New Multifunctional Textiles: Antimicrobial Treatments

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Multifunctional Textiles

- All citizens are permanently protected by flexible structures with barrier effect: **fire retardancy, noise and thermal insulation, shield against electrostatic or electromagnetic phenomena, filtration of dust or insects, etc.**

- The will to maximise the level of **safety in building, transportation** and to ensure the well-being of citizens, requires a whole re-design of flexible structure functions.

- Textile industry has to increase the **value added of its products to remain competitive**.

DEVELOPMENT OF MULTIFUNCTIONAL TEXTILES
OF INCREASED TECHNOLOGICAL CONTENT AND VALUE ADDED

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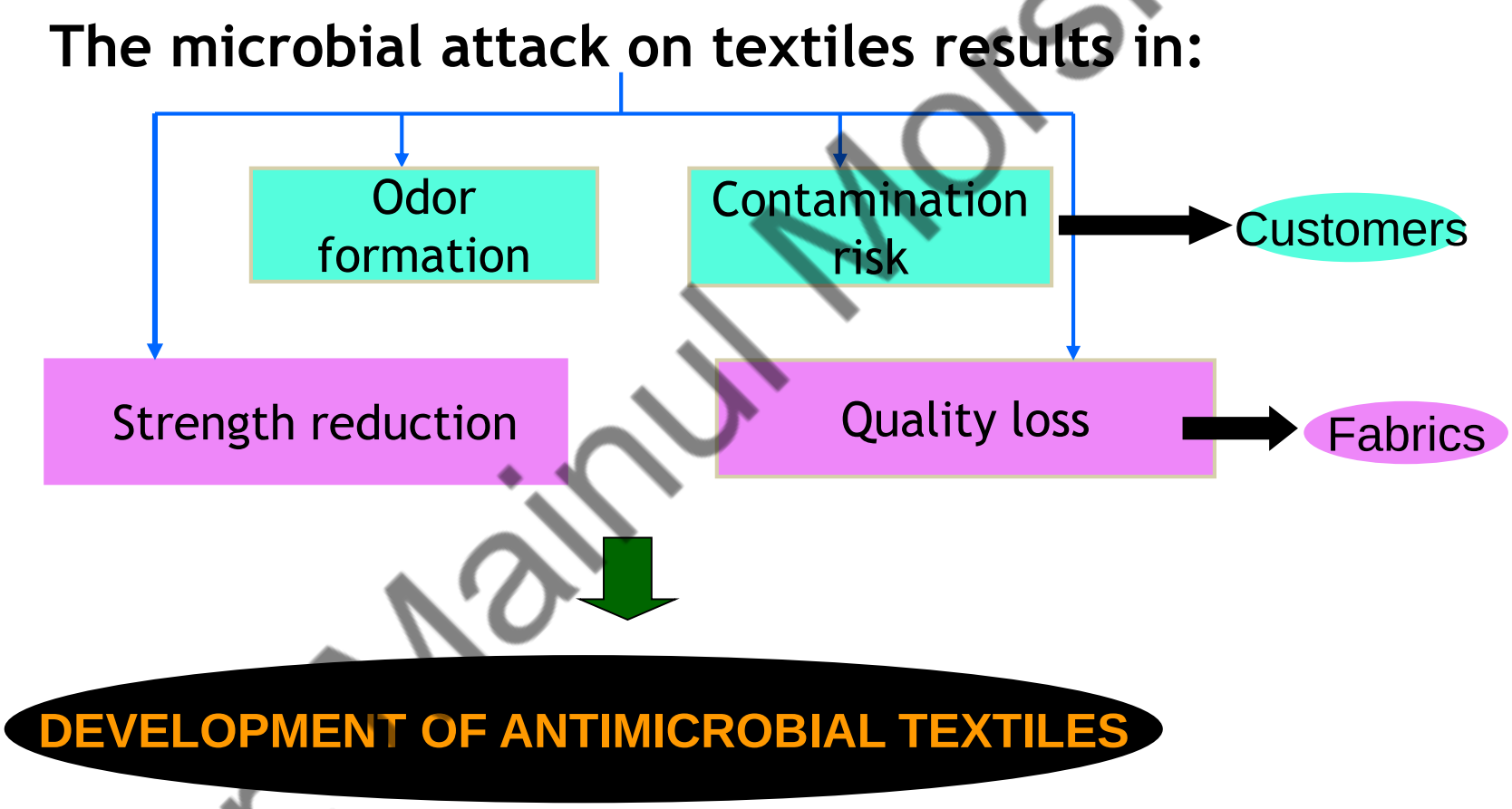
The Need for Antimicrobial Textiles



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Commercial Antimicrobial Textile Products

ANTIMICROBIAL FIBERS	
Commercial Name	**Company**
RHOVILAS ®	RHOVYL
AMICOR ®	COURTAULDS
AMICOR PLUS ®	COURTAULDS
SILFRESH ®	NOVACETA
MICROSAFE AM ®	HOECHST-CELANESE
BACTEKILLER ®	KANEBO
LIVERFRESH N ®	KANEBO
LIVERFRESH A ®	KANEBO
LUFNEN VA ®	KANEBO
SA 30 ®	KURARAY
BOLFUR ®	UNITIKA
FV 4503 ®	AZOTA-LENZING
CHITOPOLY ®	FUJI-SPINNING
THUNDERON ®	NIHO SANMO DYING

ANTIMICROBIAL TEXTILE FINISHES	
Commercial Name	**Company**
AEGIS ®	DEVAN
VANTOCIL IB ®	ZENECA
ACTICIDE ®	THEOR
KATHON ®	ROHM ET HAAS
PREVENTOL ®	BAYER
BIO-PRUF ®	MORTON
SANIGARD ®	SANDOZ-SANITIZED

ANTIMICROBIAL FIBER FINISHES	
Commercial Name	**Company**
AEGIS ®	DEVAN
EOSY ®	UNITIKA
EASOF ®	UNITIKA
UNIFRESHER ®	UNITIKA
BIOSIL B 89 ®	TOYOBO
BIOCHITON ®	ASAHI CHEM. IND.
BIO-PRUF ®	MORTON

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Some Commercial Antimicrobial Textile Products

Company	Product	Active agent	Fibre
Avecia, Zeneca, UK	Purista	PHMB (Reputex 20)	Cotton and synthetic
Aegis Environments, USA	BioGuard	QAC, Bond formation or micropolymerisation	Cotton and Synthetic
Novaceta, Italy	Silfresh	Triclosan	Acetate yarn
Rhovyl, France	Rhovyl AS	Triclosan	Synthetic
Ciba Specialty Chemicals	Tinosan	Triclosan	Cotton and Synthetic
Sterling Fibres, USA	Biofresh	Triclosan	Acrylic fibre
Acordis	Amicor Pure	Triclosan	Acrylic fibre
Thomas Research Associates, Canada	Ultrafresh, Silpure	Silver, added at finishing state	Synthetic
Trevira, Germany	Trevira Bioactive	Silver ions embedded in fibre.	Polyester
Nylstar, USA	Meryl Skinlife	Silver	Polyamide
Noble Fiber Technologies, USA	X-Static	Silver coated with 15-21% silver bonded to surface	Synthetic
O'Mara Inc, USA Sinterama, Italy DAK Americas, USA	MicroFresh SoleFresh GuardYarn Hydropur	Silver (Alphasan by Milliken). Added during extrusion process	Synthetic Yarn
AgION Technologies	AgION	Silver and inorganic ceramic	Synthetic
Kanebo Goshen, Japan	Livefresh N-NEO	Silver and ceramic ion exchange particle	Nylon
Cupron	Cupron	Copper compound. permanently bound to fibres	Synthetic

PHMB:PolyHexaMethylene Biguanide

QAC:Quaternary Ammonium Compounds

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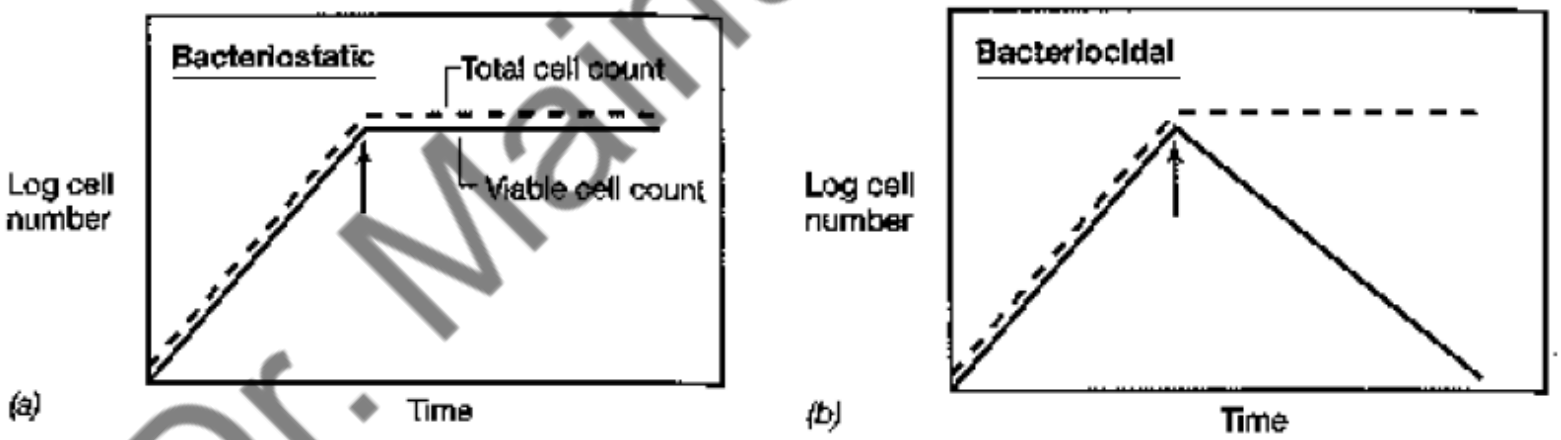
Antimicrobial Agents

- Antimicrobials are defined as the agents that either kill microorganisms or simply inhibit their growth.
- The degree of activity is denoted by:
  - «-cidal»: agent that **kill microorganisms**
  - «-static»: agents that **inhibits microorganisms' growth**



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Antimicrobial Agents

- **Antimicrobial Agents Kill Microorganisms or Inhibit Their Growth by:**
  - Cell wall damage
  - Inhibition of cell wall synthesis
  - Alteration of cell wall permeability
  - Inhibition of the synthesis of proteins and nucleic acids
  - Inhibition of enzyme action
- **Examples of Antimicrobial Agents:**
  - Metals and metal salts → deactivation of proteins
  - Quaternary ammonium salts → membrane damage
  - N-Halamines → oxidative properties
  - Others: organic molecules (e.g. Triclosan), natural substances (e.g. chitosan)

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Requirements for Antimicrobial Finishes

Antimicrobial textile finishes must exhibit:

- Effective control of bacteria, molds and fungi
- Selective activity towards undesirable microorganisms
- Absence of toxic effects for both the manufacturer and the consumer
- Durability of activity to laundering, dry cleaning, leaching
- Applicability with no adverse effects on the fabric
- Acceptable moisture transport properties
- Compatibility with other finishing agents
- Easy application, compatibility with common textile processing

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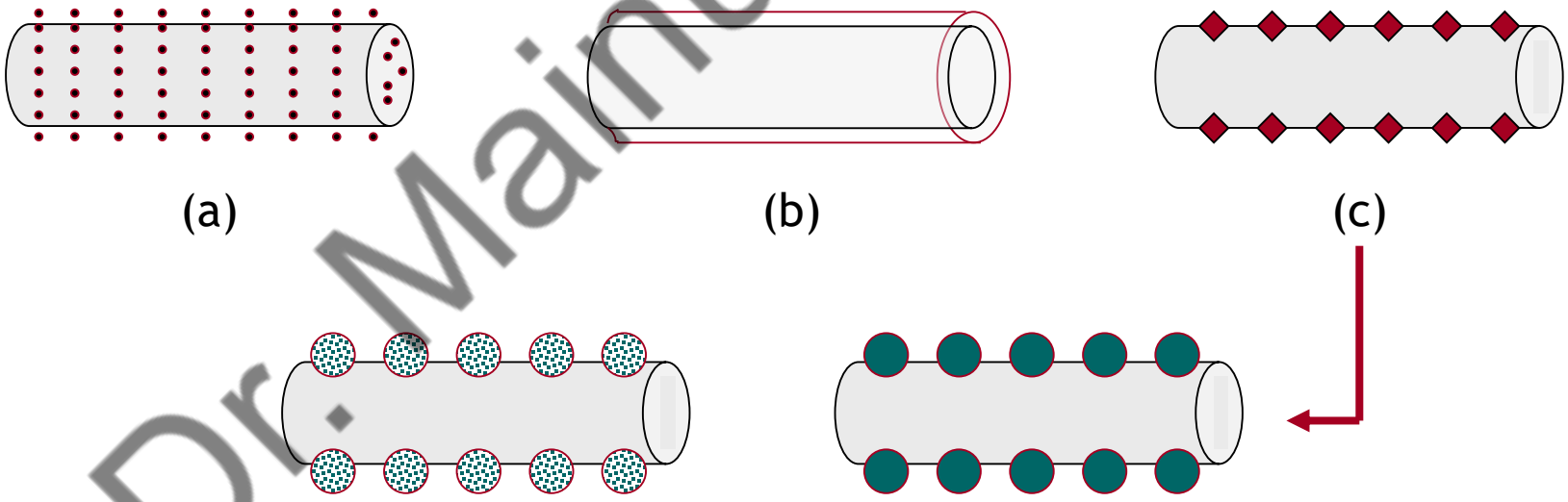
Antimicrobials Delivery Technologies

(a) **Internal Antimicrobial Release:** Viable option for **synthetic fibers**, where antimicrobials can be incorporated into the fibers when they are spun.

(b) **Surface Application:** Applicable to all fibers. The washing durability depends on materials affinity. **Surface application may interfere with textile handling properties.**

(c) **Chemical Bonding:** The best way to **achieve durability.** It requires suitable reactive groups on the textile.



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Antimicrobials Mode of Action

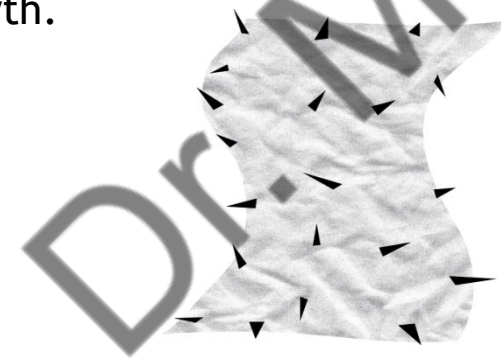
An antimicrobial textile can act in **two distinct** ways:

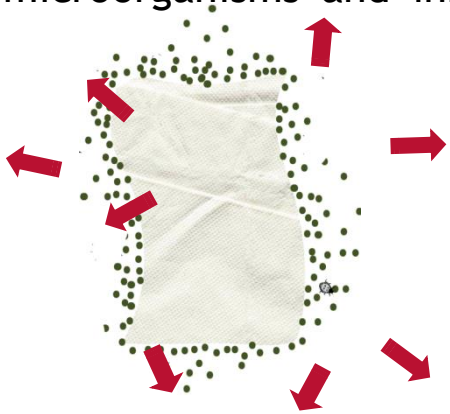
- **By contact:**

  The antimicrobial agent placed on the fiber **does not disperse** and, to attain the antimicrobial action, microorganisms have to contact the fiber.

- **By diffusion:**

  The antimicrobial agent placed on the surface or in the fiber **disperses** more or less rapidly in a humid external medium to reach the microorganisms and inhibit their growth.





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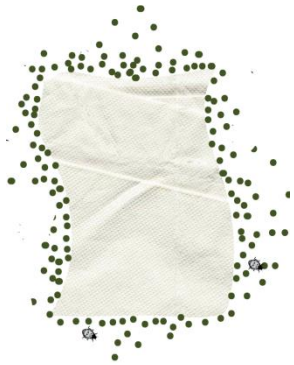
Migrating Antimicrobials



- **Diffuse from the substrate to come into contact with the microbe**
  - Migrate out of the substrate into the environment when in contact with water or humid conditions
  - Are consumed by micro-organisms
  - Chemically interrupt (poison) the cell
  - May cause adaptive micro-organisms

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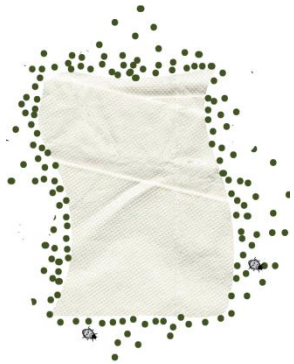
Migrating Antimicrobials



- Examples of anti-microbially active substances that require migration for their action:
  - Bis-chlorinated phenols (Triclosan)
  - Organo-tin compounds (i.e.TBT)
  - Heavy metal-organo complexes (Pb,Hg,As,…)
  - Water Soluble Quaternary compounds
  - Ag & Cu absorbed on carrier (zeolite, TiO_2, etc)
  - Chitin (Chitosan)
  - Biguanide

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Non Migrating Antimicrobials

- Are bonded to the substrate and require intimate surface contact with the microbe

  - Are bonded to the product surface
  - Are not consumed by micro-organisms
  - Mechanically interrupts (stabs) the cell wall
  - Remain functional for the life of the product
  - Will not cause adaptive micro-organisms

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Non Migrating Antimicrobials

- Examples of anti-microbially active substances that **do not migrate** in order to be active are:
  - Organo functional silanes
  - N-halamines
  - Grafting by irradiation

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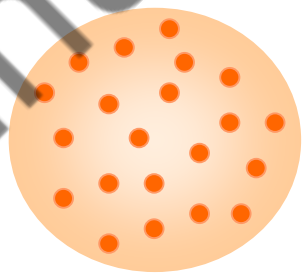
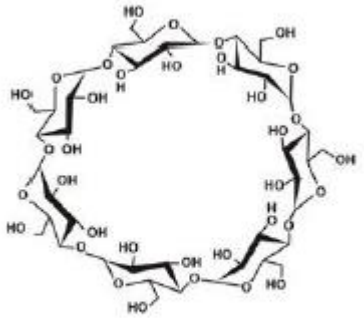
Controlled - Delivery Systems

- **Microcapsules:** the active agent forms a core surrounded by an inert diffusion barrier.
- **Microspheres:** the active agent is dispersed or dissolved in an inert polymer.
- **Cyclic Molecules:** the active agent is entrapped in the cavity of cyclic molecules (e.g. cyclodextrines).

microcapsule



microsphere



ß-cyclodextrin

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Preparation Methods of Microspheres / Microcapsules

The most commonly applied methods for microcapsules / microspheres preparation are:

- Solvent evaporation
- Precipitation polymerization
- Suspension crosslinking
- Phase separation - coacervation

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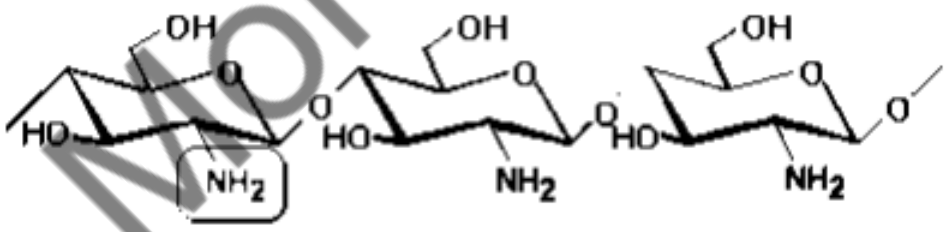
Chitosan

- Chitosan is a non-toxic, biodegradable, natural polysaccharide.
- **The only difference between chitosan and cellulose is the presence of amine (-NH/ -NH_2) group in the position C-2 of chitosan instead of the hydroxyl (-OH) group in cellulose.**



Chitosan

- Chitosan inhibits bacteria growth.
- Chitosan can form insoluble network (through its amino or hydroxyl groups).
- Due to the reactive hydroxyl groups chitosan can be chemically bound on cellulose through common durable press finishes.

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Antimicrobial Activity Tests

SN 195920-1992	Textile fabrics: Determination of the antibacterial activity: Agar diffusion plate test	Agar diffusion tests, semi-quantitative
SN 195921-1992	Textile fabrics: Determination of the antimycotic activity: Agar diffusion plate test	
AATCC 30-1993	Antifungal activity, assessment of textile materials: Mildew and rot resistance of textile materials	
AATCC 147-1993	Antibacterial assessment of textile materials: Parallel streak methods	
AATCC 90-1982	Antibacterial activity of fabrics, detection of: Agar plate method	
AATCC 174-1993	Antimicrobial activity assessment of carpets	
JIS L 1902-1998	Testing method for antibacterial of textiles	
AATCC 100-1993	Antibacterial finishes on textile materials: assessment of	Challenge test, quantitative
SN 195924-1983	Textile fabrics: Determination of the antibacterial activity: Germ count method	
XP G39-010-2000	Properties of textiles-Textiles and polymeric surfaces having antibacterial properties. Characterization and measurement of antibacterial activity	
JIS Z 2911-1992	Methods of test for fungus resistance	Fouling tests, soil burial tests
ISO 846-1997	Plastics – Evaluation of the action of microorganisms	
ISO 11721-1-2001	Textiles – Determination of resistance of cellulose containing	
New Methods	ISO TC38 WG23: “Testing for antibacterial activity”, CEN TC248 WG 13: “Textiles – Determination of the antibacterial activity – Agar plate diffusion test”	

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Concluding Remarks

- Antimicrobial agents are used in the textile sector, principally for hygiene applications.
- There are several commercial agents that can render a textile antimicrobial.
- **The characteristics of an ideal antimicrobial textile are:**
  - Permanent antimicrobial properties that are not lost during usage or washing
  - Antimicrobial activity on a wide range of microorganisms
  - The antimicrobial effect has to be limited on the surface of the textile, to not interfere with skin bacteria
  - It should not contain toxic migrating substances
- The efficacy of antimicrobial textiles may be estimated through standard test methods.

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