Functionalising textiles using environmental friendly techniques

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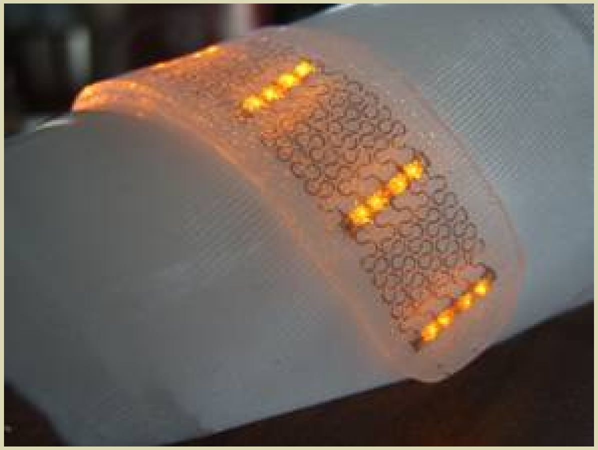
Outline

- Outline:
  - Introduction
  - Hot melt
  - UV coating
  - Plasma treatment
  - Summary

Introduction

Introduction

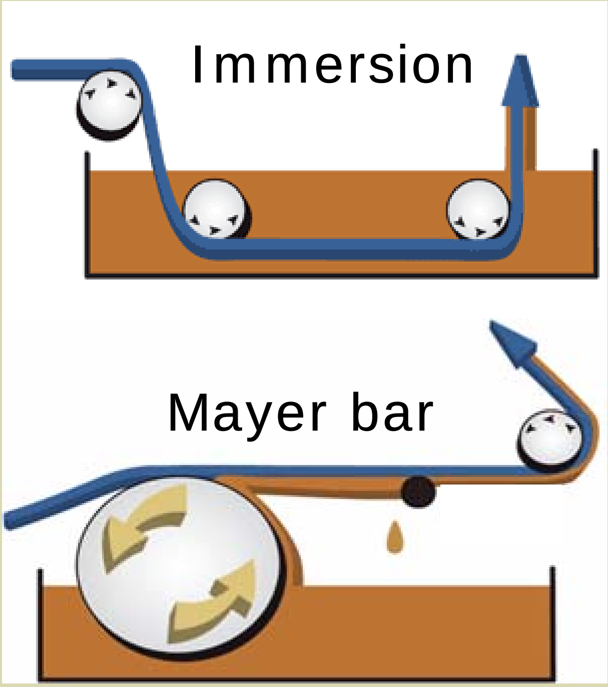
Increasing importance of textile functionalisation/ finishing



Introduction

- Several traditional methods for textile functionalisation
  - E.g. immersion, Mayer bar,…
- But:
  - Solvent-based: environmental problems
  - Water-based:
    drying → energy requirement
  - Typical numbers:
    - 1 kg of textile requires 50 litre of water
    - Temperature: 50 – 70 °C
    - Energy use in textile industry:
      60% is for heating/drying

→ Clear need for alternatives

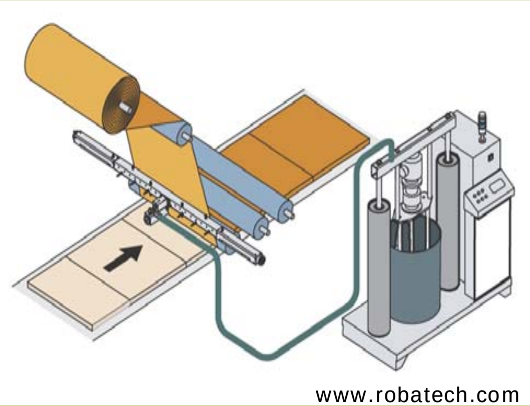


Figures: weben.icapsira.com

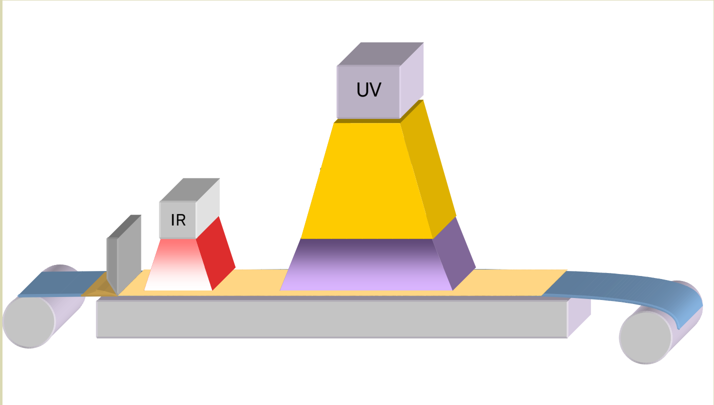
Introduction

- Highlight three alternatives:

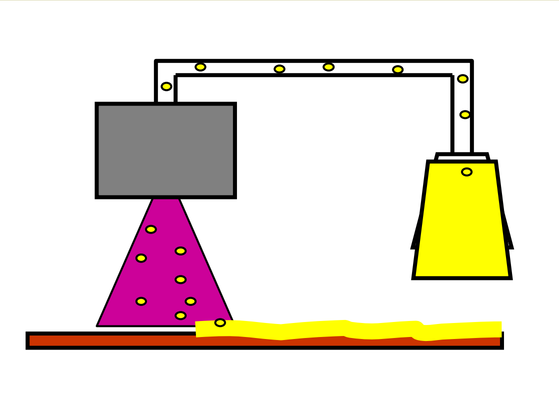
Hot melt



UV Coating

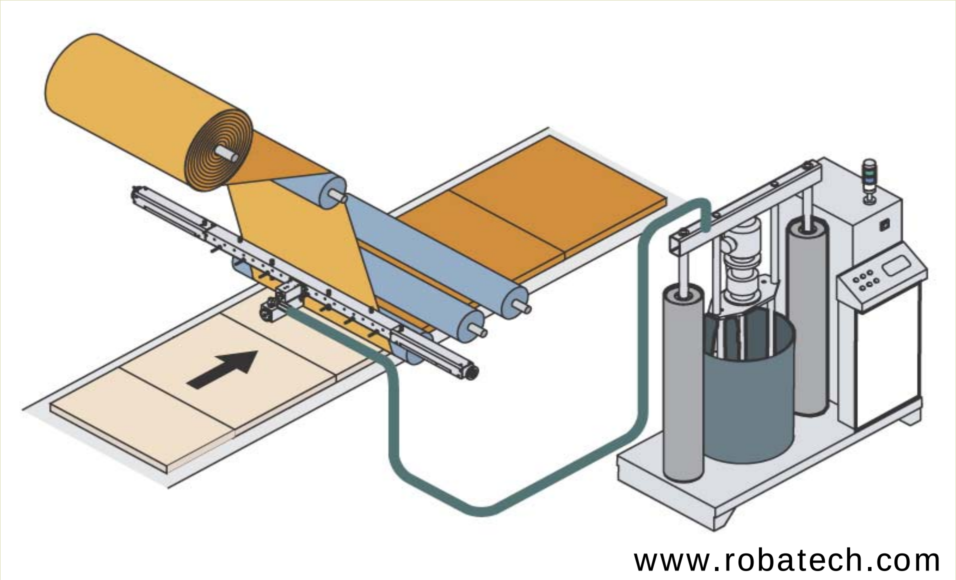


Plasma treatment



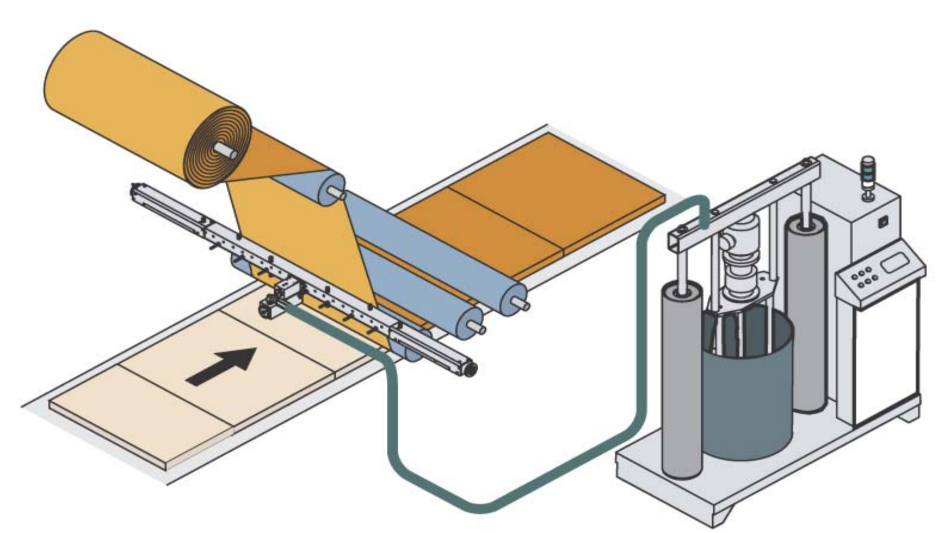
- Not included: powder coating, extrusion coating, …

Hot melt



Basics

- Hot melt:
  - 100% system (granulates, blocks,...)
  - Melting of the polymer
  - Application as melt
  - Solidifying → Coating
- Two main groups (curing based):
  - Thermoplastic hot melts:
    - Solidifying via cooling
    - Materials: PE, PP, PES, PA, EVA, TPU, silicone
  - Reactive hot melts:
    - Solidifying via cooling + drying or UV irradition
    - Materials: PU, APAO's


www.robatech.com

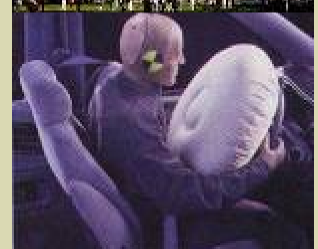
Applications: properties/ functionalities

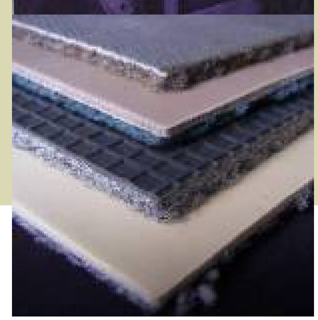
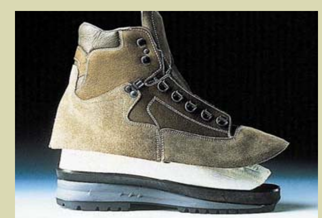
- Important properties/ functionalities:
  - Fire retardant
  - Antimicrobial
  - Fibre & pile binding
  - Delamination
  - Tear and tensile strength
  - Dimensional stability (domestic washing and drying)
  - ...
- *No* new functionalities









Hot melt ↔ other coatings

Parameter	Water based paste	Solvent based paste	Powder coating	Hot melt coating
Water	Yes (40 – 60%)	No	No	No
Solvent	No	Yes (50 -70 %)	No	No
Emission	Yes (in oven)	Yes (in oven) + hood compulsory for solvent fumes	No	Potentially at high temp. with reactive PU
Energy use	High (water evaporation)	Relatively high (solvent evaporation)	Lower (powder melting)	Even lower (hot melt polymer melting)
Waste	Paste	Solvent containing paste	Negligible – powders can be re-used	Negligible – polymer can be re-used (except. reactive polymer)

Energy use: hot melt ↔ water based

- **Comparison:** water based dispersion vs. hot melt
- **Process assumptions**:
  - Textile substrate weight: 150g/m²
  - Dry coating weight: 30g/m²
  - Line speed = 30m/min
  - Width = 1.80m
  - Water based coating:
    - 50% water in formulation
    - Energy: for water evaporation
  - Hot melt coating:
    - PO polymer, melt temperature 160°C
    - Energy: heating and melting of the polymer
- **Following results**:
  - Standard coating: 210 kJ/m²
  - Hot melt coating: 56 kJ/m²

Hot melt / standard ≈ 27%

Advantages and disadvantages

Advantages

- High line speed
- Short production lines (no oven)
- No solvents (safety)
- No auxiliary products
- No specific preparation to produce coating paste (↔ conventional coating via “paste” or “foam”)

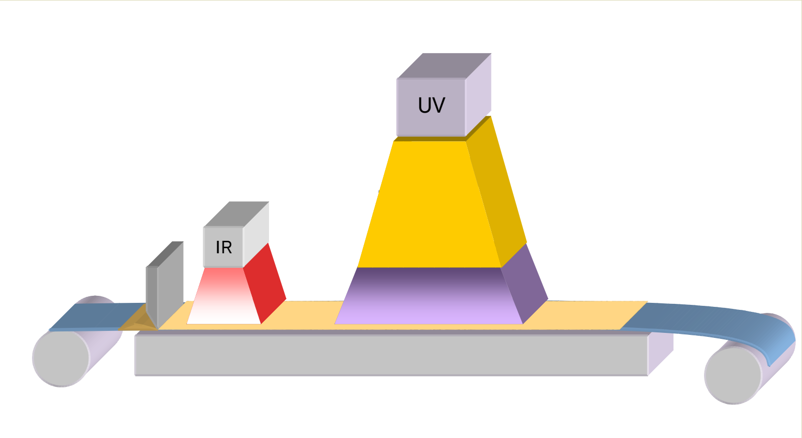
Disadvantages

- Limited flexibility for functional additives
- Tactile properties

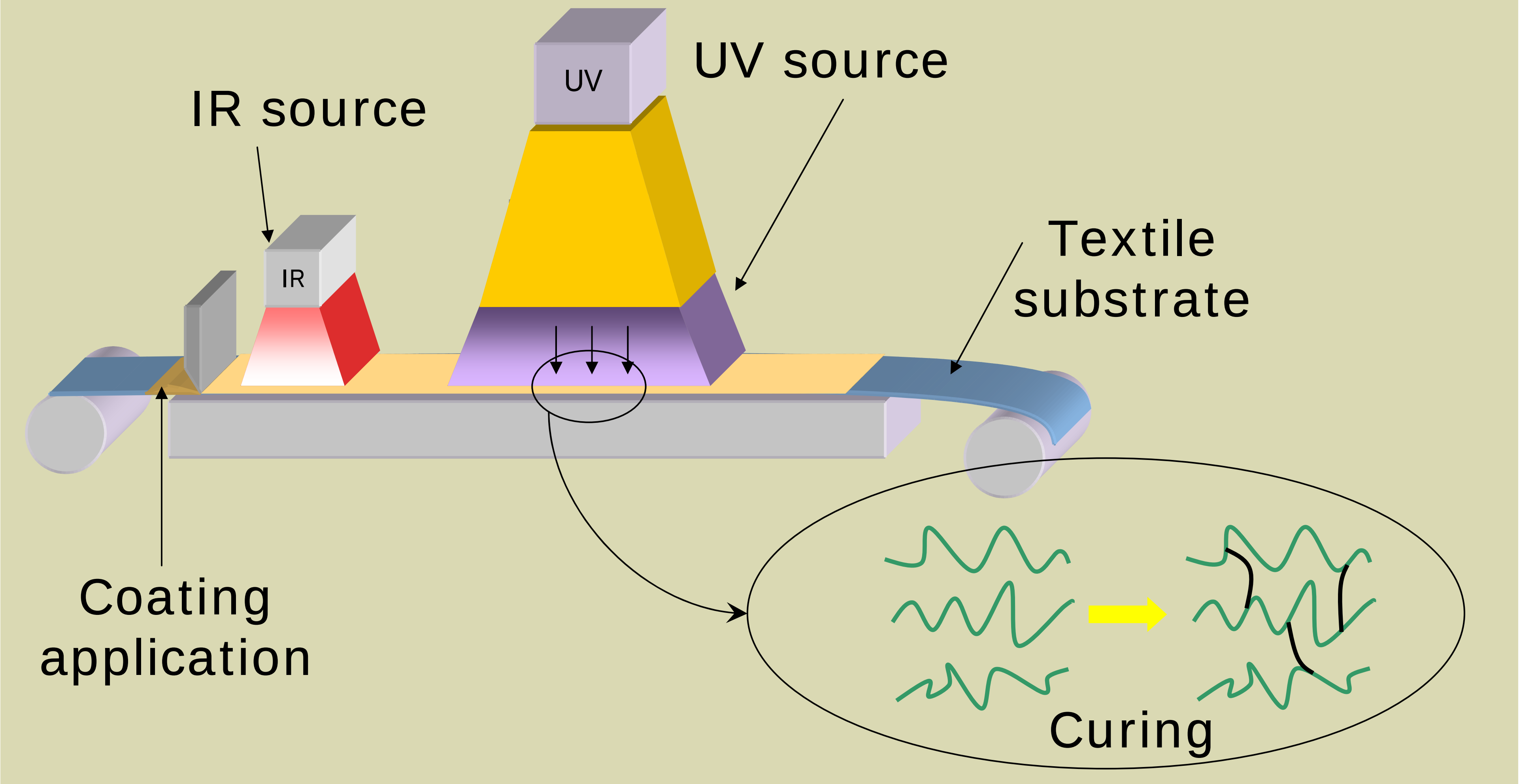
Industrial use

- Well-integrated for lamination
- R&D for (functionalised) coating via hot melt

UV coating



Principle



UV
UV source
IR source
IR
Textile
substrate
Coating
application
Curing

UV coating formulation

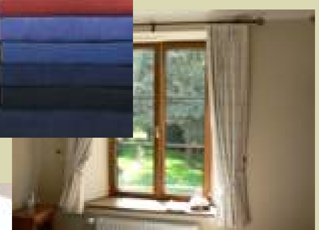
- Oligomers:
  - Adhesion, flexibility, shrinkage, …
- Monomers:
  - Monofunctional:
    - Flexibility, reactivity, …
  - Multifunctional:
    - Adhesion, shrinkage, …
- Photo initiators
- Thickeners/ thinners
- Additives

Process

- Process parameters:
  - UV source:
    - Type (Hg, doping with Fe, Ga, …)
    - Power (W/cm^2)
  - Distance between UV source - textile
  - Line speed
  - Heat production

Textile application field

Furnishing fabrics
Mattress ticking
Curtains
Wall covering



Materials

Properties

Abrasion resistance
Light fastness
Comfort properties
Tactile properties
Colour fastness

Energy use: UV ↔ water based

- **Comparison:** water based dispersion vs. UV coating (100%)
- **Process assumptions**:
  - Dry coating weight: 30g/m²
  - Textile weight: 150g/m²
  - Line speed = 30m/min
  - Width = 1.80m
  - Water based coating:
    - 50% water in formulation
    - Energy: for water evaporation
  - UV coating:
    - Energy: UV lamp
- **Following results**:
  - Standard coating: 210 kJ/m²
  - UV coating: 91 kJ/m²

UV / standard ≈ 43%

Advantages and disadvantages

Advantages

- Solvent free → reduced emissions
- High line speed
- Coating quality
- Reduced water use

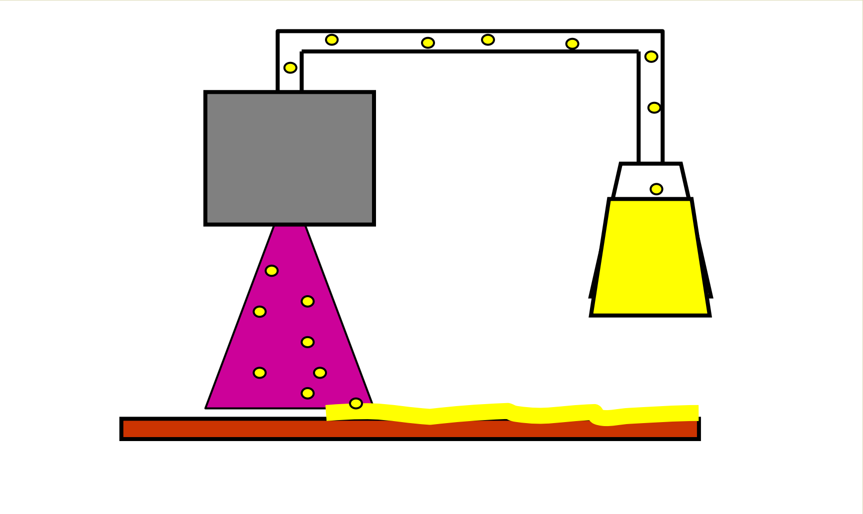
Disadvantages

- Additives (e.g. pigments) can interfere with UV light, reducing the curing
- Price of coating formulation
- Adhesion

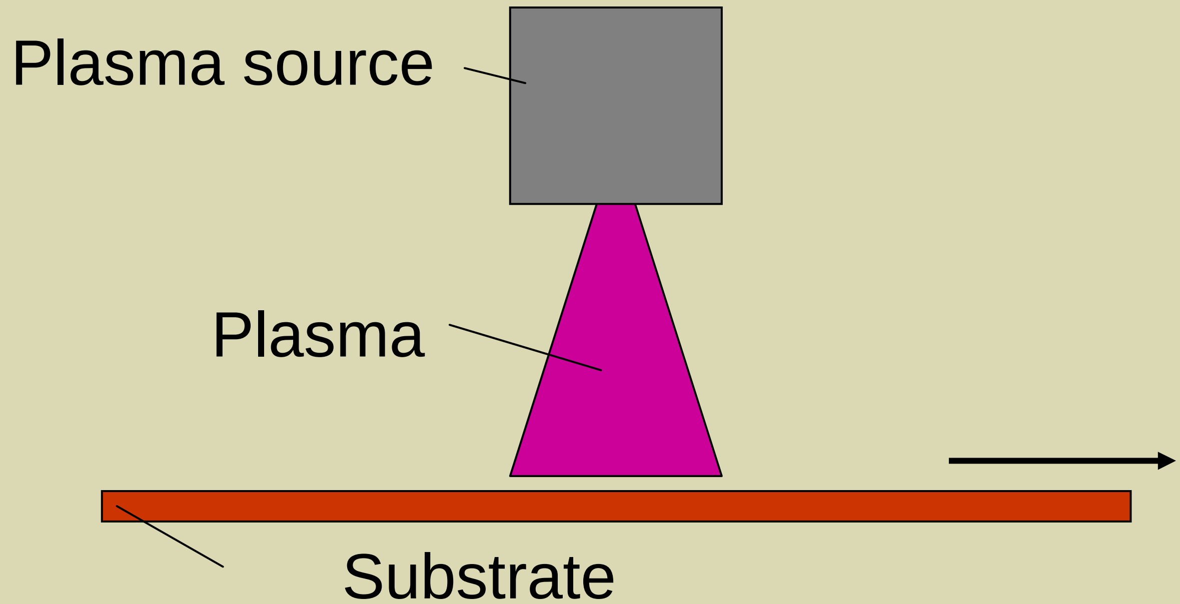
Industrial use

- R&D efforts for textile applications

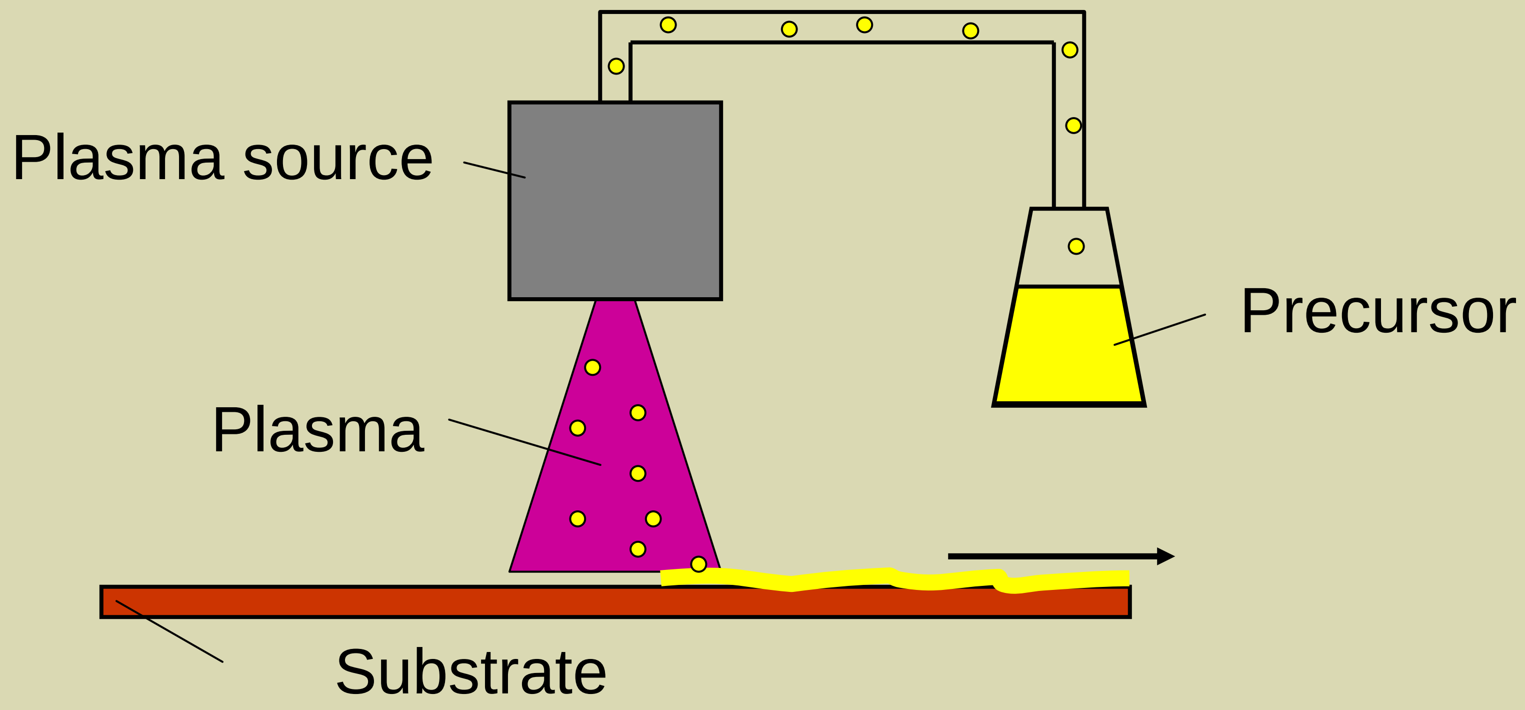
Plasma treatment



Plasma treatment



Plasma coating



- Plasma + Precursor (chosen according to the desired properties)
- Coating possible → permanent change of the surface properties
- Crucial: interaction between precursor and plasma

Possible textile applications

- Possible textile applications:
  - Oleophobic
  - Hydrophobic
  - Hydrophilic
  - Primer layer
  - Anti-fouling
  - Anti-microbial
  - Biocompatibility
  - ...

- Possible with traditional techniques $\rightarrow$ why use plasma ?

Example: antibacterial coating

- Atmospheric plasma deposition of antibacterial agent
- Surface analysis:
  - Uniform layer
  - Coating thickness: 2-5 nm
- Functional analysis:
  - Good antibacterial response
- Durability:
  - Good abrasion resistance

ToF-SIMS image, Size = $5x5mm^2$

→ Functional, durable effect with minimal add-on possible

Energy use: oleophobic process for PES

- Comparison of environmental impact:

Treatment	GWP (kg CO2)	AP (g eq SO2)	POPC (g C2H4)	EU (g PO43-)
Plasma	0,4	1,22	0,19	0,26
Traditional	1,67	2,36	2,81	0,76

Legend:

- GWP: Global Warming Potential, i.e. CO_2 emission
- AP: Acidification of ground, air, water
- POPC: Photochemical ozone creation, i.e. contribution to ozone formation
- EU: Eutrophication

- LCA Analysis of energy use:
  - Plasma process = 1/3 of traditional process

Source: www.acteco.org

Advantages and disadvantages

Advantages

- No influence on the bulk properties
- No influence on “hand”
- Functionalisation “within” substrate
- Energy saving: no water involved
- Reduced ecological impact

Disadvantages

- Limited add-on
- Treatment width
- Maximum line speed

Industrial use

- Sporadic use as pre-treatment step (plasma activation)
- R&D efforts plasma coating

Conclusions

- Textile finishing:
  - Replacing traditional water and solvent based coatings
  - Hot melt – UV coating – Plasma treatment
- All have their specific (dis)advantages, generally:
  - Disadvantages:
    - Drawback coating characteristics (e.g. stiffness, thickness,…)
    - Limited throughput
  - Advantages:
    - Minimising environmental impact
    - Strongly reduced energy use
- Technologies (becoming) ready for industrialisation