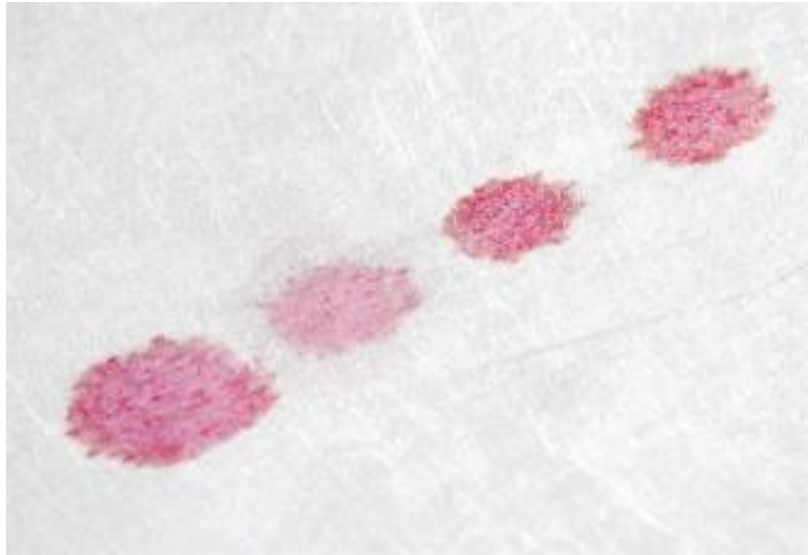




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INNOVATIVE LOW PRESSURE PLASMA COATINGS FOR GAS AND LIQUID FILTER MEDIA

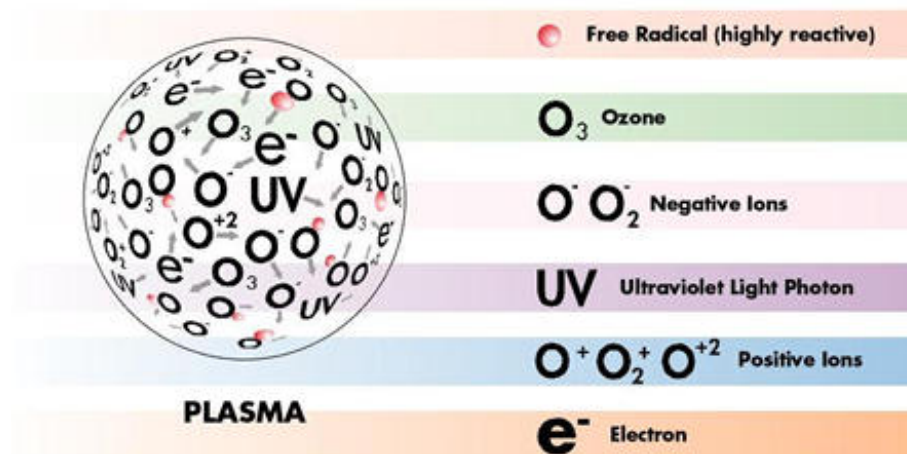
Filip Legein, MSc, MBA



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Plasma

- From solid to liquid to gas to plasma by adding energy to the system
- Molecules become more free to move until decomposed into a mix of charged particles (ions, electrons), neutrals (atoms, radicals, molecules) and photons





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Low Pressure Plasma

- Plasma is generated by an electromagnetic discharge in a gas at low pressure (and low temperature)





Applications

- Cleaning: removal of molecular contamination layers from a surface
- Etching: removal of surface material (several nm up to 1 μm)
- Activation/Functionalisation: chemical modification of the surface
- Coating: polymerization of chemical species on the surface



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CD600



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CD650/450 Roll-to-Roll



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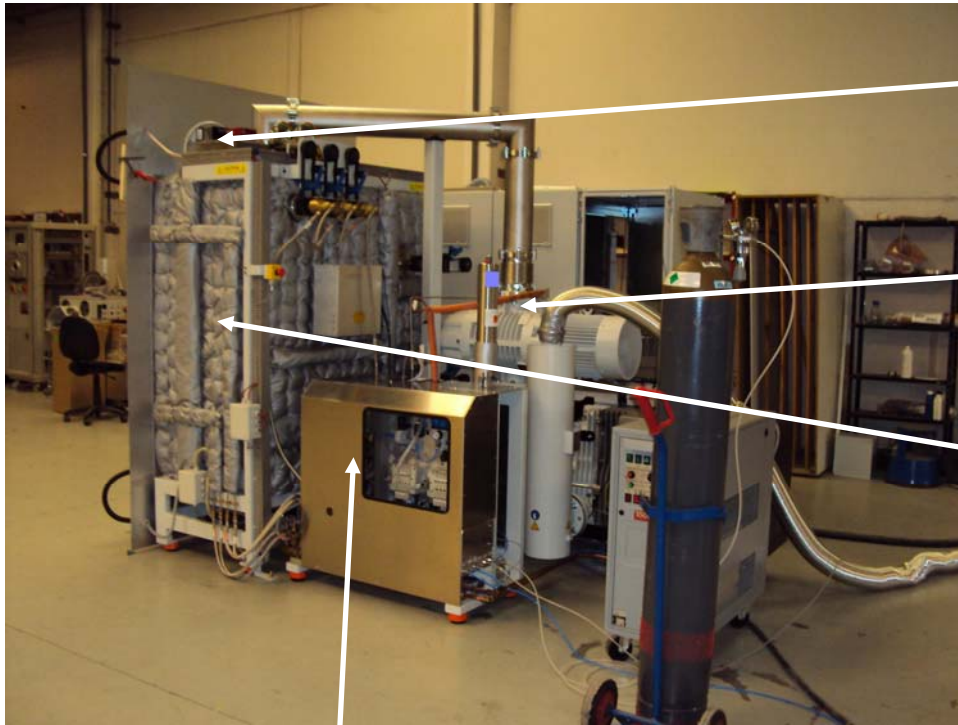
Guiding System



Water Cooled Electrodes



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Valve

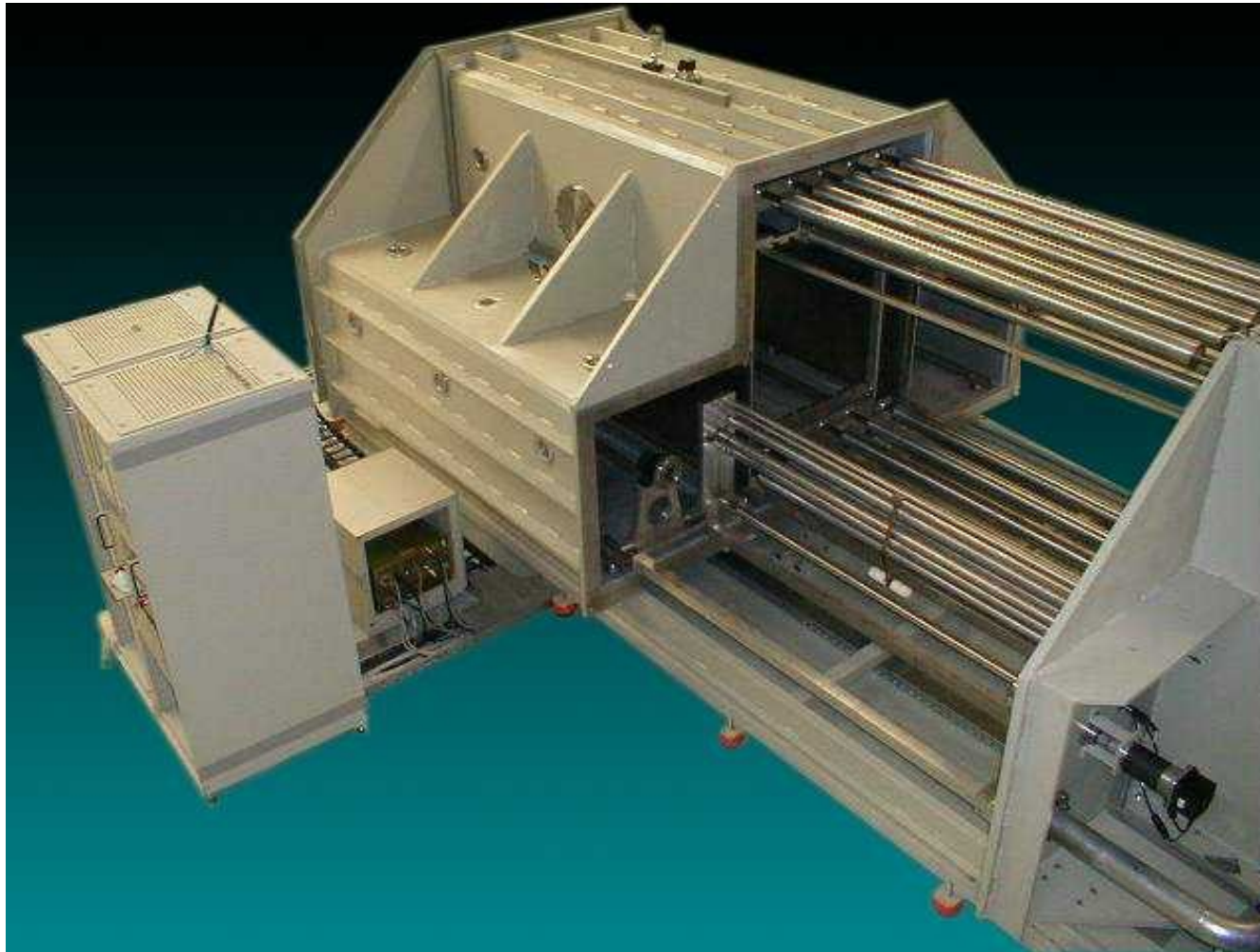
Pump Group

Heated Process Chamber

Process Gas Delivery and Distribution System



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CD1800/600 Roll-to-Roll



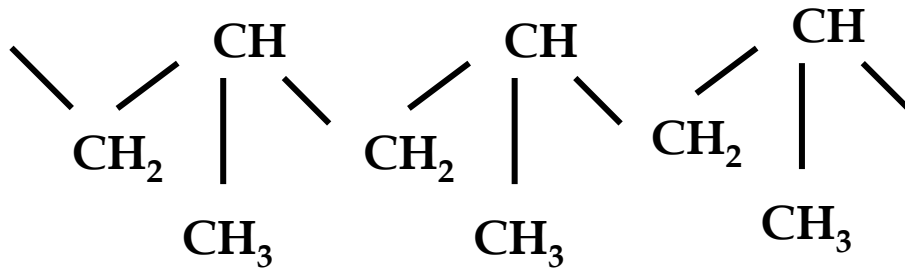
Plasma Activation

- Chemical functionalisation of outer molecular layers (1 nm deep)
- Typical gas mixtures based upon O_2 , N_2 , H_2 , N_2O , CH_4 , Ar , He , ...
- Innovative gas mixtures for hydrophilic coatings with shelf lives of two years
- Innovative gas mixtures for specialty materials such as PTFE
- Typical treatment times from 1 to 20 m/min

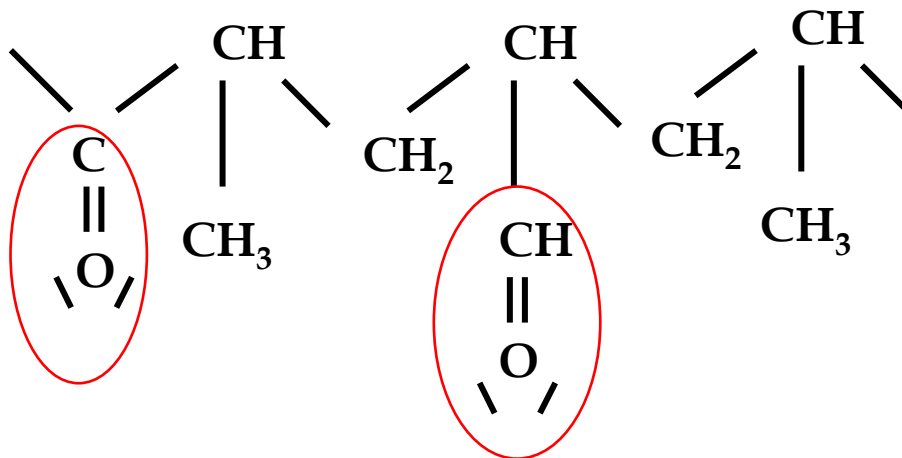


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Activation of Polypropylene



Polypropylene BEFORE
O₂-plasma treatment



Polypropylene AFTER
O₂-plasma treatment: carbonyl-
groups have been added



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Porous Filter Media

- Plasma cleaning and activation to improve wetting of plastic and ceramic filter media





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Blood Filter Media

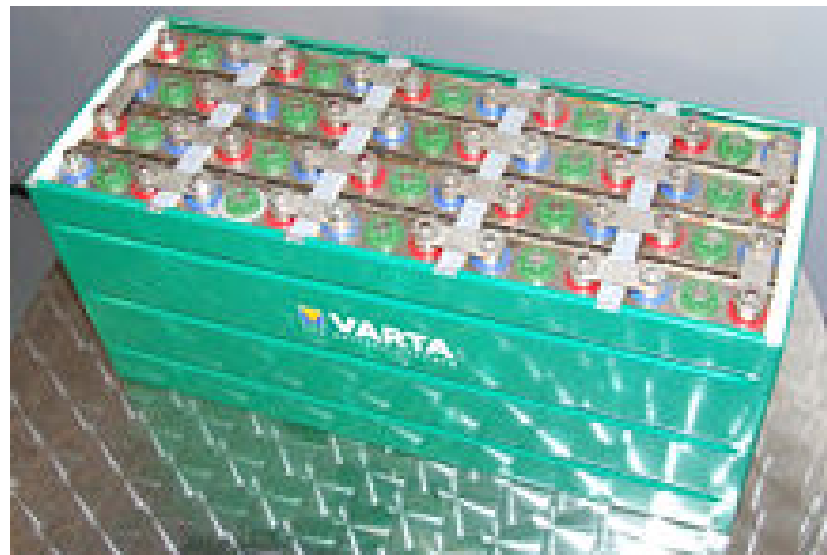
- Permanent hydrophilic coating of non woven PBT





Battery Separators

- Permanent hydrophilic coating of non woven PP
- Starting material is hydrophobic. After plasma treatment permanent wetting by KOH + H₂O is achieved





Case 1. NiMH Batteries

- Non woven PP (30 – 50 g/m²)
- After plasma treatment surface energy increased to 60 - 72 mN/m
- Rate of absorption in 30 % KOH + H₂O, after 1 minute wicking, measured 7 days after treating the substrate, on sample size of 40 x 200 mm:
 - Untreated substrate: 0 mm
 - Commercial material (not plasma treated): 5 – 10 mm
 - Plasma treated substrate: 27 – 31 mm



Plasma Polymerization

- Reaction takes place on the substrate surface
- Deposition of permanent coatings with typical thickness of tens of nm
- Different industrial applications starting from fluorocarbon gases, or liquid monomers such as perfluoromonomers or siloxanes to reach high levels of hydrophobicity and/or oleophobicity
- Typical coating speeds from 1 to 10 m/min



Liquid Filter Media

- Hydrophobic nanocoating of diesel engine filters
- Oleophobic nanocoating of electrets for respirator masks, HVAC filter media, ...
- Hydrophobic nanocoating of automotive air intake conducts
- Super oleophobic nanocoating of filtration membranes for protection of disk drives, automotive electronics, medical parts, ...



Case 2. Diesel Filter

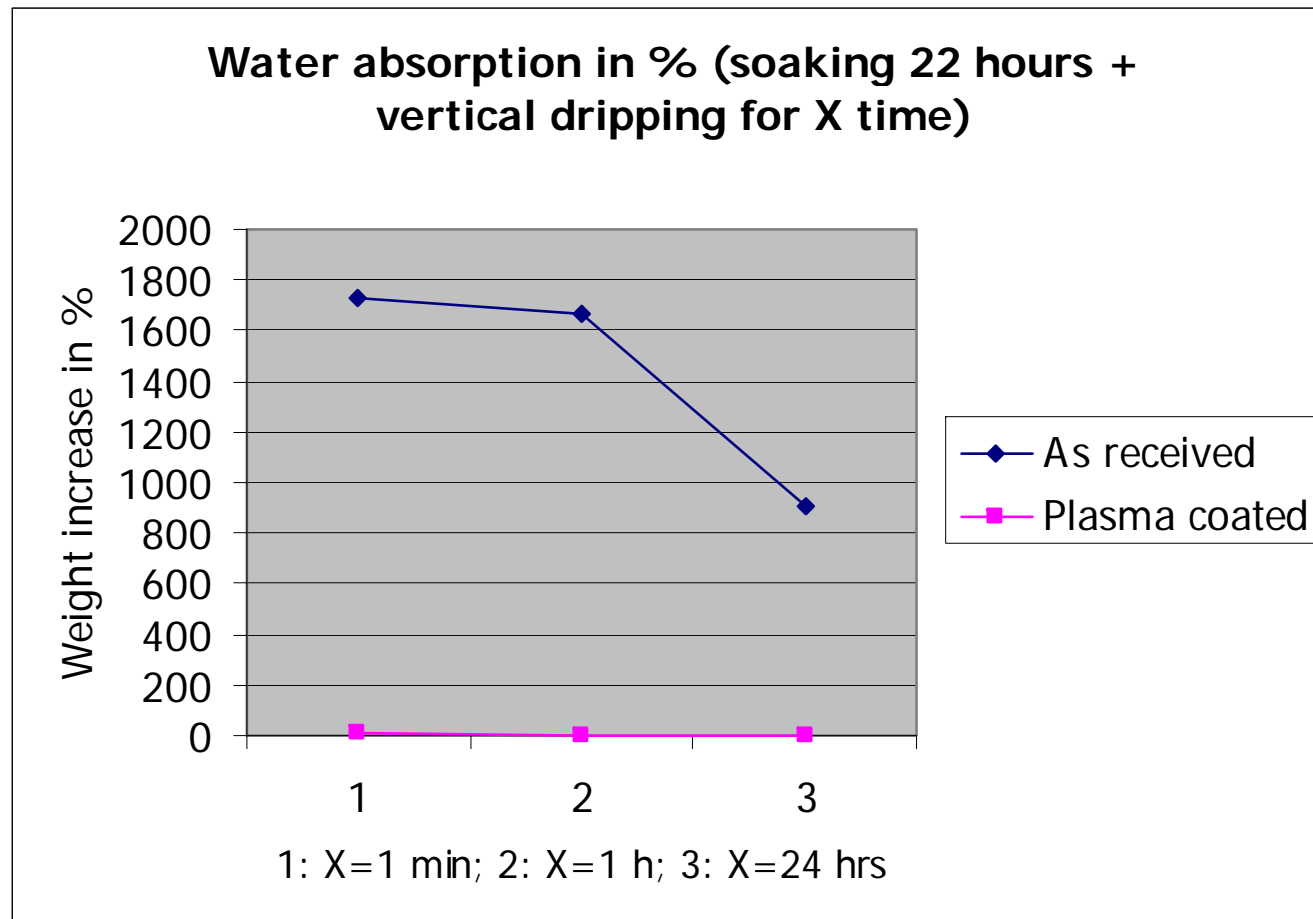
- Filter made from thick non woven PET of 500 g/m²
- Filter needs to be made water repellent
- Evaluation method :
 - Soak into water for 22 hours
 - Drip out in vertical position
 - Determine weight increase





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Case 2. Diesel Filter





Case 3. Respirator Masks

- Several layers of nonwoven meltblown PP (15 – 30 g/m²)
- Filter media substrates are electrostatically charged after coating
- Oleophobic nanocoating to improve filtration efficiency for oily particles
- Evaluation is done using a CERTITEST8130 apparatus (loading with 200 mg of DOP-particles)





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Case 3. Respirator Masks

Filter medium	Conditioning	Initial penetration (%)	Penetration after (x) minutes (%)
Supplier I – 28 g/m ²	Uncoated	1.20	6.40 (30)
Supplier I – 28 g/m ²	Plasma coated	0.48	1.08 (30)
Supplier I – 22 g/m ²	Uncoated	1.25	3.90 (10)
Supplier I – 22 g/m ²	Plasma coated	0.40	0.75 (10)
Supplier II – 25 g/m ²	Uncoated	N.A.	N.A.
Supplier II – 25 g/m ²	Plasma coated	0.02	0.03 (10)

CERTITEST 8130 measurements on different 5-layer media using DOP-particles



Cost Analysis

- Non woven PP with thickness of 40 μm
- Oleophobic nanocoating with fluorocarbon gas to reach oleophobicity level 3 (3M scale)
- Roll dimensions: width 1.8 m x length 7500 m (13,500 m^2 per roll)
- Web speed in the plasma system: 5 m/min
- Treatment time per roll: 27 hours
- In mass production one machine can handle 292 rolls per year or 3.942.000 m^2 per year



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Cost Analysis





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Cost Analysis

Cost Factor	EUR/m ²
Electricity	0.012
Process Gas	0.045
Total Running Cost	0.057
Labour	0.005
Total Variable cost	0.062
Depreciation (10 years)	0.018
Total Cost	0.080



Cost Analysis

- Total cost for oleophobic nanocoating with fluorocarbon gas to reach oleophobicity level 3 (3M scale) in mass production amounts to 0.08 EUR/m²
- Super oleophobic nanocoatings to reach level 5 to 8 (3M scale) would cost 0.16 to 0.24 EUR/m²
- Costs for activation and hydrophilic coating are typically lower because of higher coating speeds and cheaper precursors between 0.01 and 0.05 EUR/m²



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Conclusions

- Innovative low pressure plasma coatings for gas and liquid filter media are finding a growing number of customers and applications
- Dry and clean technology: environmental friendly alternative to wet chemical processes
- Controlled processing environment
- Cost effective solution



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R&D

- Gas mixtures for permanent hydrophilic effect
- Cost effective and human friendly hydro/oleophobic nanocoatings
- Use of plasma photons for sterilisation
- Multilayer coatings to create antimicrobial effect
- Roll-to-roll sputtering machines
- Upscale Atomic Layer Depositioning (ALD) technology for nanocoatings with controlled thickness into core of complex shaped materials



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Filtech 2011

- ◆ Europlasma welcomes you at the Filtech 2011 Exhibition on location H5 in hall 3
- ◆ Introducing **Nanofics*** Technology, a group of nanoscaled functional coatings developed by Europlasma for application in the filtration industry

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