Nitrous-Hydro Flame Treatment Technology and its applications

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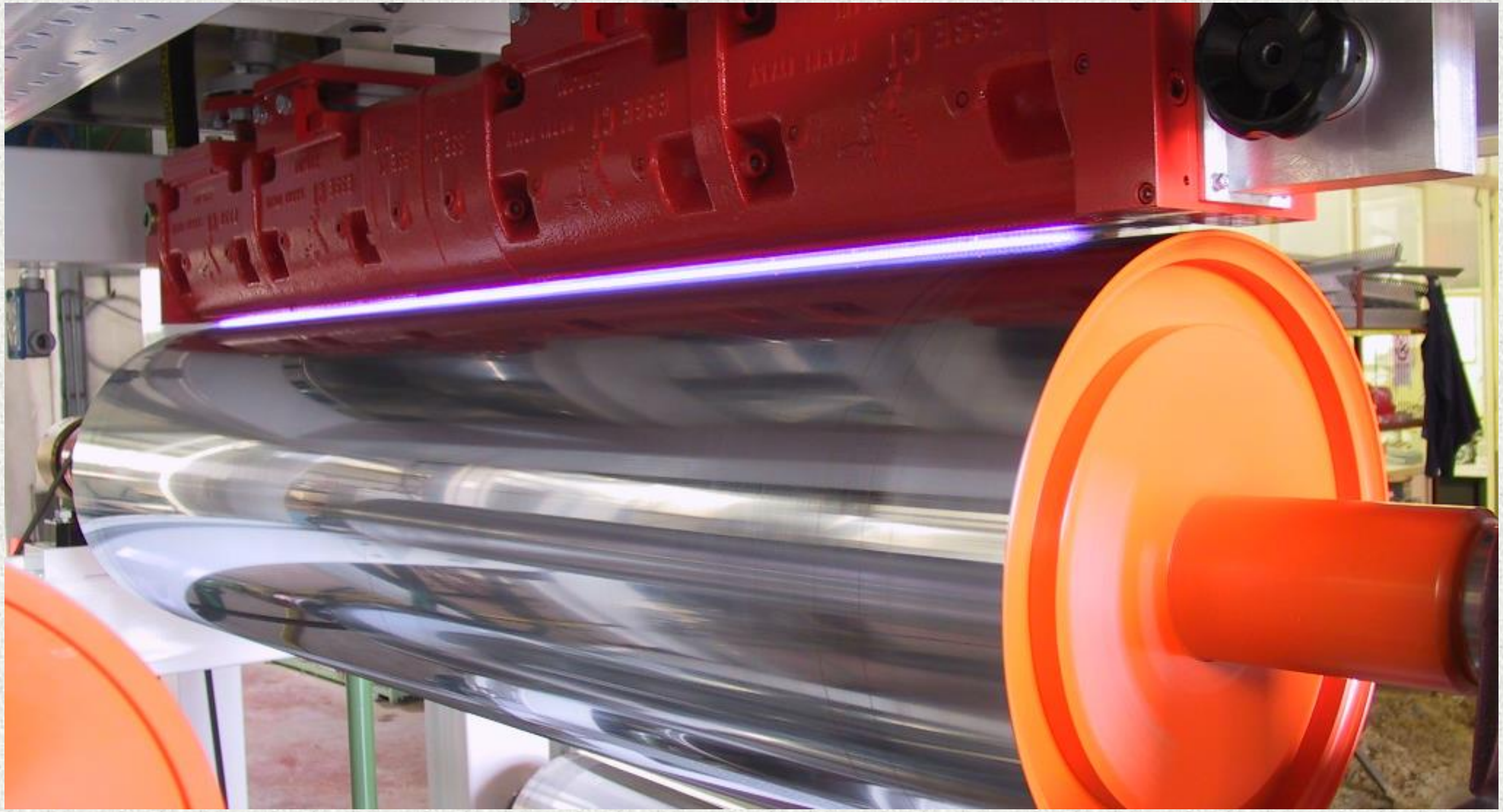
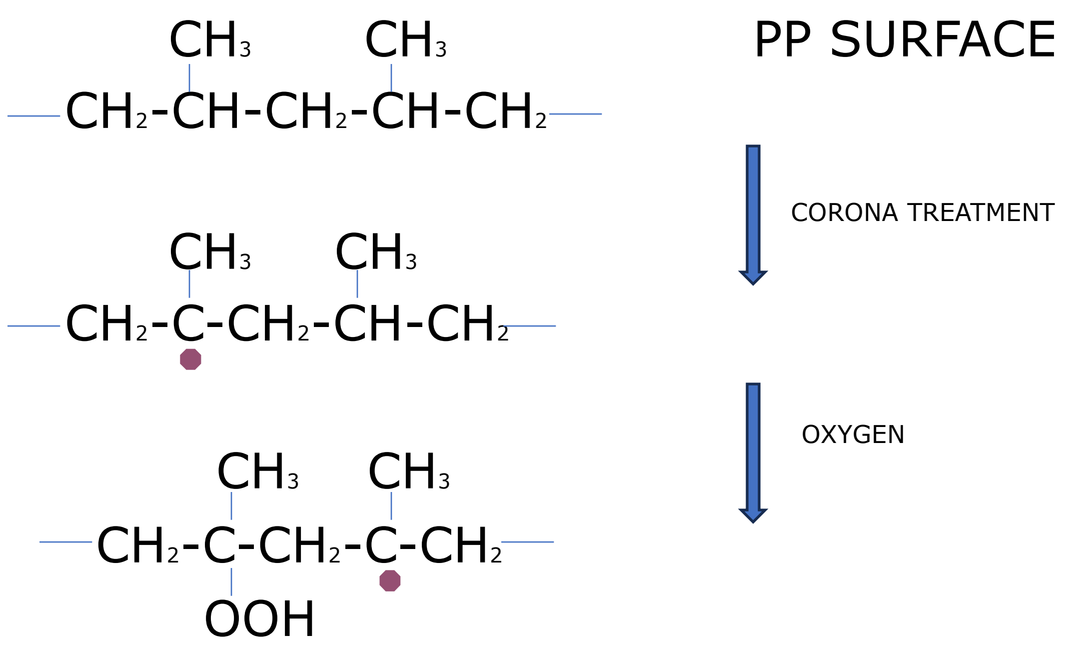
STANDARD FLAME CHEMISTRY AND OXIDATION MECHANISM.

COMPARISON WITH CORONA TREATMENT

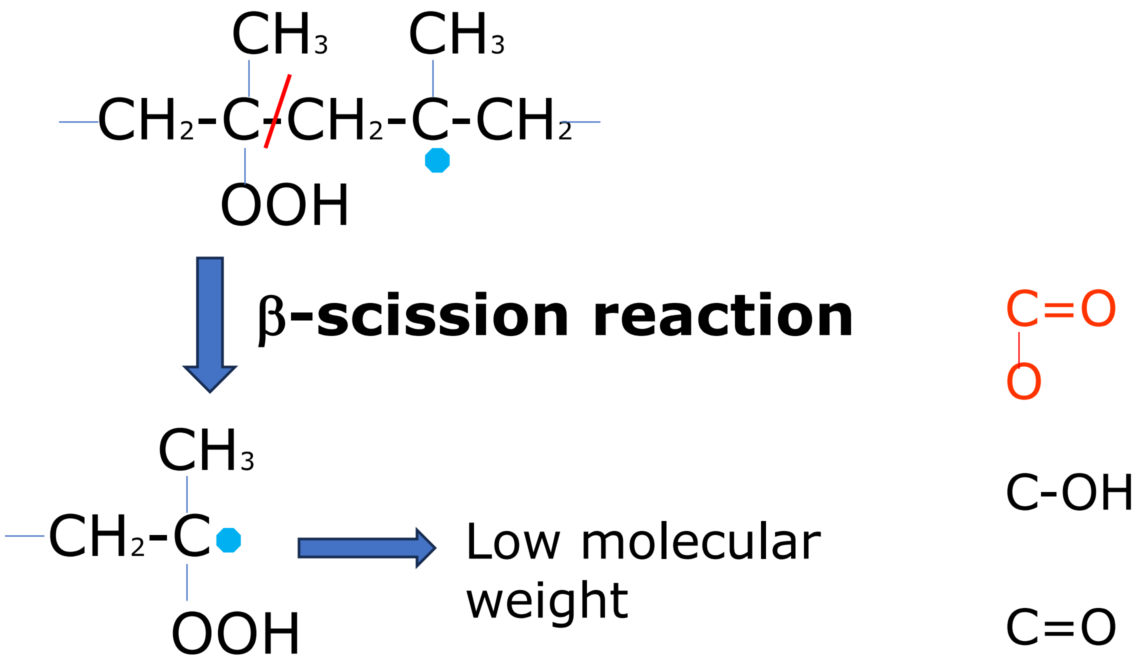
Standard Flame Treatment



CHEMICAL COMPOSITION OF A CORONA TREATED SURFACE

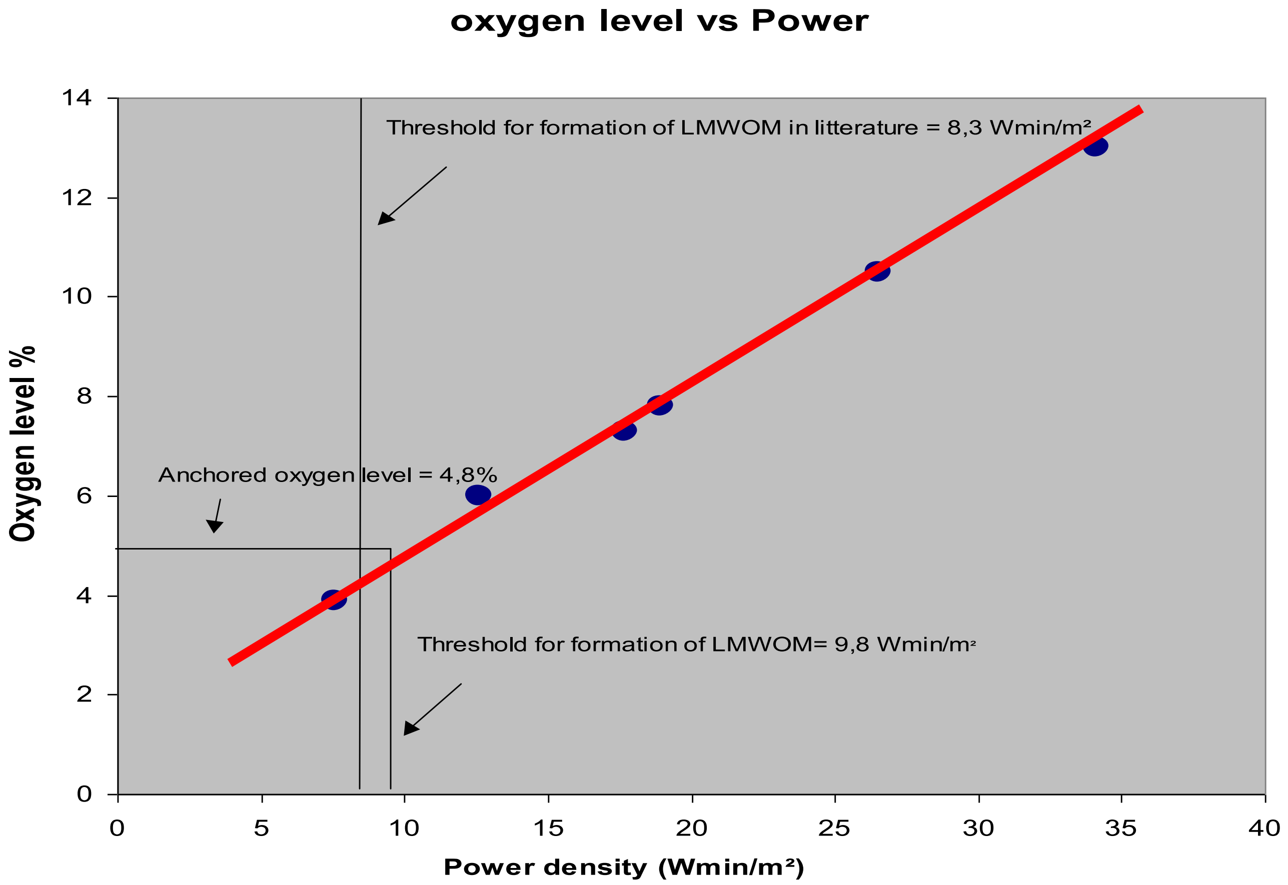


CHEMICAL COMPOSITION OF CORONA TREATED SURFACES

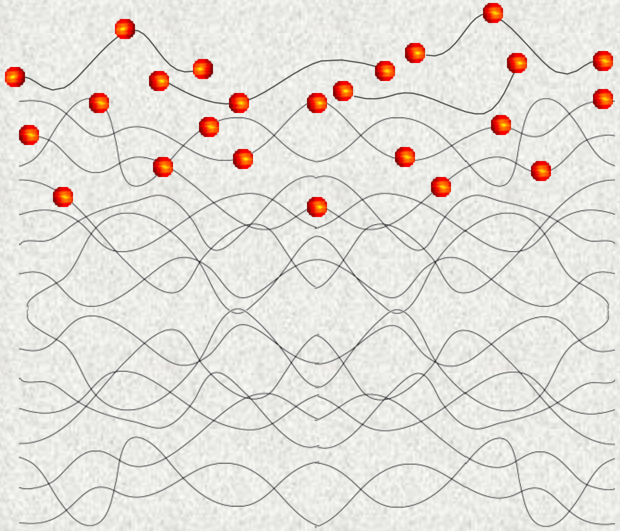


O ⇒ alkoxy radicals RO° ⇒ **LMWOM**

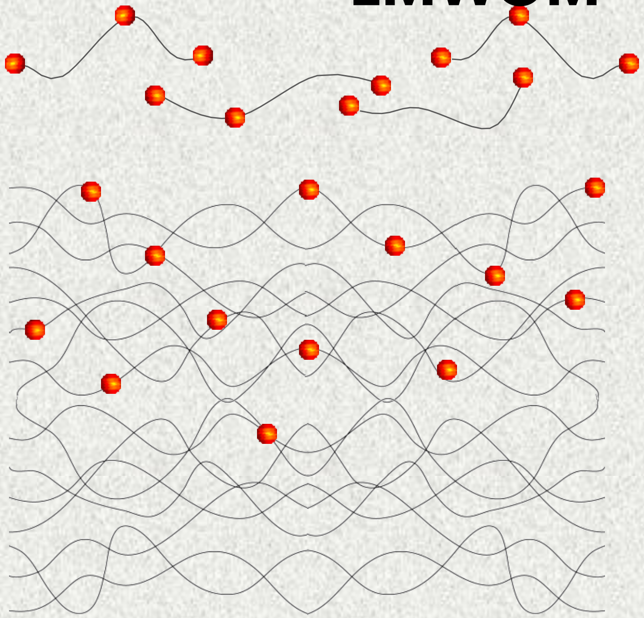
CORONA TREATMENT SURFACE OXIDATION



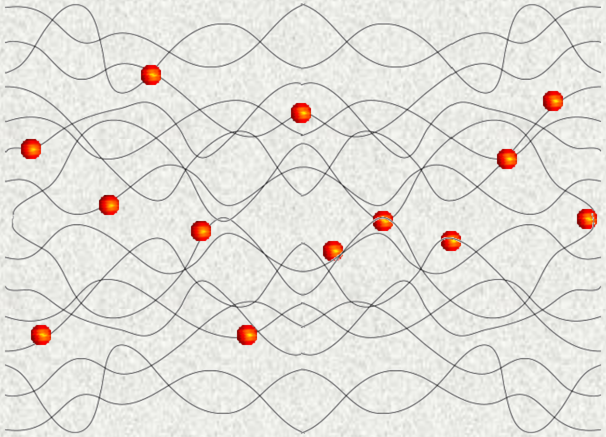
Oxidized surface
Recovery



LMWOM



Hydrophobic



NITROUS-HYDRO (NH-FT) FLAME TREATMENT

Nitrous-Hydro (NH-FT) Flame Treatment

NITROUS-HYDRO FLAME

1) Nitrous Oxide

Usage:

- Anesthetic (non-toxic on organ and tissues; TLV-TWA ACGIH:50ppm);
- Food Industry;
- Refrigerant Fluid;
- WVII (Luftwaffe GM-1);
- NOs: Intercooler effect; higher combustion air density, higher amount of combustible that can be burned.

Thermal scission at 565 ° C to produce nitrogen and oxygen +HEAT:

$2\ N_2O(g) \rightarrow 2\ N_2(g) + O_2(g) + \text{heat}$

$CH_4 + 4N_2O \rightarrow 4N_2 + 2H_2O + CO_2$
$C_3H_8 + 10N_2O \rightarrow 10N_2 + 4H_2O + 3CO_2$

2) Methane-Hydrogen Mixtures (MHM)

Usage:

- Combustible in transportation

$CH4 + 2O2 \rightarrow 2\ H2O(g) + CO_2(g) + \text{heat}$
$2H2 + O2 \rightarrow 2\ H2O(g) + CO_2(g) + \text{heat}$

Functionalities added on web surface

- Oxidized Nitrogen: NO_3, NO_2 (organic nitrates and/or nitrites);
- Reduced Nitrogen: R_1-NH_2 ; N-C=O; CNR; R-CN (amine, imine, amide, nitrile)

Flame vs. Corona/Plasma

N_2O vs NH_3

Temperature factor

APPLICATIONS

Patent Number 102022000002636 - Italy

Application Number 18/837,790 - USA

NH-FT Treated Film Types

- Bioriented Polypropylene (BO-PP), both homopolymer and coextruded skins (homo-, copo-, terpo-);
- Polypropylene white opaque, solid and cavitated;
- Cast Polypropylene (C-PP);
- Oriented Polyethilene (O-PE);
- Polyester (BO-PET);
- Biobased and Biodegradable films.

Coatings applied

- **Liquid Varnishes** and **inks** nitrocellulose/PUR - pure PUR - nitroacrylic based, in ethyl acetate or ethile acetate/alcohol, as the ones by Sun Chemical, for lamination and surface printing (roto and flexo), as Soliprop TM, Duratort PM, Solvafilm TM, Duratort PF, SOLIMAX P, SOLIPROP V. series;
- **UV inks** for Labels applications, as Siegwerk Nutriflex LM, Zeller Y81 (LM) and Flint Flexocure Force;
- **Acrylic** lacquers, as DSM NeoCryl FL-715, FL-721, BT-36 (water emulsions), B-871 (in solvent);
- Polyvinylidene Chloride (**PvdC**) lacquers, as Solvay, Diofan family (A050, A297, B203);
- **PVOH/EVOH** lacquers, as Kuraray, Exceval (AQ4104), Poval (2598-R) and Michelman Michem Flex B3513, B3530 and ENF0922;
- **PET** and **Oxygen barriers varnishes**, as Sunbar series by Sun Chemical;
- **AlOx** and **Aluminum**.

Results (after industrial scale tests)

- **Immediate (t = 0) Adhesion** of lacquers, inks, varnishes on poly substrates, **<u>without the need to use any primer, adhesion promoters or hardener</u>**, as:

a) PUR primer - as DSM NeoRez R-600 and NeoRez R-610 for acrylic coatings;

b) PUR primer - as DSM NeoRez R-610 or PUR/PET BASF Epotal for PVDC coatings;

c) PEI primer - as BASF Lupasol WF - for PVOH/EVOH coatings;

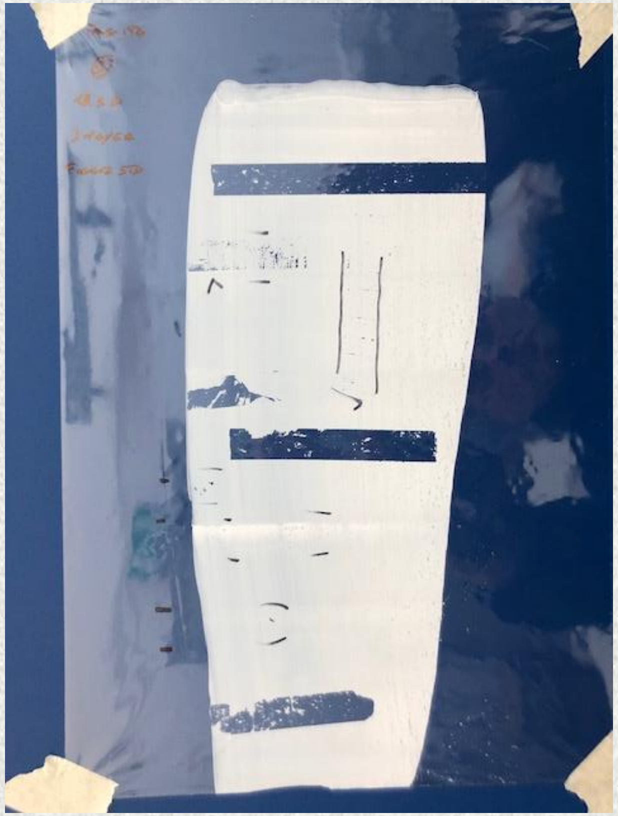
d) Ti chelated adh. promoter - as NT 9013000165 Sun Chemical - for nitro inks.

- t = 0 Adhesion even in overlay printing and coating (two coatings or ink layers put on Nitrous Flame treated surface);
- No need to primerize/coat web surface prior to UV inks application;
- Excellent coating adhesion and sealability (acrylic/acrylic, acrylic/nitro and acrylic/PET), even with BOPP coated homopolymer, <u>after 18 months</u>;
- High metal adhesion **on BOPP homopolymer** metallized substrates, without any need of a primer layer or a tie-layer (EVOH). Metal surface energy high retention. 18 months after treatment inks adhesion on aluminum, without any adhesion promoter.

<u>Above results cannot be reached by std. Flame, corona or plasma treatment</u>

Nitrocellulose liquid INK adhesion on BOPP

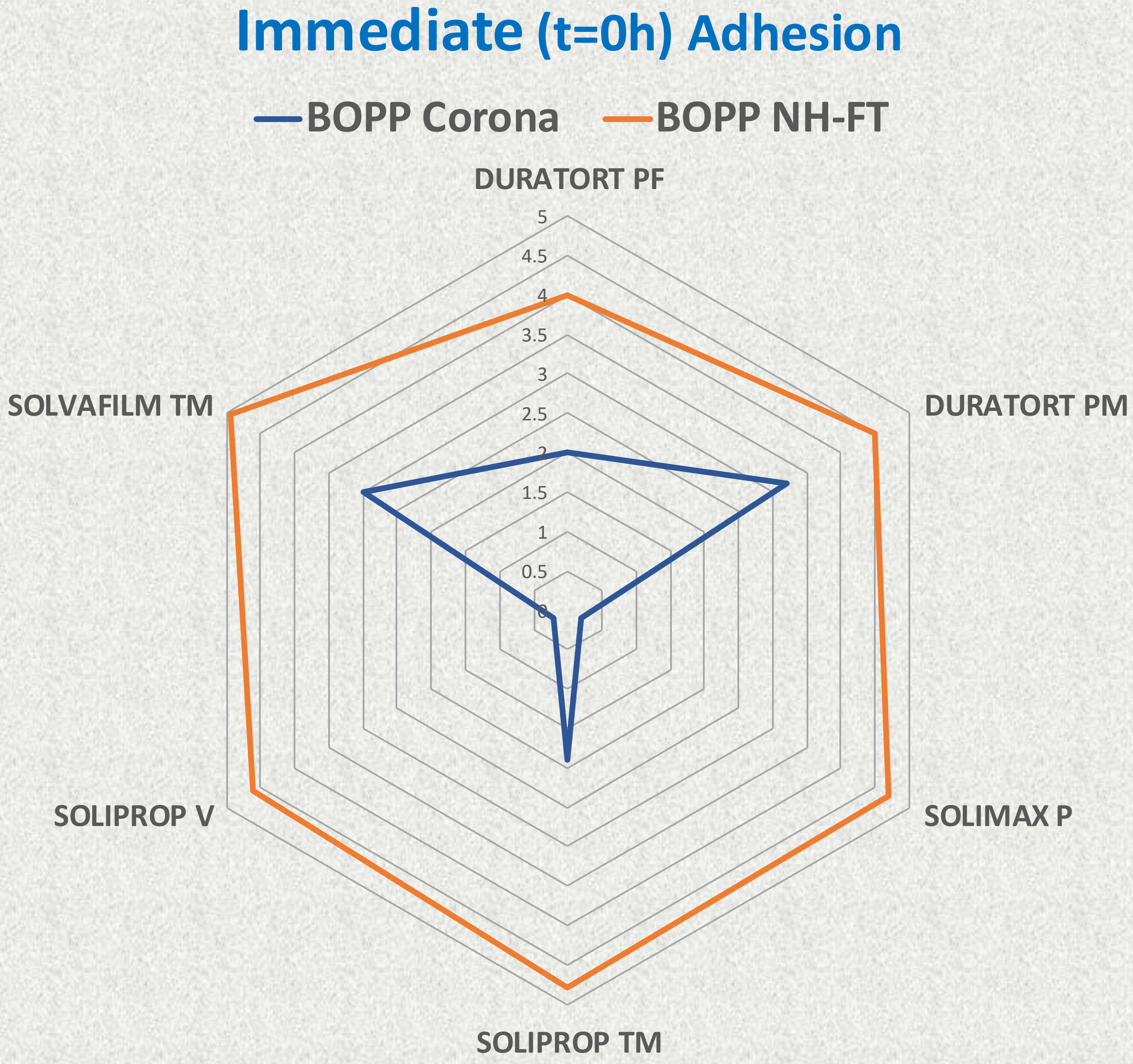
Corona Treated



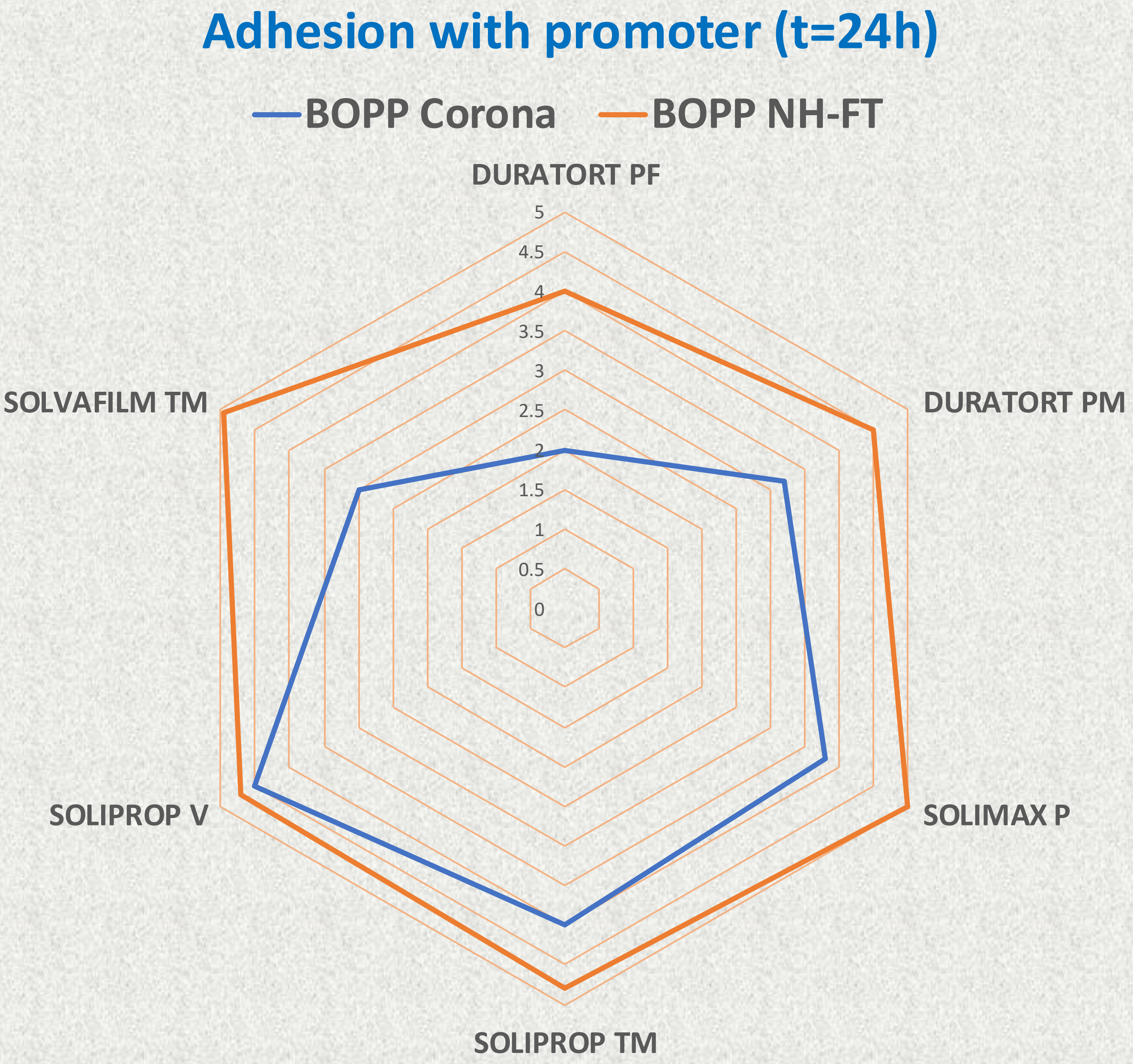
Standard Flame Treated

Nitrous-Hydro Flame Treated

<u>**NO**</u>
<u>ADHESION PROMOTER</u>



WITH ADHESION PROMOTER



CASE STUDY 1 - ORIENTER

1) <u>LINE DATA</u>:

Max web width: 10 m;

Process speed: 450 m/min on **18μm**;

Programmed/Actual run time: 8760/8400 h;

Theoretical Film production per year: 2268*10^6 m2/year;

Theoretical film produced per year: 36,86*10^6kg/year (A-B-C and B-C)

2) <u>ACTUAL FILM PRODUCED AND PP CONSUMPTION</u>:

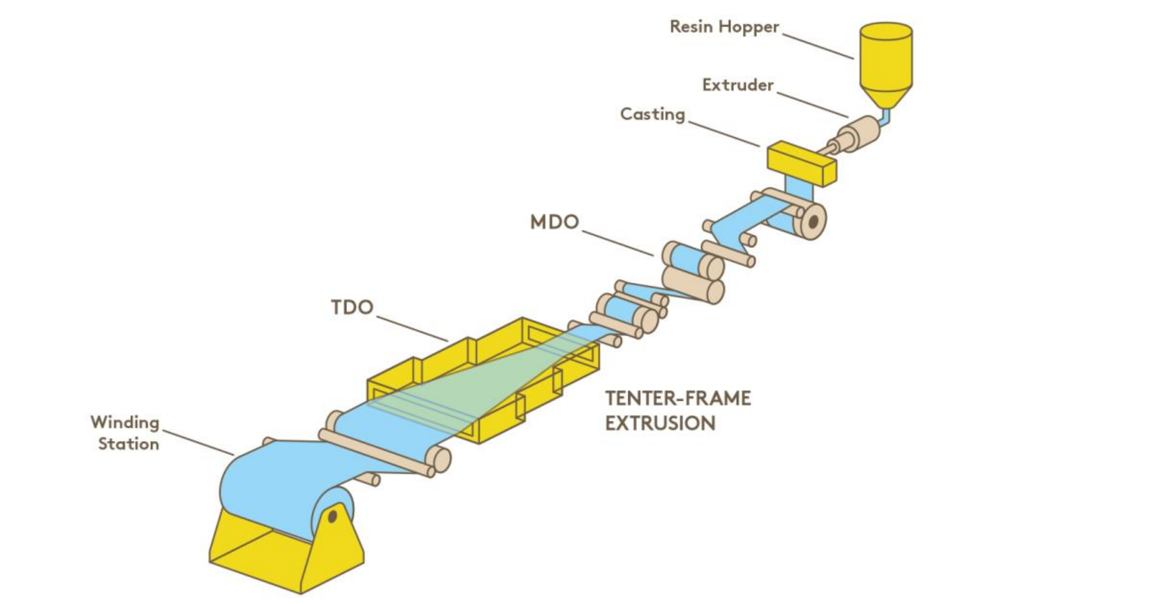
- 31,2*10^6kg/year A-B-C;
- 31,9*10^6kg/year B-C;

DT = 8% on A-B-C and 7% on B-C;

RECLAIM = 1,8*10^6kg/year A-B-C; 2,2*10^6kg/year B-C;

PP CONSUMPTIONS:

- 35,0*10^6kg/year A-B-C;
- 34,6*10^6kg/year B-C;



3) <u>PRODUCTION COSTS</u>:

(materials, menwork, utilities, general costs):

Total:

- A-B-C + Std. Flame: 78*10^6 €/year;
- B-C + NH-FT Flame: 64,8*10^6 €/year.

4) NET <u>SAVINGS B-C + NHFT</u>:

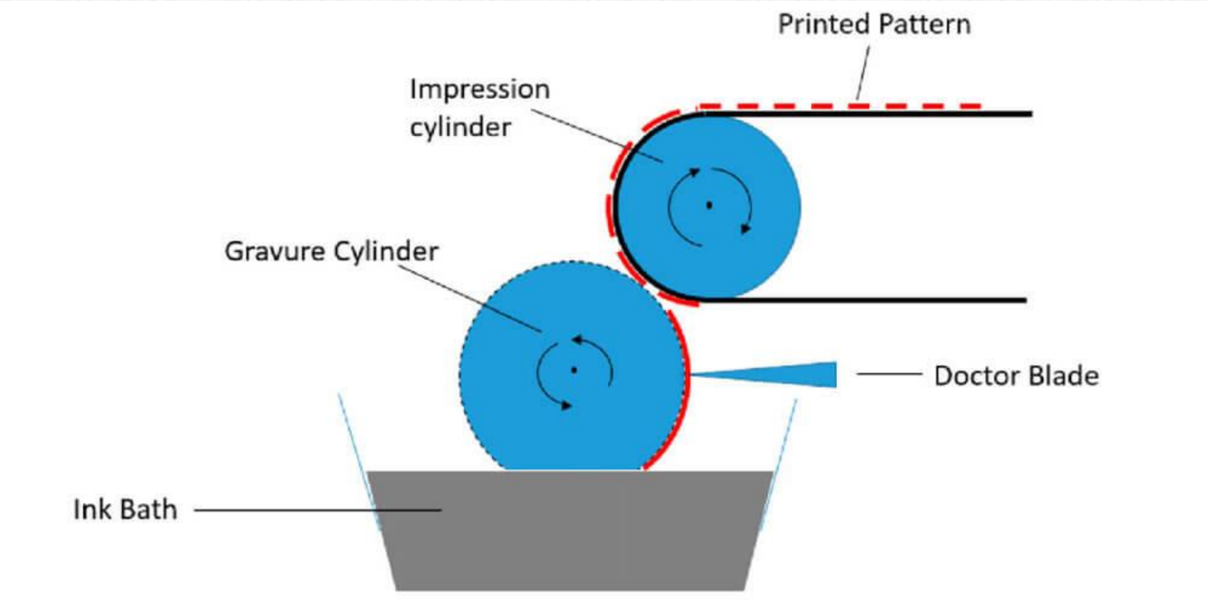
A-B-C + Std. Flame vs. B-C + NH-FT

0,093 €/kg

CASE STUDY 2 – PRINTING PRESS

1) LINE DATA:

Lamination printing 70%, Surface printing 30%;
Average web width: 1,2 m;
Process speed: 260 m/min;
Actual run time per year: 264 days/6336 h;
Average print run: 40,000 m;
Number of colors: 8-color press;
Uptime: 0,50.



2) INKS and CATALYST:

- White Ink: 45%; 2,5g/m2;
- Color Inks: 30%; 1,2g/m2;
- Catalyst (Aromatic Isocyanate): 44%; 7,50% w/w;
- Ink tray capacity in each color station: 70kg;
- Ink tray renewal frequency:
  - 1/day white ink;
  - 2/day color inks.
- Number of color station added with catalyst: 2-5.

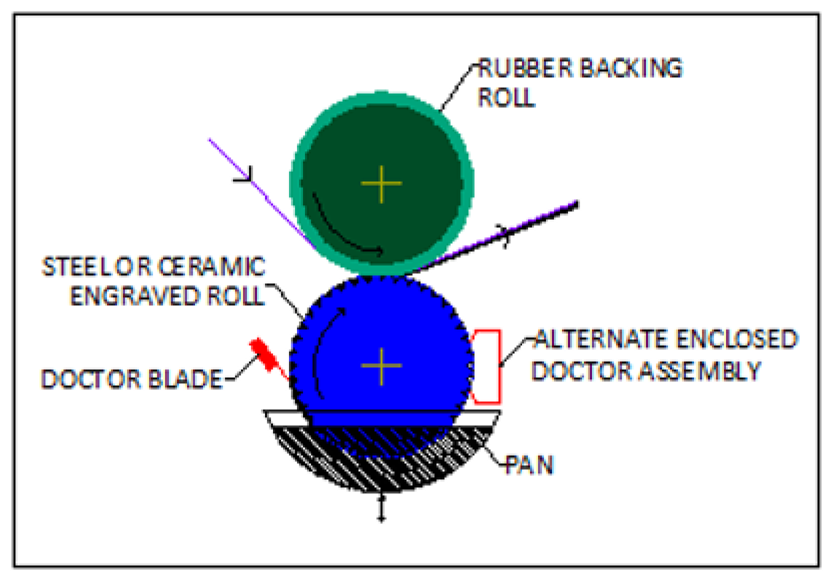
3) NET SAVINGS:

620,000 - 1,400,000 €/year

CASE STUDY 3 – COATING (2 sides coating)

1) <u>LINE DATA</u>:

Average web width: 2,8m;
Web thickness: 18μm;
Process speed: 400m/min;
Scheduled run time per year: 8064h;
Uptime/Slitting Yield: 0.88/0.88;



2) <u>LACQUERS AND PRIMERS</u>:

- A = Acrylic coating grammage: 0.8g/m2;
- Primers: PUR 0.12g/m2; PEI 0.04g/m2
- Coated film (2 sides) grammage: 17.9g/m2
- Production per year after slitting: 7×10^6kg .

3) <u>NET SAVINGS</u>:

C2-C3-C4 w primer vs. C3 w/o primer

0,54 €/kg

NH-FT BENEFITS

- **Process easiness and flexibility**:

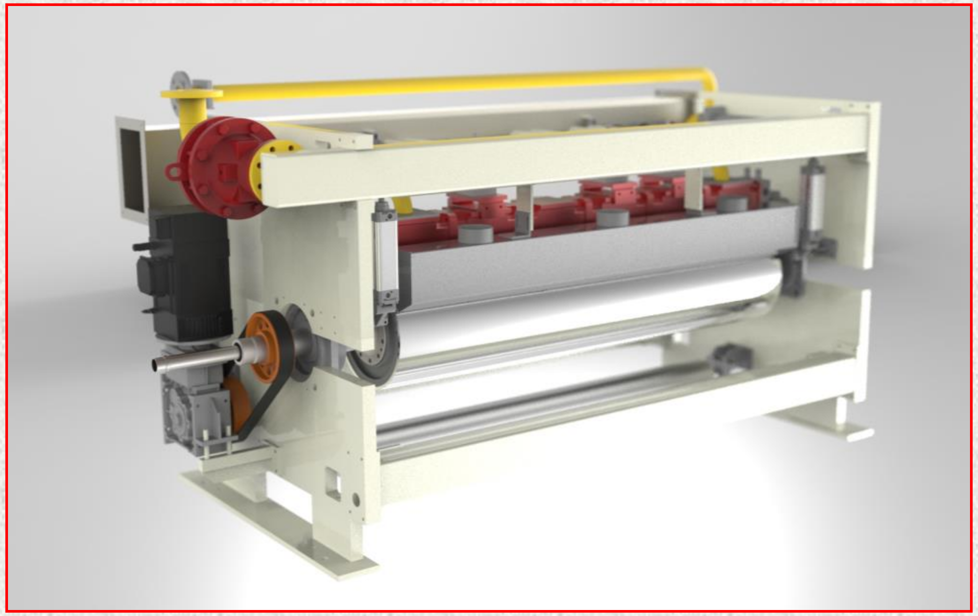
a) Immediate inks adhesion, no need to wait cross-linking up to 24h;

b) Extended ink pot-life, thanks to no cross-linker presence;

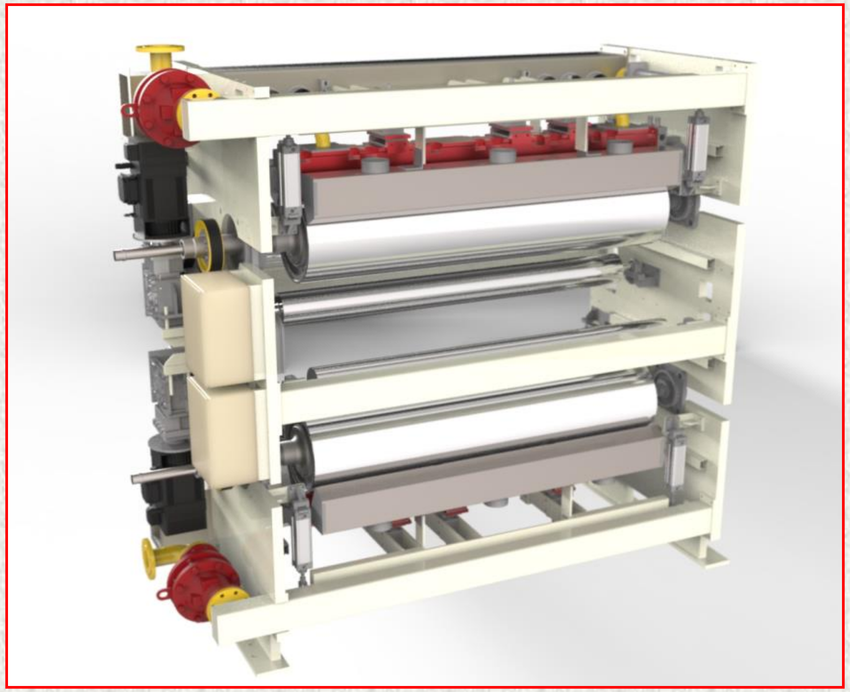
c) Possibility to use one ink for different substrates (as PP, PE, PET).

- **Huge savings, thanks to catalyst/primers/adhesion promoters and their issues elimination;**
- **Removal of eco-toxicological risk coming from adhesion promoters and primers;**
- **No issues for adhesion in high humidity conditions, as happens when using adhesion promoters and primers;**
- **Great step forward towards recyclability and mono-materials.**

NH-FT Flame Treatment Systems



SINGLE SIDE TREATMENT STATION



DOUBLE SIDE TREATMENT STATION

THANK YOU FOR YOUR ATTENTION!

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