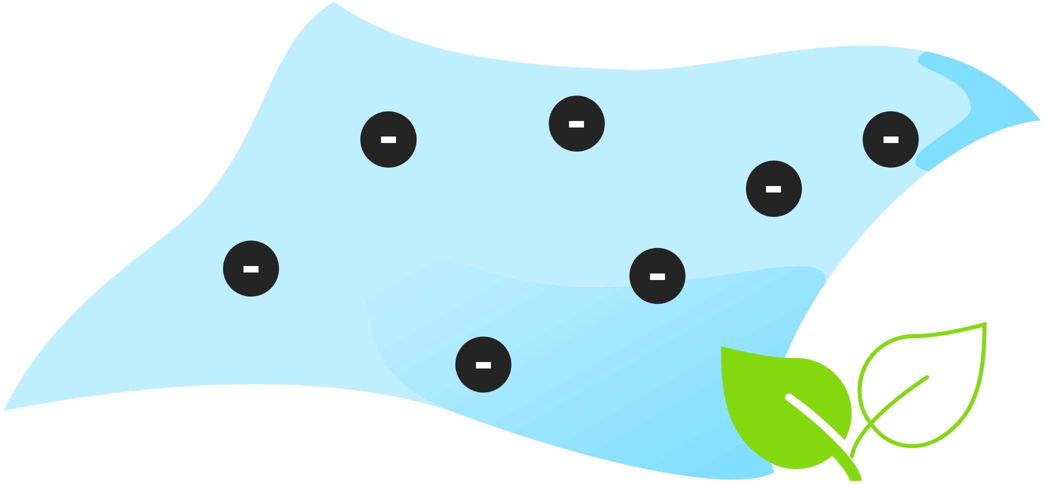
* Depending on the degree and type of chemical modification, cellulose acetate is biodegradable or not.

Incompatibilities possible with biobased fibres



Quaternary ammonium compound
e.g. benzalkonium chloride

Cellulose-based disinfectant wipe
e.g. viscose



Active substances can be adsorbed onto the biobased fibre material

The sustainable future of surface disinfection

organic acid complex

The sustainable future of surface disinfection

Sustainability

- Packaging
- Wipe material
- Formulation

- made from only one type of plastic (monofoil)
- 100% plastic-free, natural fibre
- more than 98.5% ingredients of natural origin

organic acid complex

Material compatibility

- excellent compatibility with all surfaces close to the patient, e.g. acrylic glass

Less harmful to people and environment

- no hazard symbols, no hazard or precaution statements
- all ingredients are biodegradable and do not accumulate

Microbiological efficacy

- Bactericidal, yeasticidal, and virucidal in 2 min (EN 14476 & EN 16615)

HARTMANN

Helps. Cares. Protects.

Thank you for your attention

Use surface disinfectants safely.
Always read the label and product information before use.

SCIENCE CENTER HARTMANN

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