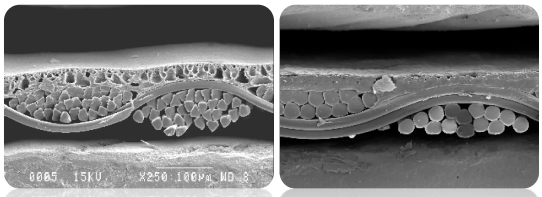
Coating Technology: State-of-the-Art & Future Perspectives



Sirris: 21.10.2014
Gent
Prof Dr Marc Van Parys - UNITEX

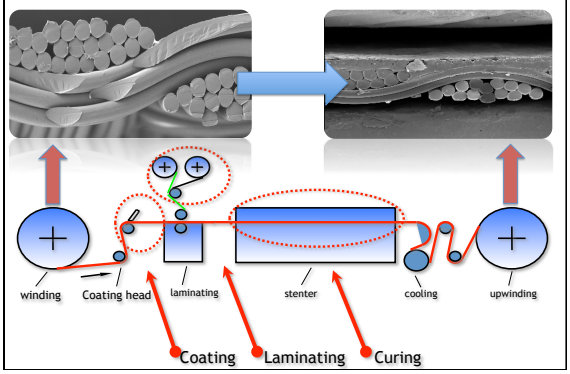
Field of Applications	Product examples	Anticipated growth
Agrotech	Covering foils, pond foils ...	3,2 %
Buildtech	Diaphragms, weather protection, solar cells ...	4,3 %
Clothtech	Shoes, smart textiles, waterproof textiles ...	2,7 %
Geotech	Dam @ Refuse dump construction, drainage & filtration textiles ...	4,6-8,5 %
Hometech	Floor coverings, furniture upholstery, furniture covers, wall coverings ...	2,7 %
Indutech	Conductive textiles, 3D textiles, fuel cells ...	3,5 %
Medtech	Medical hygiene textile, napkins, plasters ...	4,6 %
Mobitech	Aircraft, automobile @ ship building, airbags truck tilts ...	4,6 %
Packtech	Packaging materials, fluid products ...	3,2 %
Protech	Special work wear (bullet & fireproof jackets, sun shades ...	2,5-3,2 %

Materials for Sportswear

Intelligent textiles

- Adaptive – SSP – Shape memory textiles
- Sensoric textiles
- Slow-Release systems
- Self-healing
- Phase-change-materials (PCMs)
- Self-cleaning textiles
- Self Diagnostic textiles
- IR Reflection
- EC-textiles
- Superparamagnetic textiles
- Data & Signal Transmission
- Light Transmission

Solvent & Waterbased systems



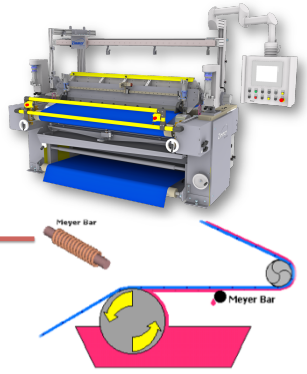
CONVENTIONAL COATING TECHNIQUES

Direct Coating

- Knife coating
  - Knife over air
  - Knife over roll
  - Knife over blanket
- Screen coating
- Kiss roll
- DIP coating
- Spray Coating

Indirect Coating

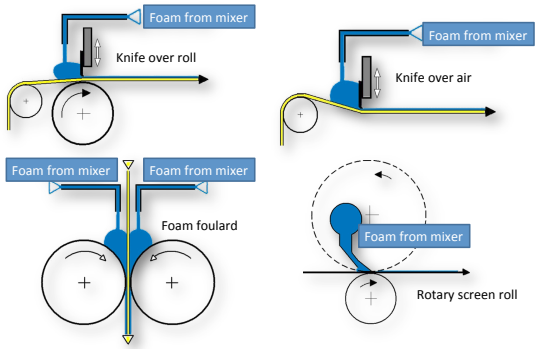
- Transfer coating
- Reverse roll
- Gravure coating



Classification according to the physical properties

Medium	**Solvent**	DMF, Toluene, MEK …
		Water
	Dispersion	Macro
		Micro
	Paste (Foam)	Organosols – hydrosols
		Plastisol
	100%	Solids (Hot melt)
		Liquids (radiation curable)

Paste - Foam Coating



Overview COATING polymers

Polymers	PVC
	Poly acrylates
	PUR
	Silicones
	Fluorcarbons
	Specialty elastomers

NEEDS OF TEXTILE INDUSTRY

INNOVATION

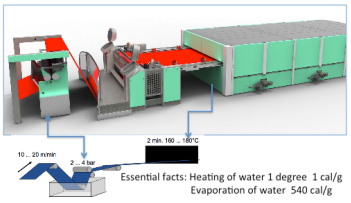
AN OVERALL APPROACH TO THE NEEDS OF TEXTILE INDUSTRY DEMANDING FOR **CHANGING PRODUCTION STRATEGIES**

- FLEXIBLE, VERSATILE PRODUCTION
- SHORTER RUN LENGTHS (OFTEN < 100 m)
- REDUCED OF RESOURCES (WATER - ENERGY – CHEMICALS)
- INTEGRATION OF MANUFACTURING PROCESSES – **New Business Models**
- CHEAPER COSTS (TOTAL COST)
- REDUCED STOCKS

GROWING DEMAND FOR TEXTILE PRODUCED USING **SUSTAINABLE OPERATIONS** AND FOR **PRODUCING PRODUCTS CLOSER** TO THE MARKET

digifun Water & Energy issues

Actual Situation In textile finishing



1 kg Textile = 30 l Water

1.	Initial moisture:	70 %	Heat energy:	674 kW with HR	53 m/min
	Residual moisture:	8 %	Electrical energy:	117 kW	
	Temperature:	130/150 °C			
	Air:	1450 rpm			

- Water availability and access become critical issues
- Cost of water & energy use varies greatly across Europe
- Water legislation becomes stricter, raising compliance costs

Solventbased Coatings (DMF, MEK, Toluene …)

- VOC/HAP
- Inflammable
- Afterburning residus
- Solvent recuperation

High Risk – Toxic – Hazardeous - SVHC substances

- Brominated FR-retardants (PBB, PBDE …)
- Some Phosphates (indoor air quality)
- Heavy metals – Hg, Cr^{6+}, Pb, Cd …
- Formadelhyd binders
- C8-Fluorcabons …

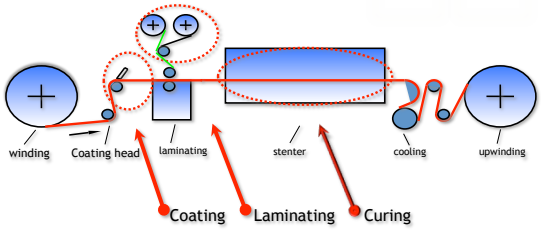
FEELING MORE PRESSURE

NEAR TERM STRATEGY HORIZON 2020

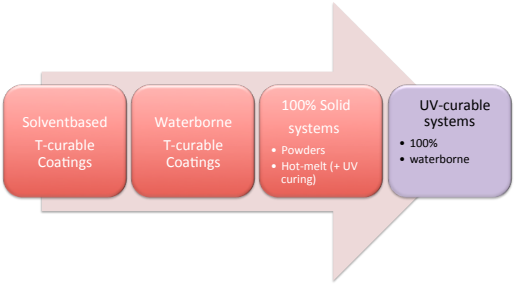
GREATER RESOURCE EFFICIENCY

Solvent based systems → **Water** based systems → **100%** systems

Limited to → Powder | Hot melt



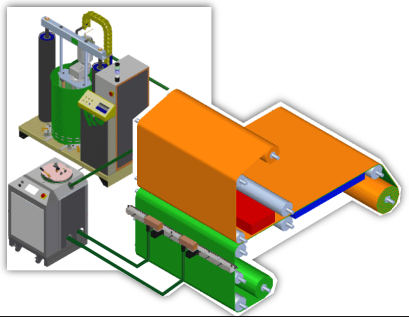
CHANGE THE COURSE:
FROM WET TO DRY



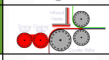
Recent – Future Coating Technologies

- Hotmelt Coating, incl. UV- hotmelt coating
- UV-EB coating
- Plasma Coating
- New Curing systems
  - Plasma - Microwave
- Digital Coating
  - Piëzo
  - Valve-jet
- Magnetron Sputtering
  - Non Reactive
  - Reactive

100% Systems
Powder & HOTMELT

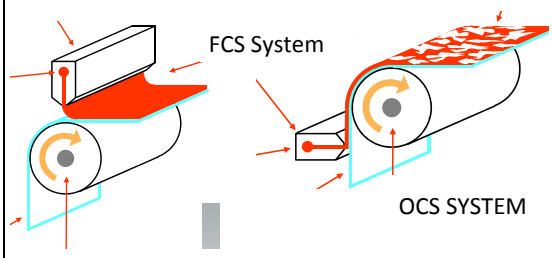


100% Solid Coating Systems

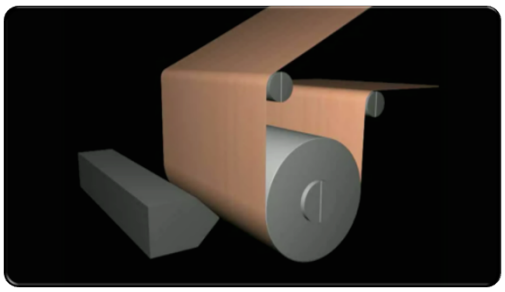
Compound	Method	Lay-out	Remarks	Application level/speed
Powder	Scatter coating		- Easy technology - Especially for applying glues - Quick change powders - Dust formation possible	5-500 g/m2 10-50 m/min
Hot melts	Slot die		- Indirect method - Thin coatings possible - Investment high - Maintenance	15-80 g/m2 80-240 m/min
	Reverse roll		- Relative cheap method - 'Simple' system - Limited production speed	40-1000 g/m2 50 m/min
	Spray		- Different possibilities (dots, lines, ...) - Relatively high cost	5-100 g/m2 10 - 170 m/min
	Screen		- Design coating possible - Dot coating - Expensive technique	15-25 m/min

- Possibility of OCS (Open Coating System) or FCS (Full Coating Systems)
- Continu coating, intermittent, stripes, ...
- One or both side application
- Many hotmelt suppliers such as Kleiberit, Dakota Coatings, Schaetti, ECS, Forbo, Jowat
- Different Hotmelt-systems
  - **Non-reactive hotmelts** : EVA, PUR, copolyamide, copolyester ...
  - Reactive hotmelts : reactive side-group (R-N=C=O) reacting with each other and substrate Activation by
    - **T - Humidity**
    - **UV or EB-radiation**
    - Physical + Chemical Adhesion
    - High Solvent & T-resistance

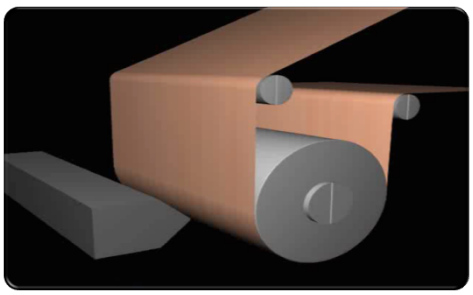
HOTMELT Possibilities



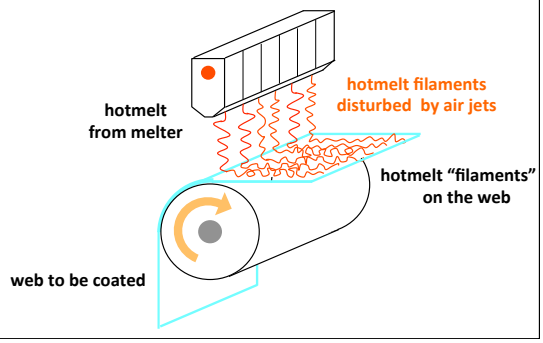
Slot-die Coating - FCS coating



Slot-die: Intermittent coating



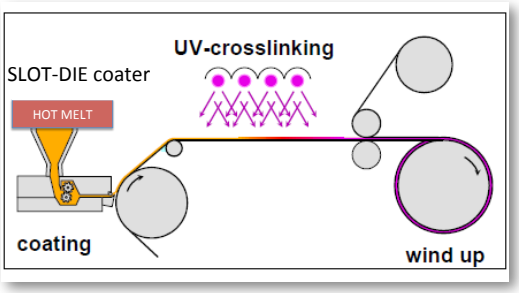
Spray Hotmelt



Why choosing Hot Melt-Technology?

- Production of full recyclable products (waste reduction)
- Substantial lower need for "floorspace"-> compact units
- Shorter changeover times (attractive for small production runs < 1000 m)
- High production speeds, resulting on additional cost reduction (energy) Limited "Capex" (no need for thermal oven & afterburner)
- Possibility for incorporation Functionalities

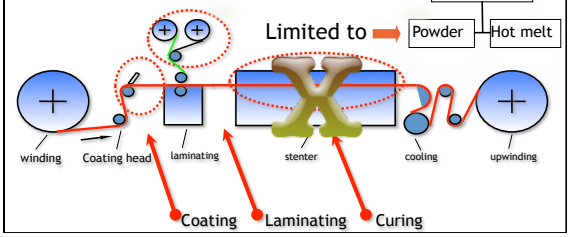
UV-Hot Melt



- Physical + Chemical Adhesion
- High Solvent & T-resistance

Solvent based systems → **Water** based systems → 100% systems

Limited to → Powder | Hot melt



UV-Coating

Liquid UV-coatings

100% UV-formulation

Waterborne UV-formulation

2-systems

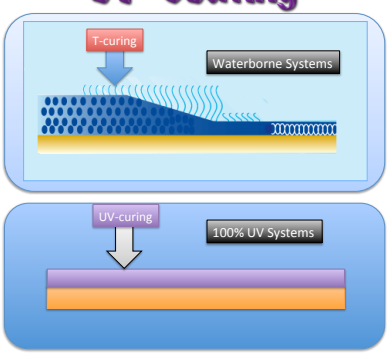
100 % UV-system

- Most important group
- Monomer diluent
- Liquid
- No solvent/water (no drying)
- Formulation (oligomer ...)
- UV-LED Fixation

Waterborne UV-system

- Waterborne dispersion
- Mainly without monomer
- Thickener (Important !)
- Water evaporation - (IR) drying
- UV-LED fixation

UV-Coating

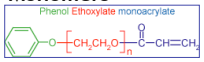


UV-Coating

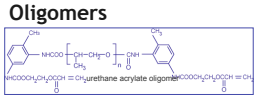
NEW CHEMISTRY !!!

Monomers

Phenol Ethoxylate monoacrylate



Oligomers



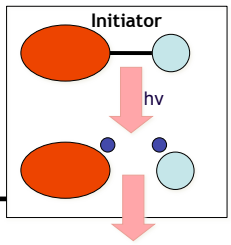


Photo-initiator

Others:

adhesion promoters, O2-inhibitors ...

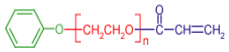
Monomer Selection

Monomer	Flexibility	Reactivity	Solvent resistance	Tensile strength	Shrinkage	Adhesion
Mono	↑	↓	↓	↓	↓	↑
Di						
Tri						
Tetra						

Monomer thinner:

- low MW
- network incorporation
- no volatilization
- choice: wetting, flexibility & low shrink

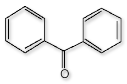
Phenol Ethoxylate monoacrylate



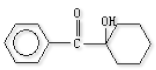
3. PHOTO-INITIATORS

Examples:

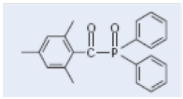
1. Benzophenone - 254 nm



2. 1-hydroxy-cyclohexylphenyl-keton
   247, 280, 333 nm



3. Diphenyl (2,4,6 **t**rimethylbenzoyl) **p**hosfine **o**xide –
   TPO Type - 380 nm



4. ADDITIVES

1. **Monomer thinner**
   2- (2-ethyoxyethoxy) ethylacrylate , tetrahydrofurfuryl metacrylate & 2-fenoxy-ethylacrylate
2. **Stabilisators**
   - avoiding premature polymerisation during exposition
   - radical scavengers f.e. HALS, additional protection against direct sunlight (anti-yellowing property)
3. **O2-inhibitors**
4. **Adhesion promotors** - f.e. organosilanes
5. **Pigments**
   - absorbing or scattering UV--lightt à inhibition UV-curing
   - majority UV-curable coatings: pure or silica
   - proper choice of photo-initiator or combination UV-formulation with white coloured pigment possible

UV-LIGHT SPECTRUM

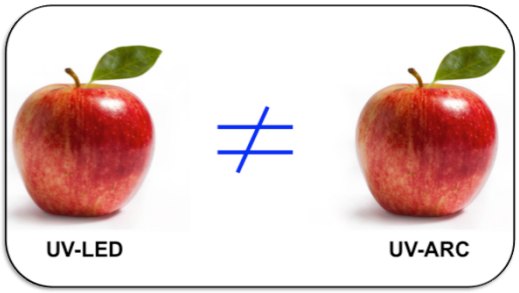
RADIATION SOURCES

UV-ARC (Ga, Fe, Hg)

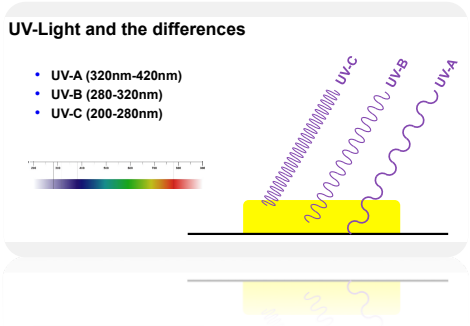
UV-LED (395 nm)

EB

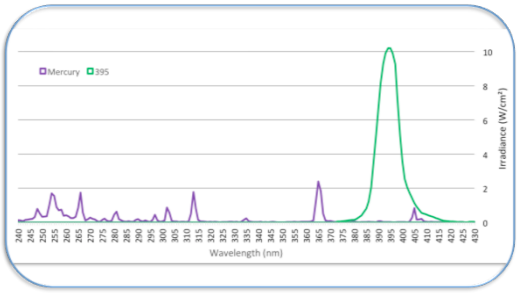
UV-arc versus LED



UV-LIGHT SPECTRUM



UV-arc versus LED



Source:IST-D

BENEFITS		FEATURES
ADVANCED CAPABILITIES	LED	Heat-sensitive thin substrates Deep, through curing Small compact units Controlled curing intensity
OPERATING ECONOMICS		Energy efficient Long lifetime Simplified maintenance Increased Yields Low Operating temperatures Instant 100% availability with on and off mode Power adjustable in a linear way (between 0 and 100%)
ENVIRONMENTAL BENEFITS		Mercury free Ozone free Workplace safety UV-A wavelength

UV VERSUS EB CURING

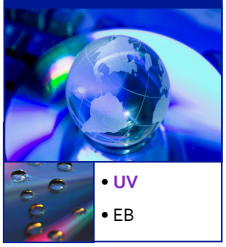
UV-Coating

- Wavelength range 1-100 µm
- Energy: 2.2 – 7 eV
- Surface effect
- Requires Photo-initiator
- Less expansive Curing Unit

EB-Coating

- Wavelength range 10^{-4} - 10^{-7} µm
- Energy: 100 – 300 keV
- Deeper Penetration
- Requires no Photo-initiator
- Expensive unit
- Borader choice of ingredients

IRRADIATION COATINGS



- UV
- EB

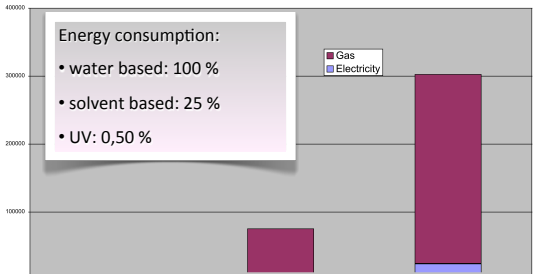
PROS

- VOC/HAP ▼
- IR-drier → oxidation VOC → emission ▼
- Production speed ▲
- Flexibility & versatility▲

CONS

- Interference pigments
- More expansive products
- Often adhesion problems
- Toxicity acrylate chemistry
- Odour
- Skinfriendly (?)

Energy consumption



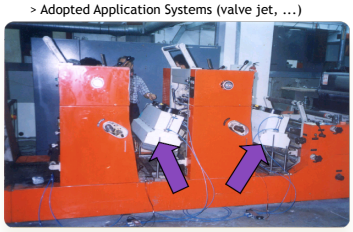
UV-Coating

Application Techniques

> Conventional Coating techniques

a. DIP, kiss-roll, knife-coating, Meyerbar, …
b. Implementation of UV-sources in existing coating line

> Adopted Application Systems (valve jet, …)

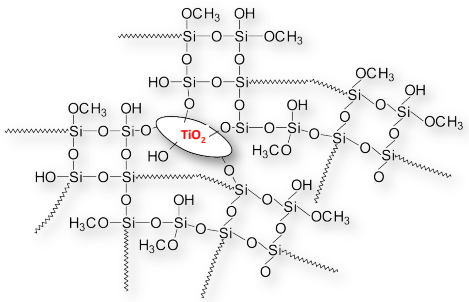


Nanoparticles

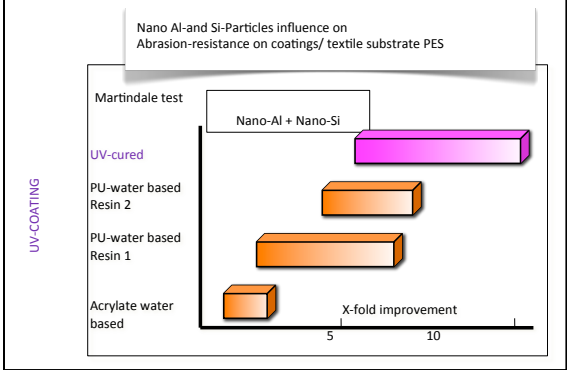
- Self Cleaning
- Air purification
- UV-protection
- IR-effects
- Superparamagnetic
- Conductive effects
- Sol-gel technology

TiO_2 - SiO_2
TiO_2 - SiO_2
TiO_2 - ZnO
ZrC - ITO - VO_2
Ferro fluids
nanotubes - graphene
inorganic binder for
SiO_2 - TiO_2…

Sol-gel



Incorporation of nanoparticles in inorganic-organic hybrid polymer networks

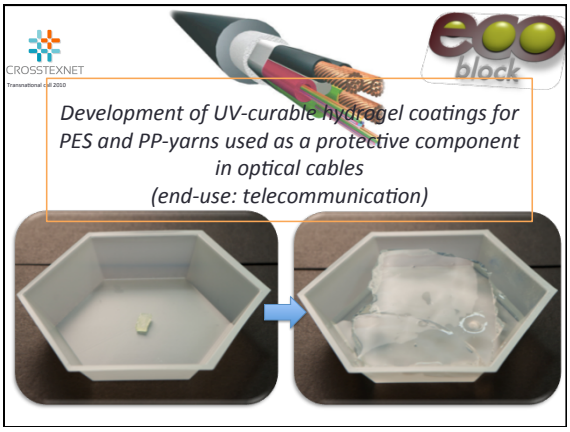


Development of UV-curable hydrogel coatings for PES – PP-yarns used as a protective component in optical cables

Supporting Organisations

CHEMSTREAM SUSTAINABLE CHEMISTRY — SME
RTD
COUSIN COMPOSITES — SME Coordinator

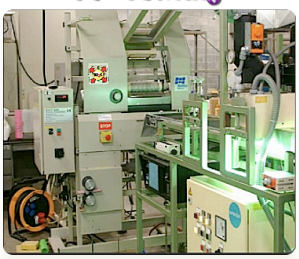
CROSSTEXNET



ADVANCED POLYMERS

TO2C

UV-Coating



Yarn Coating System

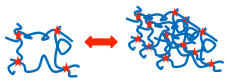
- yarn winder/unwinder
- coating application unit
- IR system (water based systems)
- UV-curing

High Swelling Yarns

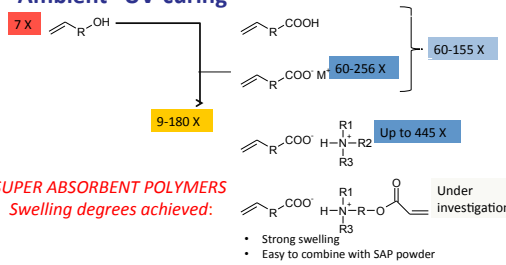
UV-curable hydrogel coating
IPN-based

Purpose:
water blocking - leak detection

UV-curable Hydrogels



"Ambient" UV-curing



SUPER ABSORBENT POLYMERS
Swelling degrees achieved:

- Strong swelling
- Easy to combine with SAP powder

50

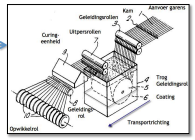
eco block

WP 2: Development of hydrogel-coating concept on lab-scale

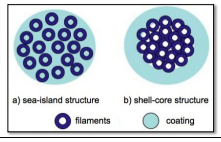
Product parameters:
Prototype formulations

Process parameters:
Applications systems

DIP



Nozzle



eco block

Some results on semi-industrial scale

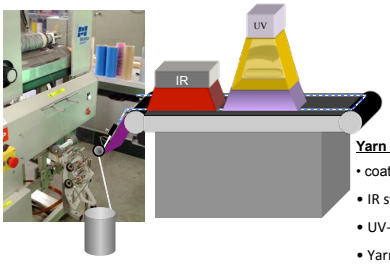
Spec	Original Status	UV-curable hydrogels	Competitor reference	Units
Dtex PES yarn	1670		1670	Unit
Dtex coated yarn	4100		3444	g / m
Coated yarn weight	0.410		0.344	g / 10 km
Coating weight	0.243		0.177	g / m
Water absorption of coated yarn	18		29.3	g / m
Water absorption of coating	74.07		165.5	g H_2O / m yarn
Water absorption of coated yarn	43.9		85	g H_2O / g coating

UV-curable Conductive Formulations for Yarn Coating

- Construction of yarn coating system

modular system

iWT



CROSSTEXNET

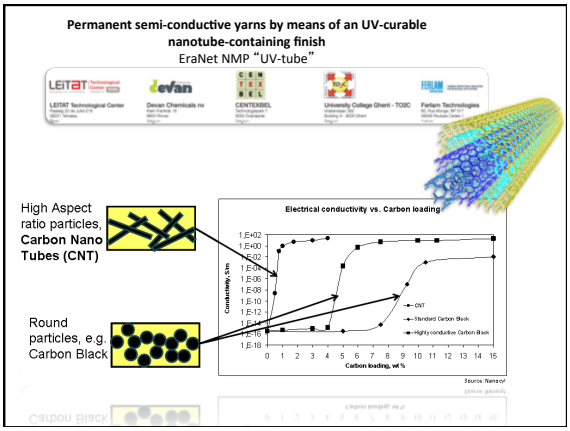
Yarn coating platform

- coating application unit
- IR system
- UV-curing
- Yarn winder

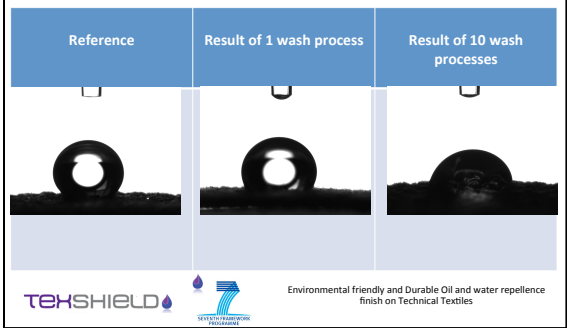
UV-coated yarns – nano-tubes

Permanent semi-conductive yarns by means of an UV-curable nanotube-containing finish

EraNet NMP "UV-tube"



Hydrophobic UV-curable Coatings

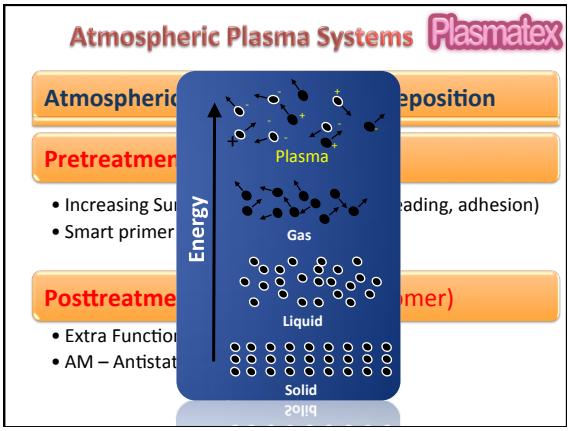


TEXSHIELD

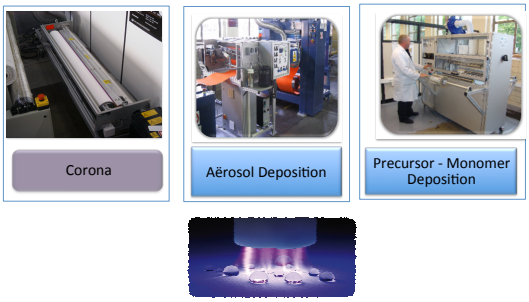
Environmental friendly and Durable Oil and water repellence finish on Technical Textiles

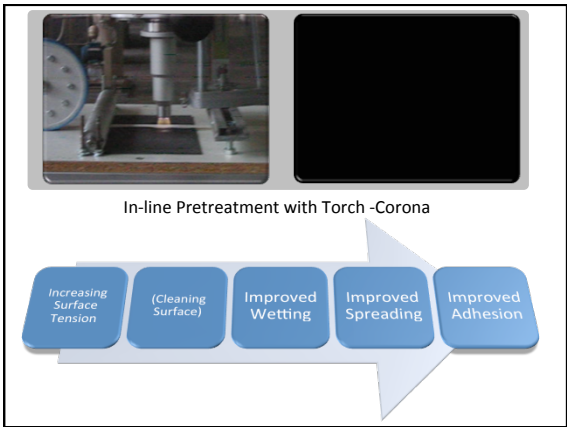
Atmospheric Plasma Systems

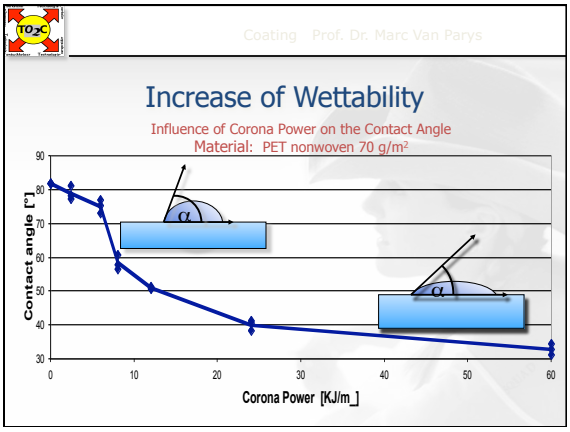
Plasmatex



Plasmatex







Atmospheric Plasma Deposition
Precursor/Monomer Assisted

Corona-based

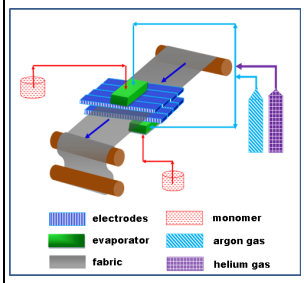
SBDB-based
(Surface Dielectric Barrier Discharge)

Activation energy :
Plastics: 8-12 kJ/m^2,
Textile: 60-240 kJ/m^2

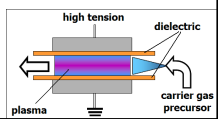
Textile demands
higher energy density

1. Atmospheric plasma technology

GRINP plasma unit

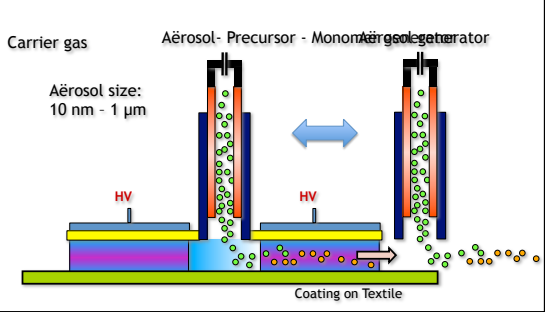


- atmospheric *dielectric barrier discharge* plasma configuration
- *glow discharge*: noble gases (He, Ar)
- *precursor*: gas /vaporized monomer/aerosol
- *power*: 0,5 – 10 W/cm²



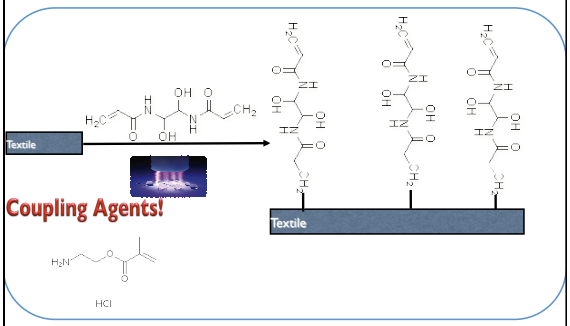
Plasmatex

Precursor Assisted Plasma Deposition



Grafting

Smart Primer



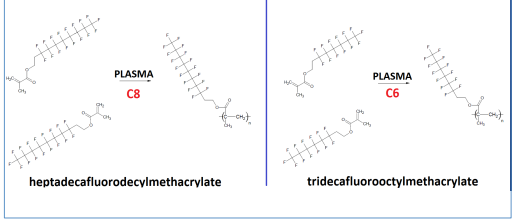
Low pressure Plasma

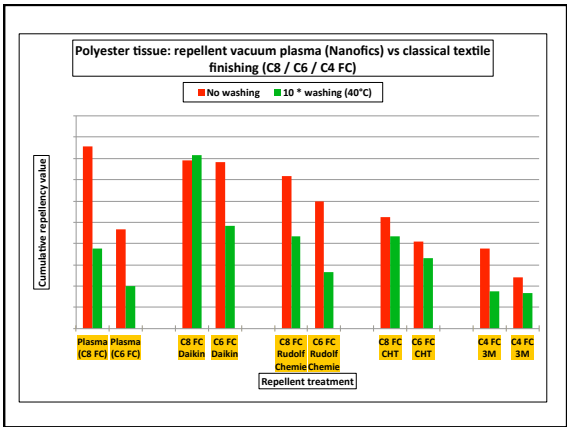
- Europlasma equipment

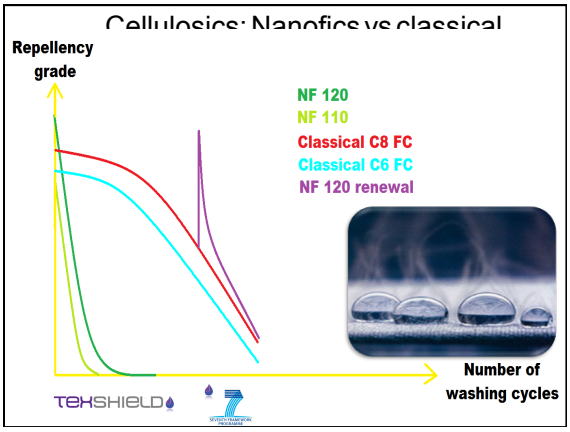
Low pressure plasma – injection of precursors

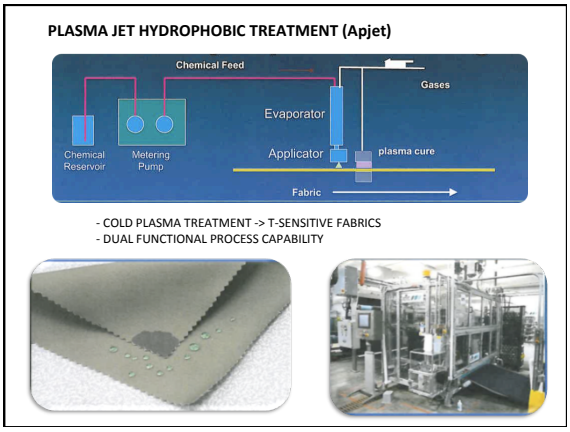
(10^{-5} – $2*10^{-3}$ atm)

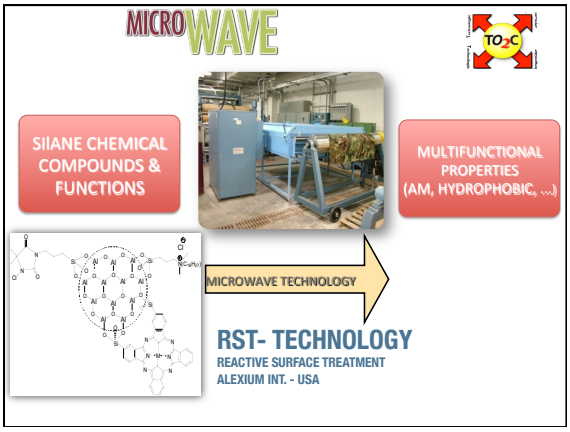
Plasma polymerisation of acrylic perfluoromonomers

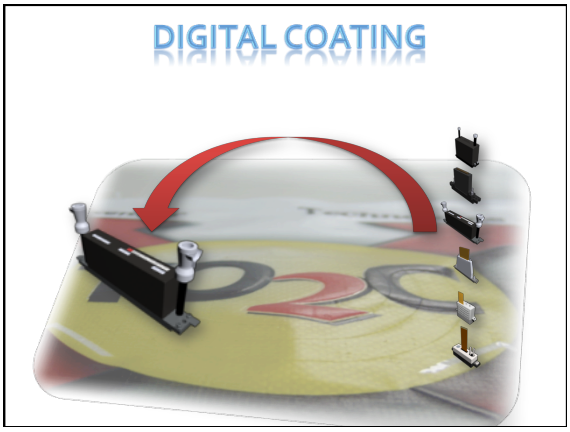


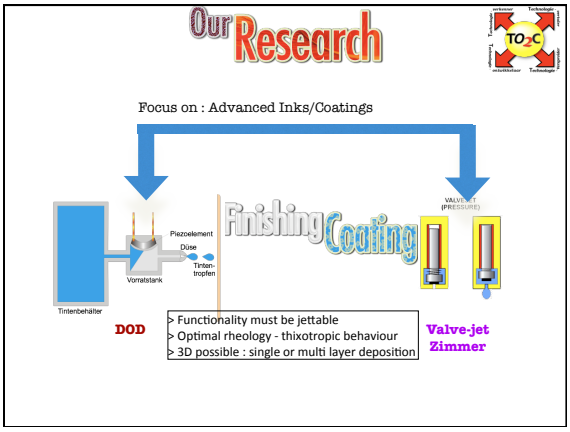

Polyester tissue: repellent vacuum plasma (Nanofics) vs classical textile finishing (C8 / C6 / C4 FC)
No washing
10 * washing (40°C)
Cumulative repellency value
Plasma (C8 FC)
Plasma (C6 FC)
C8 FC Daikin
C6 FC Daikin
C8 FC Rudolf Chemie
C6 FC Rudolf Chemie
C8 FC CHT
C6 FC CHT
C4 FC 3M
C4 FC 3M
Repellent treatment


Cellulosics: Nanofics vs classical
Repellency grade
NF 120
NF 110
Classical C8 FC
Classical C6 FC
NF 120 renewal
Number of washing cycles
TEXSHIELD


PLASMA JET HYDROPHOBIC TREATMENT (Apjet)
Chemical Feed
Gases
Evaporator
Chemical Reservoir
Metering Pump
Applicator
plasma cure
Fabric
- COLD PLASMA TREATMENT -> T-SENSITIVE FABRICS
- DUAL FUNCTIONAL PROCESS CAPABILITY


MICROWAVE
SILANE CHEMICAL COMPOUNDS & FUNCTIONS
MULTIFUNCTIONAL PROPERTIES (AM, HYDROPHOBIC, ...)
MICROWAVE TECHNOLOGY
RST- TECHNOLOGY
REACTIVE SURFACE TREATMENT
ALEXIUM INT. - USA


DIGITAL COATING


Our Research
Focus on : Advanced Inks/Coatings
Finishing Coating
DOD
> Functionality must be jettable
> Optimal rheology - thixotropic behaviour
> 3D possible : single or multi layer deposition
Valve-jet Zimmer

Development of Printheads

The firing frequency is being increasing to speed up printer speed (> 30 kHz)

New heads required higher viscosity inks (moved from 3 to > 12 mPas)

Jet volume is increasing (4 pl up to 150 pl)

Functional Ink Challenges

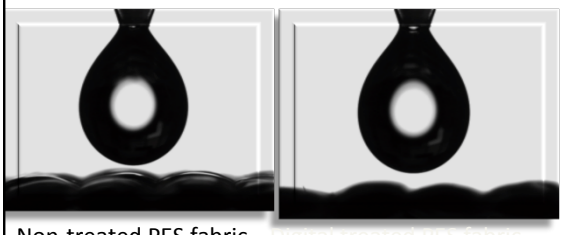
Higher Firing Frequencies

Higher Viscosity

Broader choice of ingredients

More jet volume

New HYDROPH0BIC inkjet inks



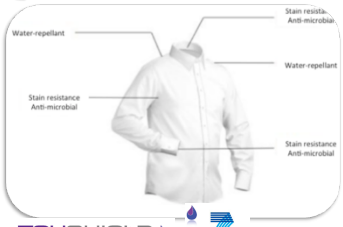
Non-treated PES fabric

Digital treated PES fabric

TEXSHIELD

Digital micro-disposal of functional inks

- Full coverage - functionalization
- Localisation or patterning functionalization



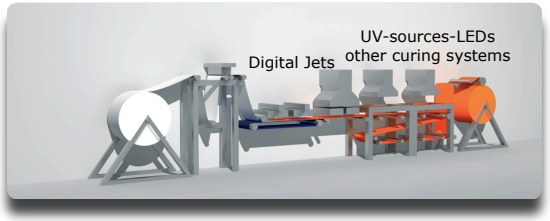
Actual projects:
Surface-engineering

- Superhydrophobic inks
- Antistatic inks

TEXSHIELD

Factory of the Future

Yarn/ fabric + DP coating + UV/ LED/ EB = New textile



Prof. Dr. Marc Van Parys
University College Ghent
UNITEX