2010 PLACE CONFERENCE

A PLACE to Soar

April 18-21, 2010
Albuquerque Marriott
Albuquerque, New Mexico USA

TAPPI
people resources solutions

events.tappiplace.org

Promoting Adhesion - Corona, Flame, Ozone and Plasma Surface Treatment

Presented by:

Rory A. Wolf

VP Business Development

Enercon Industries Corporation

TAPPI
people resources solutions

www.tappiplace.org

PLACE

POLYMERS • LAMINATIONS • ADHESIVES • COATINGS • EXTRUSIONS

Atmospheric Surface Treatment Technology Array




Station Designs	Wide Web (.56m – 2.5m)	Narrow Web (.25 - .55 m)	Ultra-Wide (2.6m – 10m)	3D (.01m - .24m)
Discharge Types	Corona, Flame, Ozone, Plasma	Corona, Flame, Plasma	Corona	Corona, Flame, Plasma
Design Types	Bare Roll, Covered Roll, Universal Roll	Bare Roll, Covered Roll, Universal Roll	Covered Roll, Universal Roll	No Roll Required
Primary Markets	Converting, Flexible Packaging	Labels, Tags, Converting	Film Production	Automotive, Electronics, Medical
Process Applications	Printing, Coating, Laminating	Printing, Coating, Laminating	Printing, Coating, Laminating	Printing, Coating, Laminating

www.tappiplace.org

PLACE

POLYMERS • LAMINATIONS • ADHESIVES • COATINGS • EXTRUSIONS

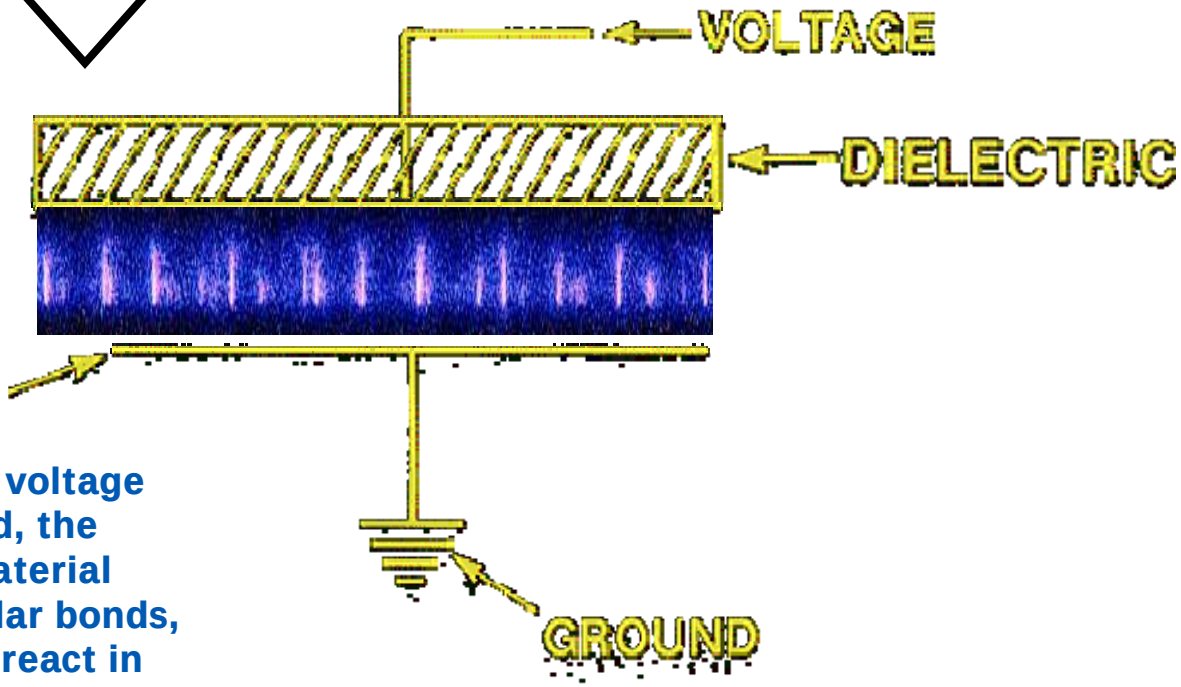
Overview of Corona Treating Systems

www.tappiplace.org

PLACE

POLYMERS • LAMINATIONS • ADHESIVES • COATINGS • EXTRUSIONS

Profile of a Corona Discharge



A corona discharge is a high voltage arc in air. When air is ionized, the electrons collide with the material surface to break the molecular bonds, creating free radicals which react in the presence of oxygen to form high polarity functional groups.

www.tappiplace.org

PLACE

POLYMERS • LAMINATIONS • ADHESIVES • COATINGS • EXTRUSIONS

Profile of a Corona Discharge

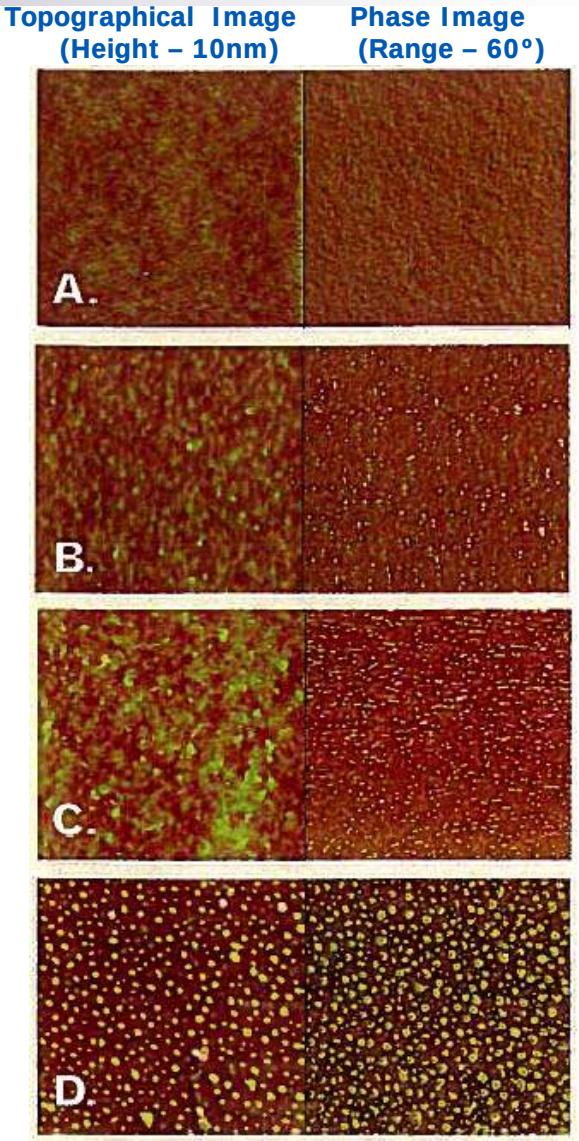
2x2 micron images of PET film

A.No Corona Treatment

B.WD = 1.16W/ft²/min
(12.5W/m²/min)

C.WD = 1.93W/ft²/min
(20.8W/m²/min)

D.WD = 2.71W/ft²/min
(29.2W/m²/min)



www.tappiplace.org

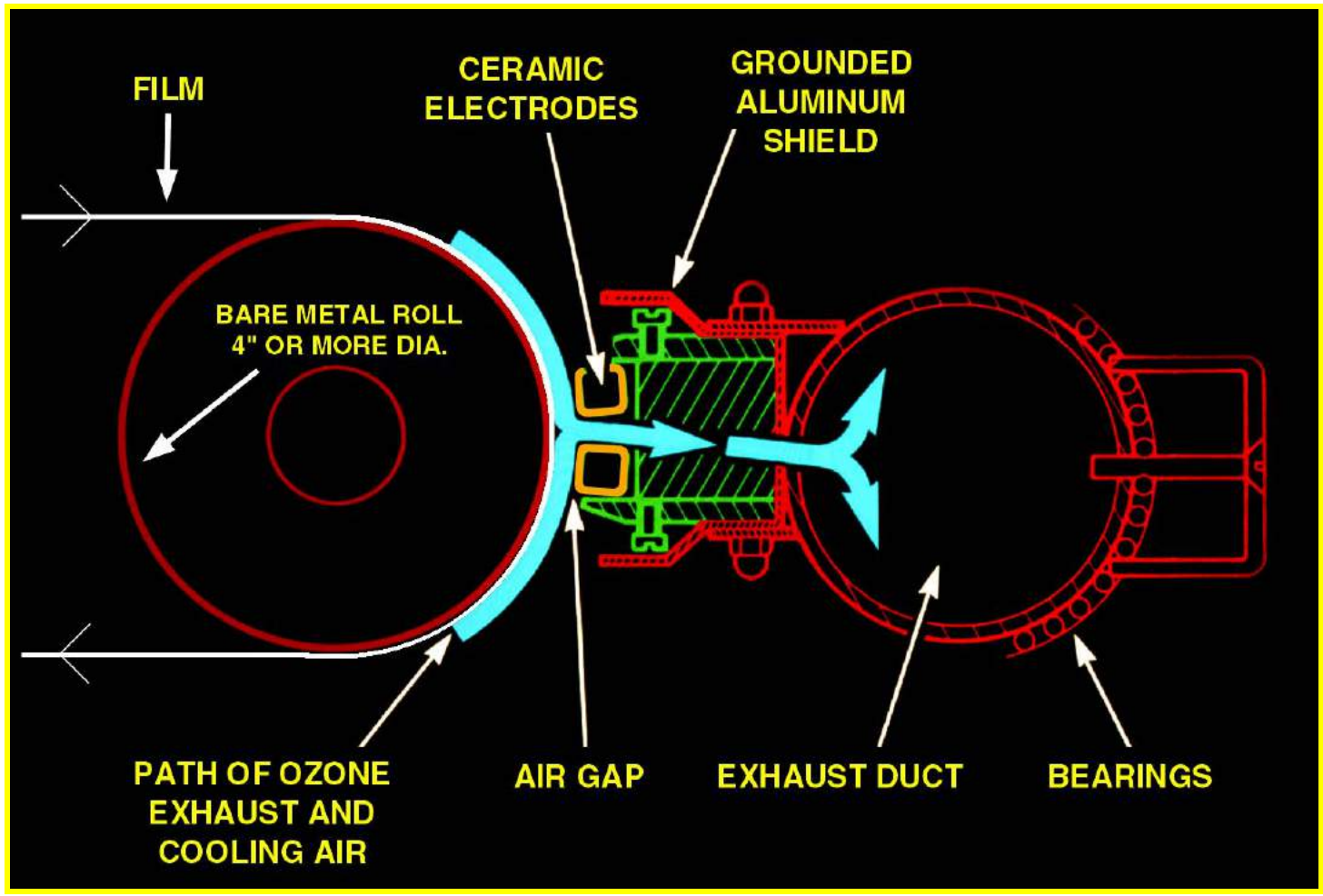
PLACE

POLYMERS • LAMINATIONS • ADHESIVES • COATINGS • EXTRUSIONS

Overview of Corona Treating Systems

Bare Roll

Overview of Corona Treating Systems



www.tappiplace.org

PLACE

POLYMERS • LAMINATIONS • ADHESIVES • COATINGS • EXTRUSIONS

Overview of Corona Treating Systems

Benefits of Bare Roll

- Can treat any substrate including metallized films and foils
- Safe
- No roll covering to fail
- Open station design

Drawbacks

- On difficult to treat materials, may require a higher watt density
- Unable to lane treat

www.tappiplace.org

PLACE

POLYMERS • LAMINATIONS • ADHESIVES • COATINGS • EXTRUSIONS

Overview of Corona Treating Systems

Covered Roll

www.tappiplace.org

PLACE

POLYMERS • LAMINATIONS • ADHESIVES • COATINGS • EXTRUSIONS

Overview of Corona Treating Systems

Benefits of Covered Roll

- Economical (depending on roll covering)
- Can treat most polymers
- Can vary treat width
- Used primarily in film extrusion

Drawbacks

- Roll coverings can fail easily
- Cannot treat metallized films and foils

www.tappiplace.org

PLACE

POLYMERS • LAMINATIONS • ADHESIVES • COATINGS • EXTRUSIONS

Overview of Corona Treating Systems

www.tappiplace.org

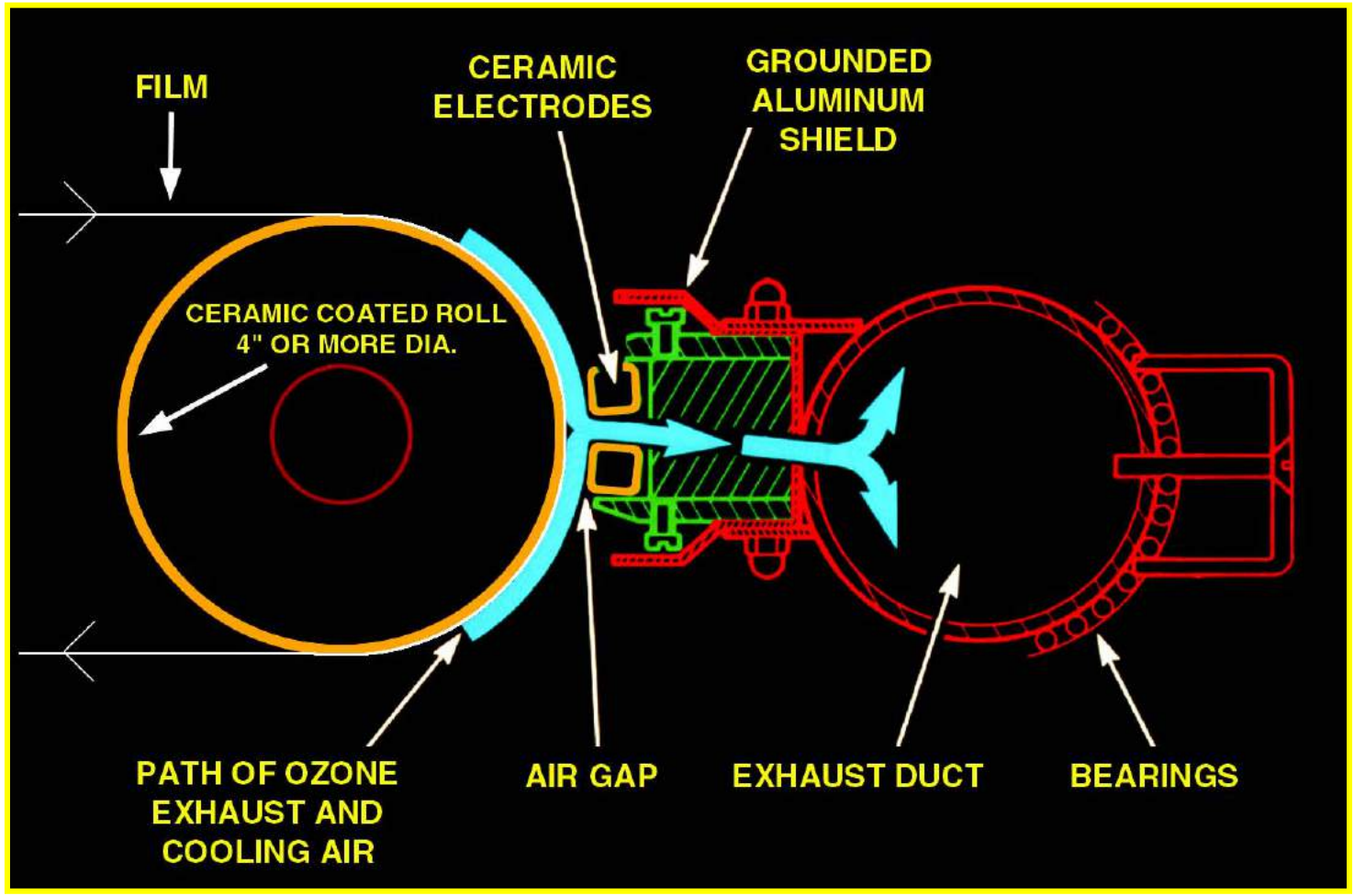
PLACE

POLYMERS • LAMINATIONS • ADHESIVES • COATINGS • EXTRUSIONS

Overview of Corona Treating Systems

Universal Roll

Overview of Corona Treating Systems



www.tappiplace.org

PLACE

POLYMERS • LAMINATIONS • ADHESIVES • COATINGS • EXTRUSIONS

Overview of Corona Treating Systems

Benefits of Universal Roll

- Can treat any substrate including metallized films and foils
- Safe
- Open station design

Drawbacks

- On difficult to treat materials, may require a higher watt density
- Unable to lane treat

www.tappiplace.org

PLACE

POLYMERS • LAMINATIONS • ADHESIVES • COATINGS • EXTRUSIONS

Corona Discharge Safety

The standard Safety interlocks provided with surface treaters are:

- **Zero Speed Interlock**
- **Electrode Position Interlock**
- **Exhaust Air Flow Interlock.**

Other optional interlocks may include:

- **Differential Pressure Interlock for purged systems,**
- **Access Door Interlocks**
- **Trip Cable Interlocks**
- **E-Stop Interlocks.**

Each of these interlocks are connected in series. If just one of the interlocks is open, the power supply will not be allowed to enter the RUN mode when the start command is received.

www.tappiplace.org

PLACE

POLYMERS • LAMINATIONS • ADHESIVES • COATINGS • EXTRUSIONS

Corona Treating Developments

www.tappiplace.org

PLACE

POLYMERS • LAMINATIONS • ADHESIVES • COATINGS • EXTRUSIONS

High Definition Corona Technology

Enhanced Discharge (PV) Electrode Assemblies

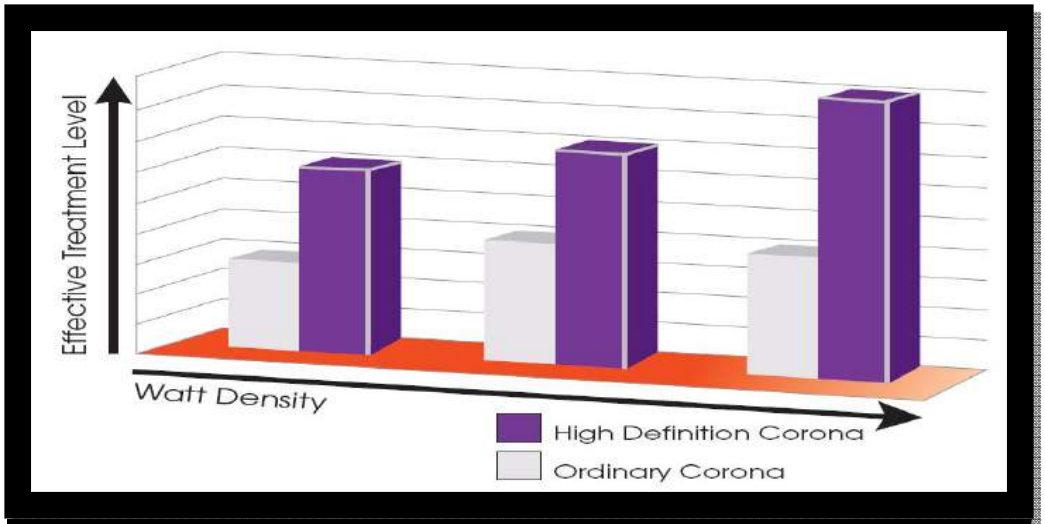
- Reduce # of Electrode Assemblies Required
- Reduce Web Direction and Height Dimensions
- Create Better Station “fit” Within the Line
- Increase Power Density Capacity
- Reduce Station Cost

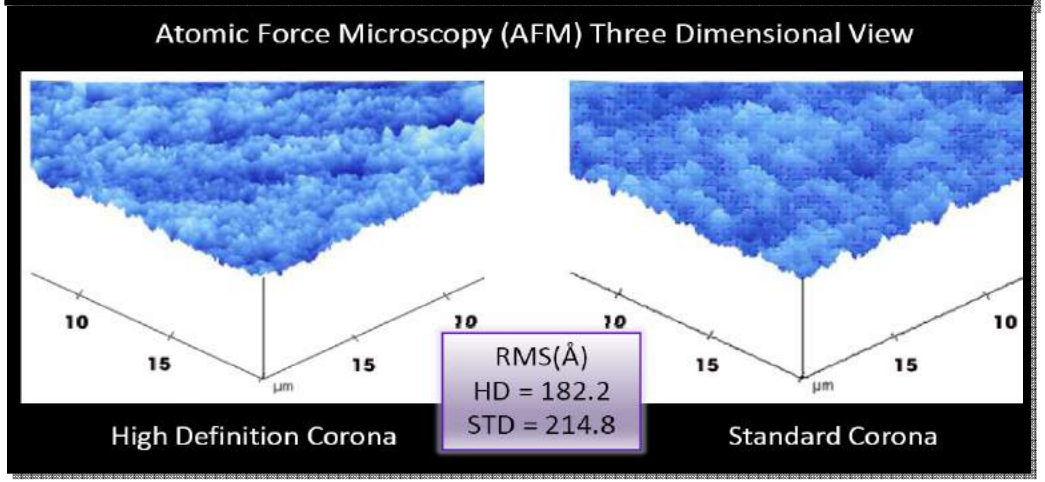
www.tappiplace.org

PLACE

POLYMERS • LAMINATIONS • ADHESIVES • COATINGS • EXTRUSIONS

High Definition Corona Technology





www.tappiplace.org

PLACE

POLYMERS • LAMINATIONS • ADHESIVES • COATINGS • EXTRUSIONS

Corona Treating Developments

Primary Flexible Packaging Usages

- **Water-based, solvent-based, UV/EB ink, coating & adhesive adhesion**
- **Graphics processes supported include Flexographic, Rotogravure, Offset, Screen.**

www.tappiplace.org

PLACE

POLYMERS • LAMINATIONS • ADHESIVES • COATINGS • EXTRUSIONS

Flame Plasma Treating & Developments

www.tappiplace.org

PLACE

POLYMERS • LAMINATIONS • ADHESIVES • COATINGS • EXTRUSIONS

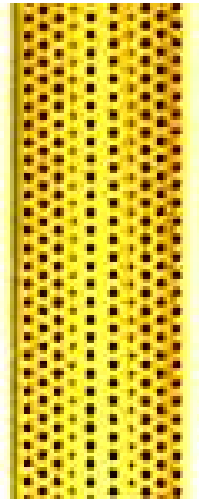
Flame Treating Developments- Burners

Ribbon Burners

- Cast Iron Body
- Stainless Steel Ribbon Ports
- Water Cooled with Continuous Tubes on sides of Ribbon Stacks

Drilled Port Burners

- Aluminum Body
- CNC-drilled Ports in Brass insert
- Water Cooled with Lateral Ports between Burner Sections.



Flame Treating Developments- Safety

- Flame Detection
- Off-Set of Flame Temperature
- Line Speed below the Set Point
- Max or Min Gas Pressure
- Min Air Pressure
- Web Break
- Emergency
- Flash Back Control
- Incorrect Distance (Gap) between Flame and Surface
- Timer for Ignition
- Gas Leakage Control

Control Response

- Cut-Off Gas Flow
- Sound and Flash Alarm

www.tappiplace.org

PLACE

POLYMERS • LAMINATIONS • ADHESIVES • COATINGS • EXTRUSIONS

Flame Plasma Treating Developments

Primary Flexible Packaging Usages

- Removes fibers from paperboard surfaces prior to extrusion coating, preprinting or labeling
- Best process for high-speed BOPP film processing for single or multiple layer structures for Snacks / Confectionary, Frozen / Dry Foods, Dairy, & Soaps / Detergents application markets.

www.tappiplace.org

PLACE

POLYMERS • LAMINATIONS • ADHESIVES • COATINGS • EXTRUSIONS

Ozone Treatment & Developments

www.tappiplace.org

PLACE

POLYMERS • LAMINATIONS • ADHESIVES • COATINGS • EXTRUSIONS

Overview of Ozone Treatment

- Reduce coating weight (ozone polarizes the hot melt)
- Reduce melt temperature
- Enhance adhesion
- Achieve higher line speeds
- Optimize melt stability & neck-in
- Improve heat seal characteristics
- Reduce odor and off-taste

www.tappiplace.org

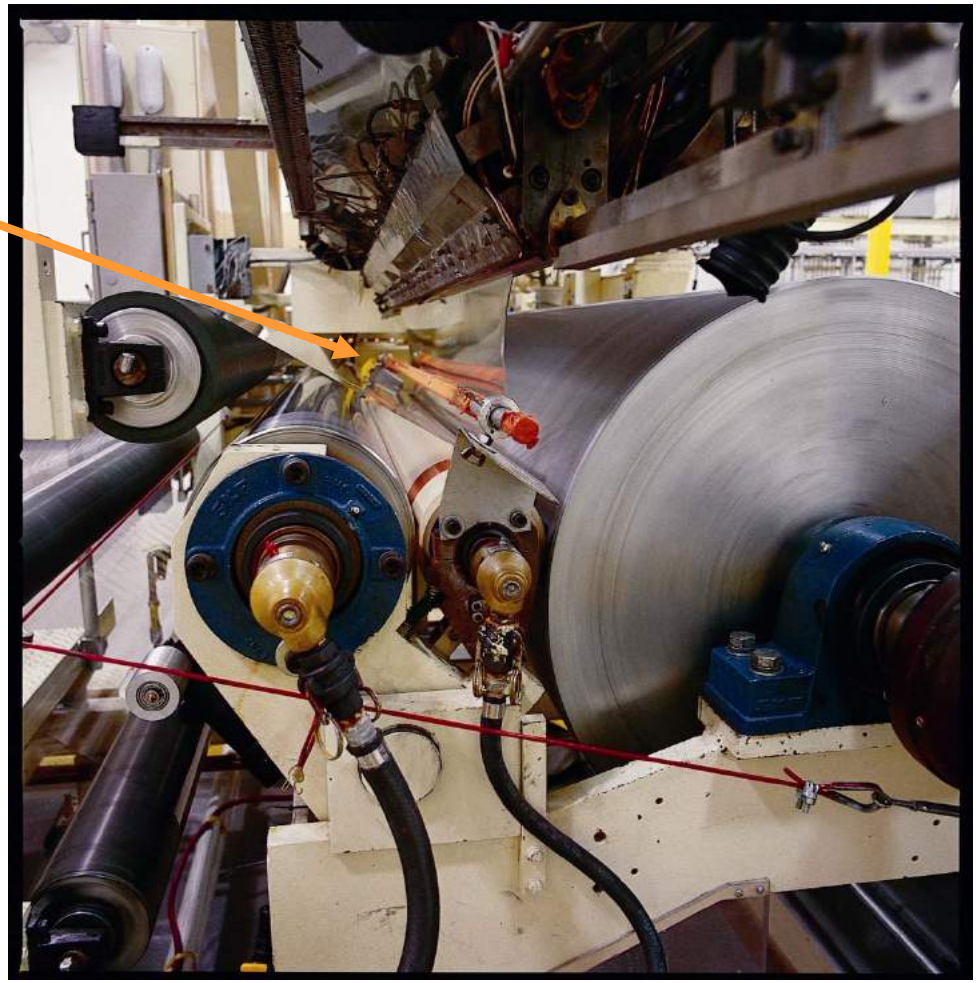
PLACE

Polymers • Laminations • Adhesives • Coatings • Extrusions

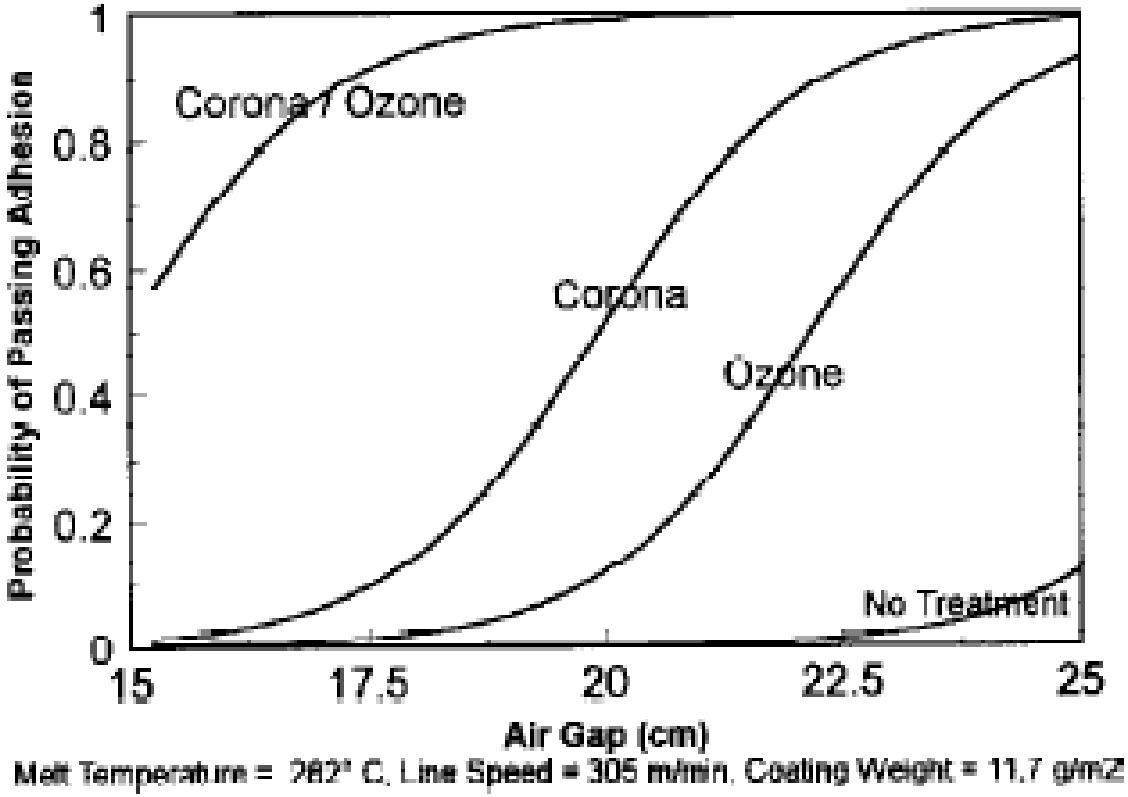
Overview of Ozone Treatment

Ozone Applicator

4cm away, 90° perpendicular to the melt curtain



Overview of Ozone Treatment



Melt Temperature = 282° C, Line Speed = 305 m/min, Coating Weight = 11.7 g/m2

www.tappiplace.org

PLACE

POLYMERS • LAMINATIONS • ADHESIVES • COATINGS • EXTRUSIONS

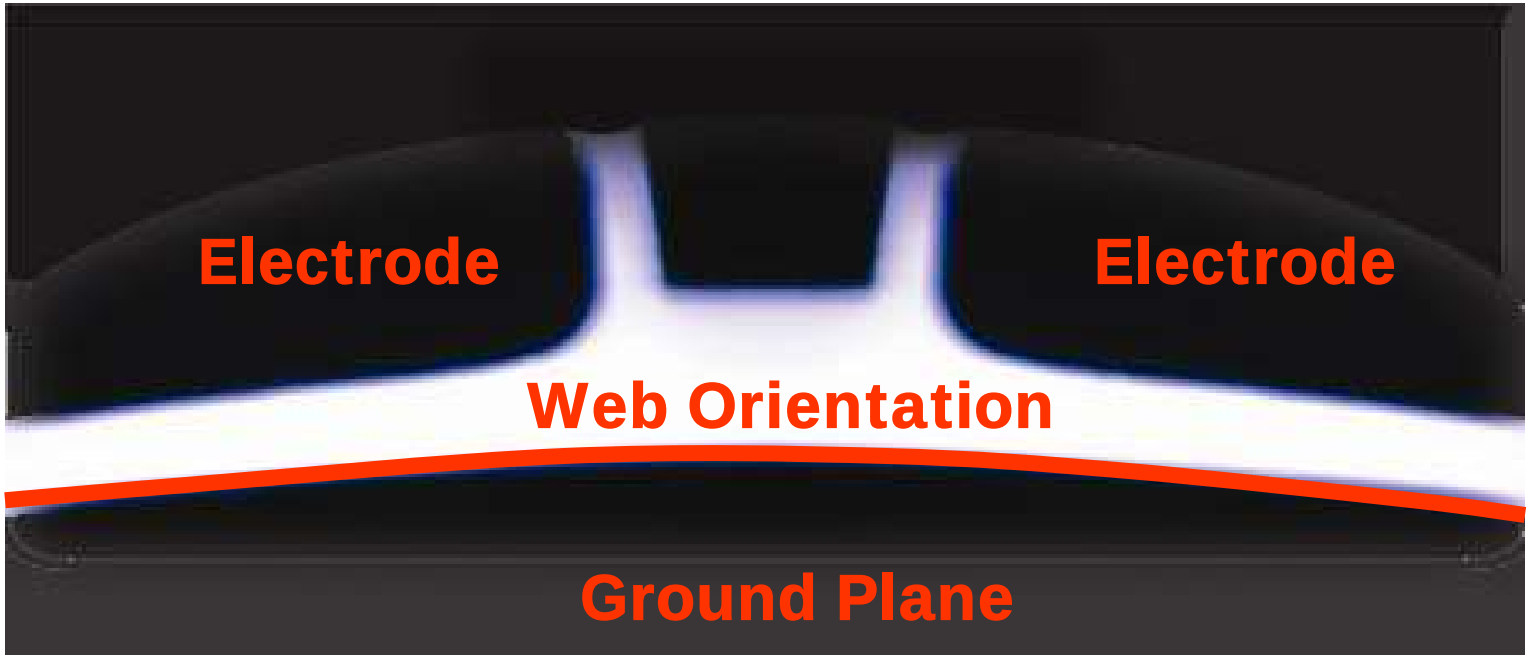
Atmospheric Plasma Treating & Developments

www.tappiplace.org

PLACE

POLYMERS • LAMINATIONS • ADHESIVES • COATINGS • EXTRUSIONS

Atmospheric Plasma Treating



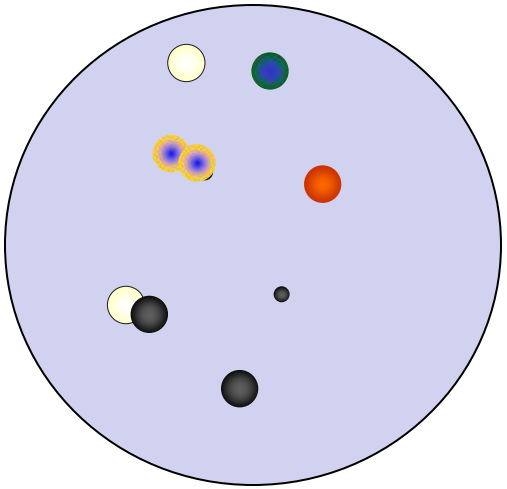
www.tappiplace.org

PLACE

POLYMERS • LAMINATIONS • ADHESIVES • COATINGS • EXTRUSIONS

Atmospheric Plasma Treating

plasma : *n* ; **"Fourth state of matter", (Solid, Liquid, Gas, Plasma.) Mixture of charged ions & energetic electrons generally in equilibrium.**



www.tappiplace.org

PLACE

POLYMERS • LAMINATIONS • ADHESIVES • COATINGS • EXTRUSIONS

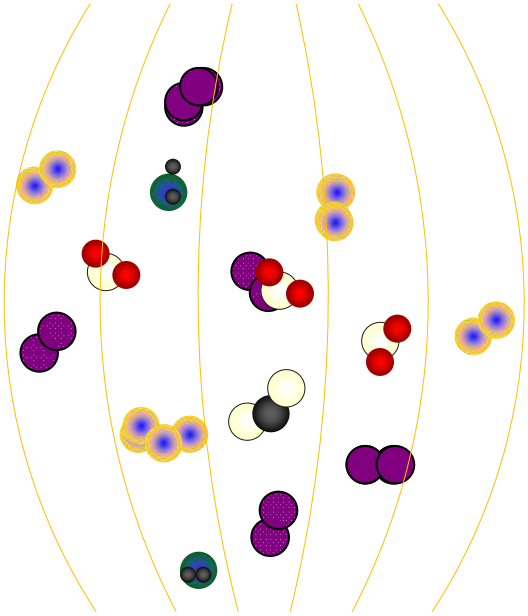
Atmospheric Plasma Treating

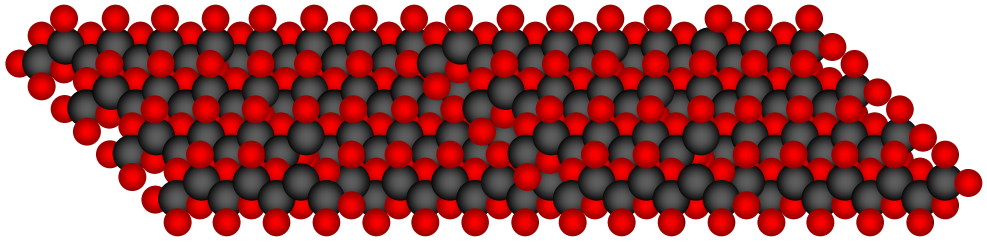
Recipe

1) Take one photon, and allow it to randomly liberate one bound electron from a gas molecule.

2) Accelerate this free electron in an electrical field, forcing it to collide with other gas molecules with enough kinetic energy to separate the atoms, or free more electrons.

3) Increase power in the electric field to create an avalanche of electron collisions.



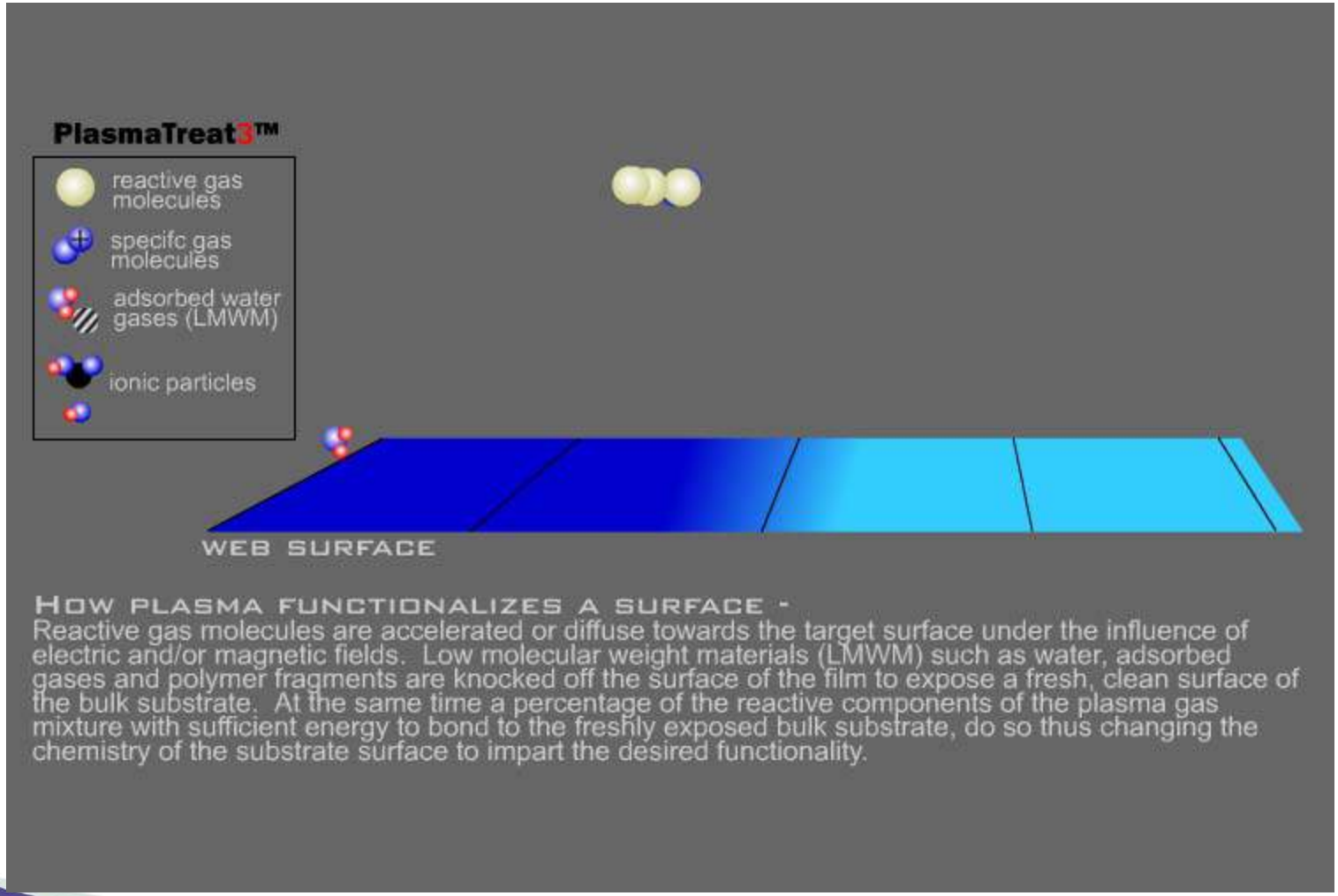


www.tappiplace.org

PLACE

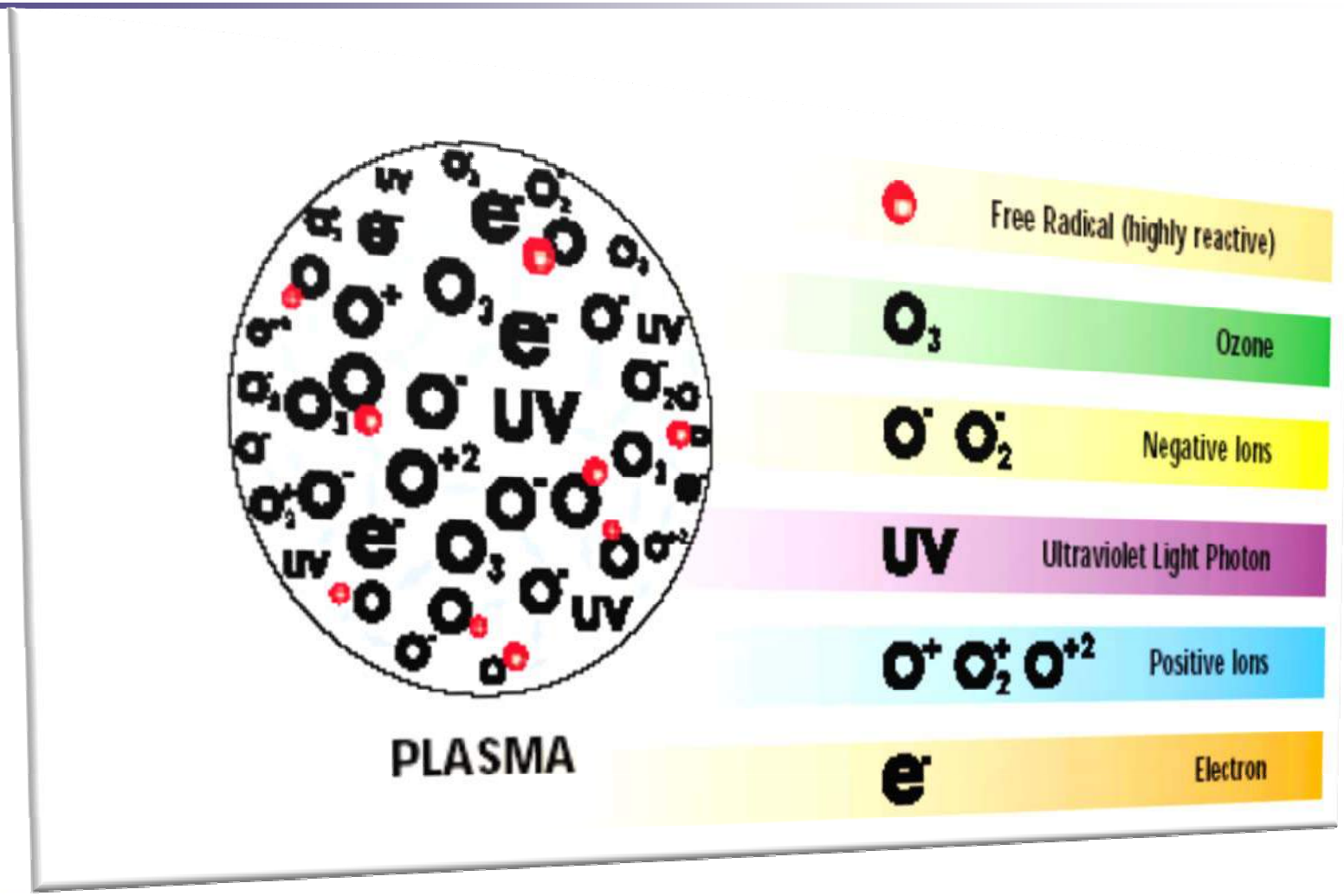
POLYMERS • LAMINATIONS • ADHESIVES • COATINGS • EXTRUSIONS

Plasma Treatment Functionalization Process



HOW PLASMA FUNCTIONALIZES A SURFACE -
Reactive gas molecules are accelerated or diffuse towards the target surface under the influence of electric and/or magnetic fields. Low molecular weight materials (LMWM) such as water, adsorbed gases and polymer fragments are knocked off the surface of the film to expose a fresh, clean surface of the bulk substrate. At the same time a percentage of the reactive components of the plasma gas mixture with sufficient energy to bond to the freshly exposed bulk substrate, do so thus changing the chemistry of the substrate surface to impart the desired functionality.

Atmospheric Plasma Systems



www.tappiplace.org

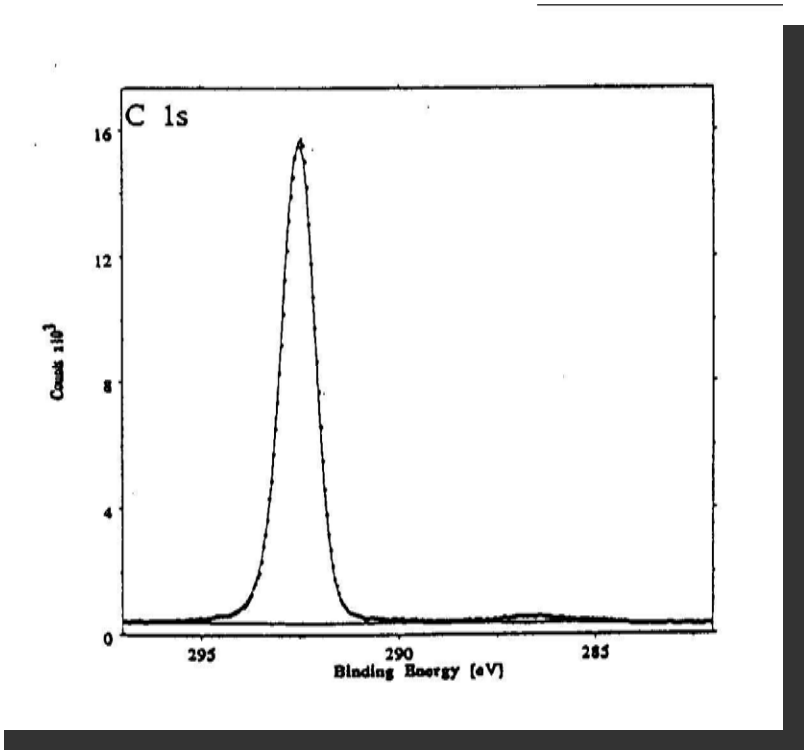
PLACE

POLYMERS • LAMINATIONS • ADHESIVES • COATINGS • EXTRUSIONS

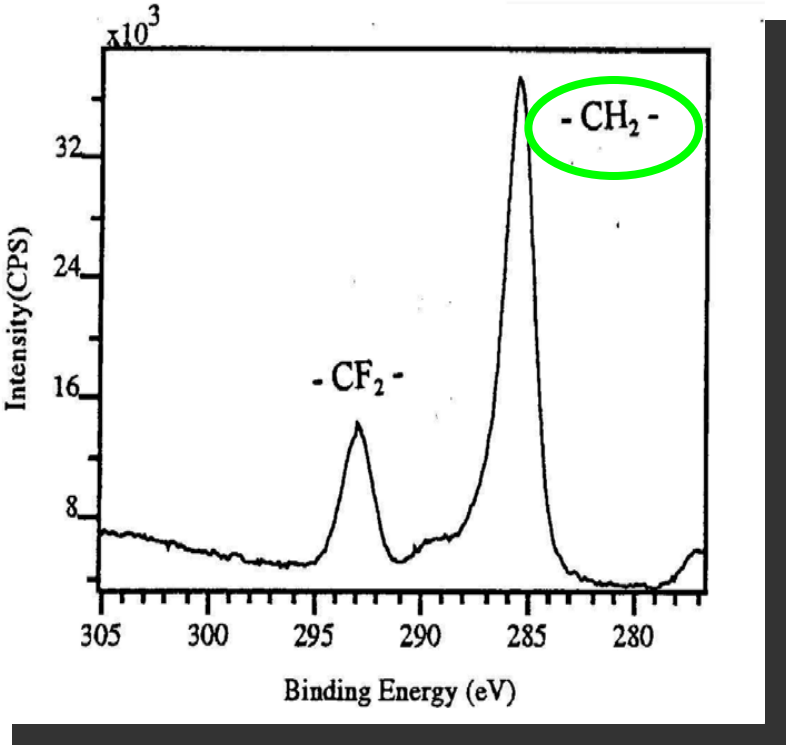
Atmospheric Plasma Systems

- **Plasma Activation**
  - ⇨ Changes free radicals on the surface by substituting chemical groups on the polymer chain being modified.
- **Plasma Deposition**
  - ⇨ Hydroxyl, carbonyl, carboxyl, carboxylic, amino-carboxyl, and amine chemical groups on surface
- **Plasma-Induced Grafting**
  - ⇨ Free radicals are created along the polymer backbone.

Atmospheric Plasma Systems



XPS spectrum results of untreated PTFE sample



XPS spectrum results of treated PTFE sample

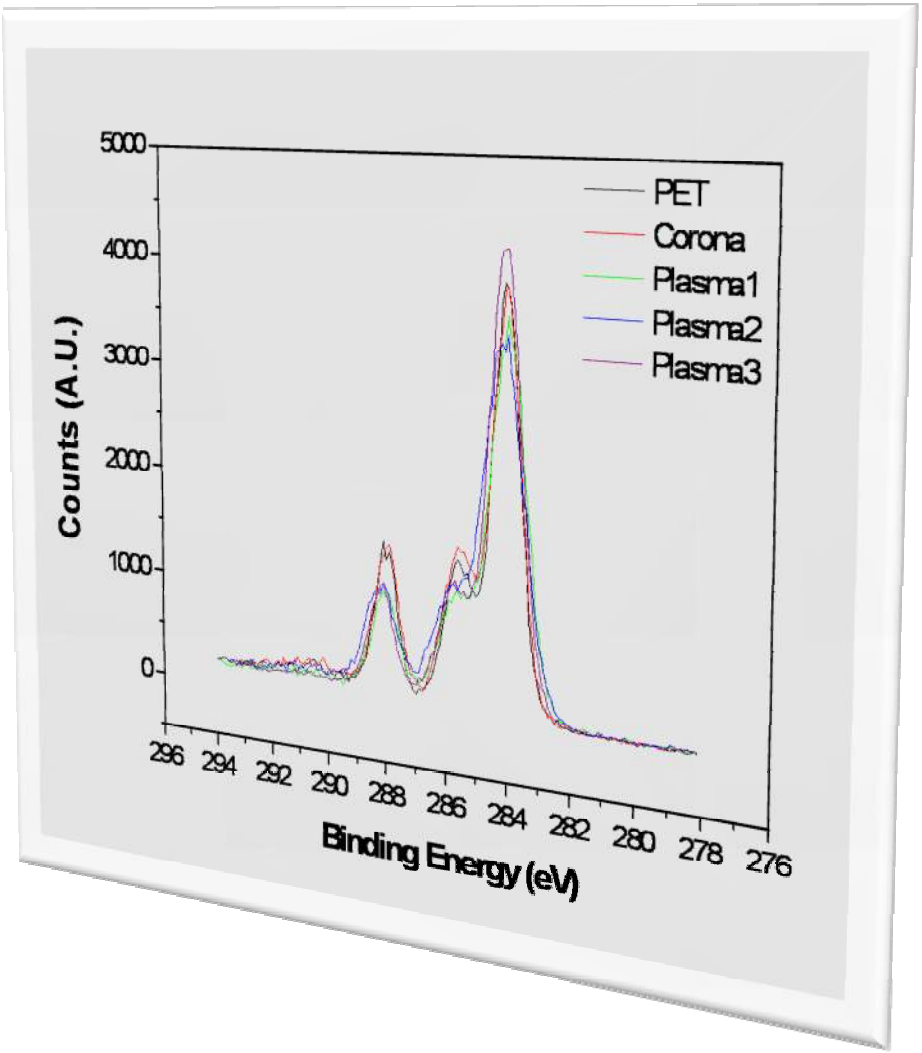
www.tappiplace.org

PLACE

POLYMERS • LAMINATIONS • ADHESIVES • COATINGS • EXTRUSIONS

Peak Broadening - Plasma Treatment on PET Film

Peak Broadening occurs due to multiple functional groups being present on the surface.



www.tappiplace.org

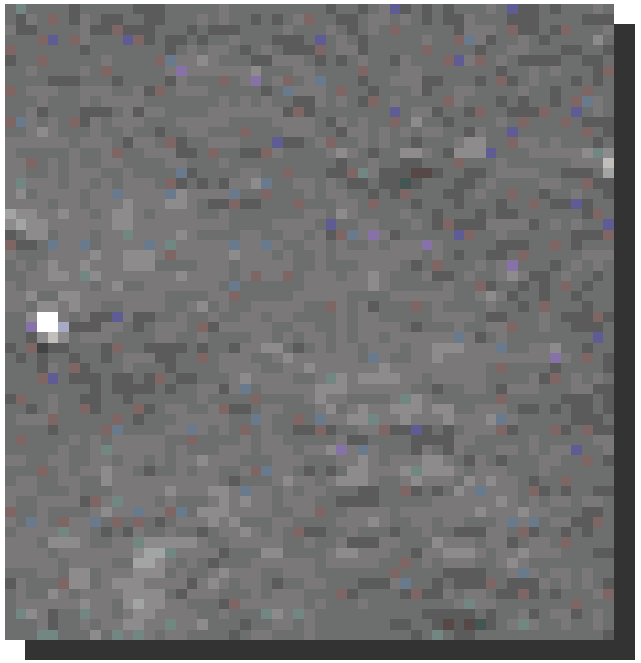
PLACE

POLYMERS • LAMINATIONS • ADHESIVES • COATINGS • EXTRUSIONS

Plasma Treatment Micro-Etching Effect

PE Film (30,000 SEM magnification)

Original Film



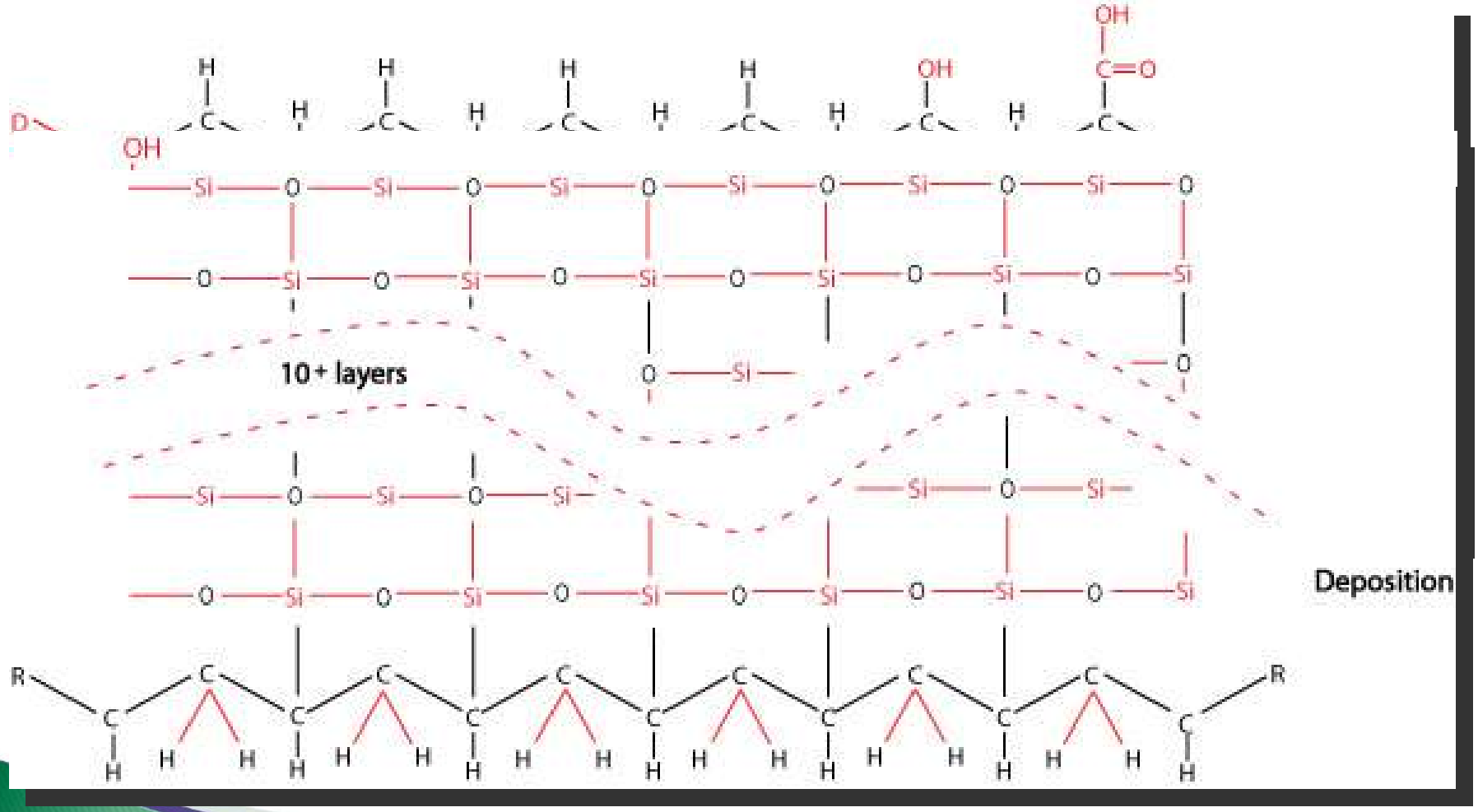
Plasma-Treated

www.tappiplace.org

PLACE

POLYMERS • LAMINATIONS • ADHESIVES • COATINGS • EXTRUSIONS

Atmospheric Plasma Systems



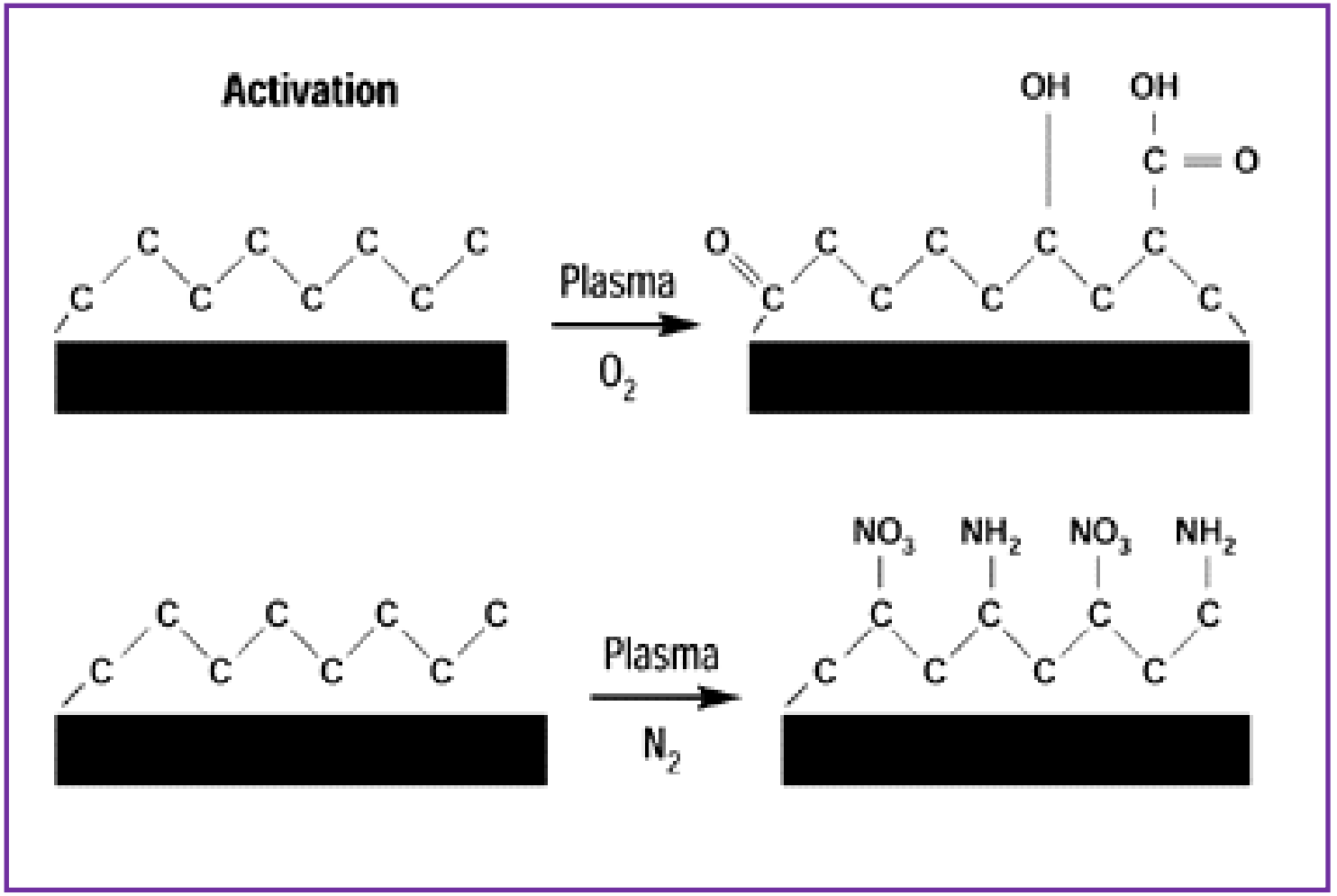
www.tappiplace.org

PLACE

POLYMERS • LAMINATIONS • ADHESIVES • COATINGS • EXTRUSIONS

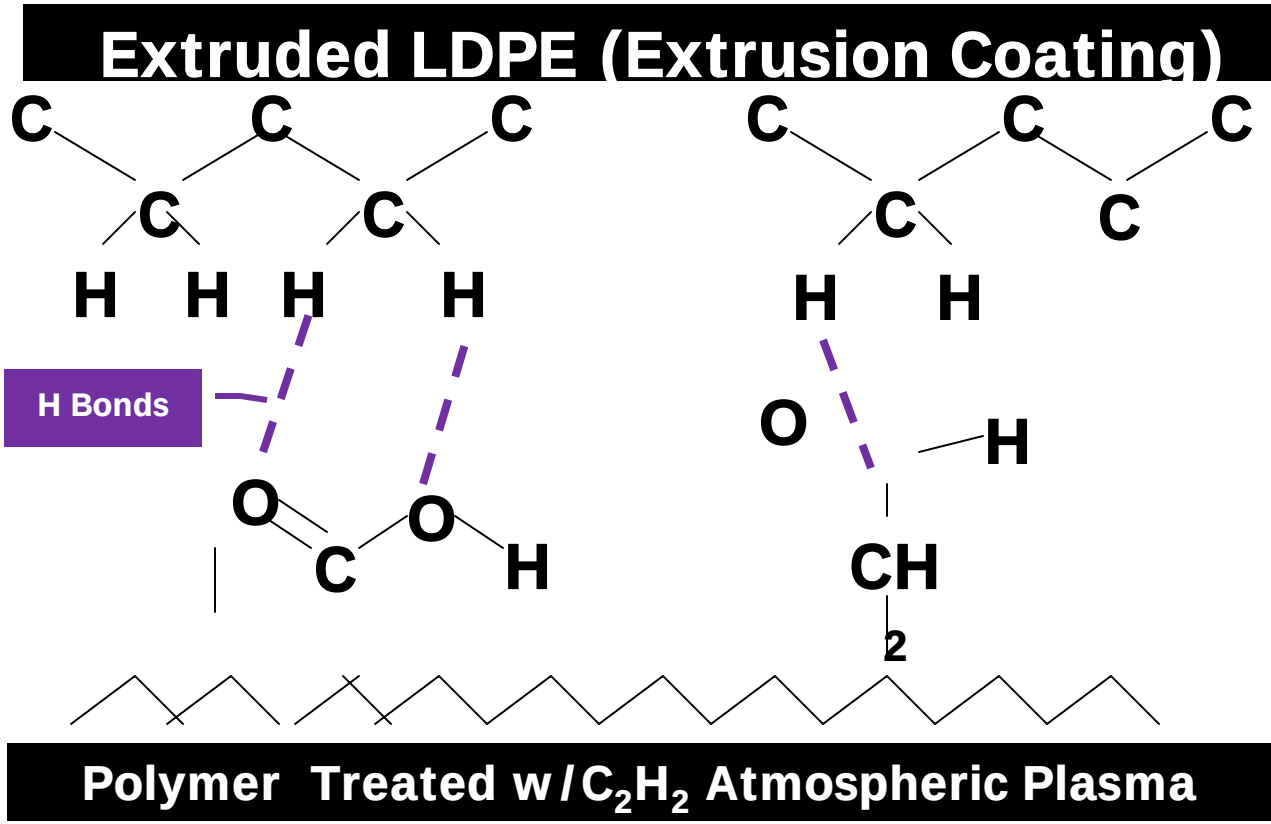
Current Plasma Application Markets

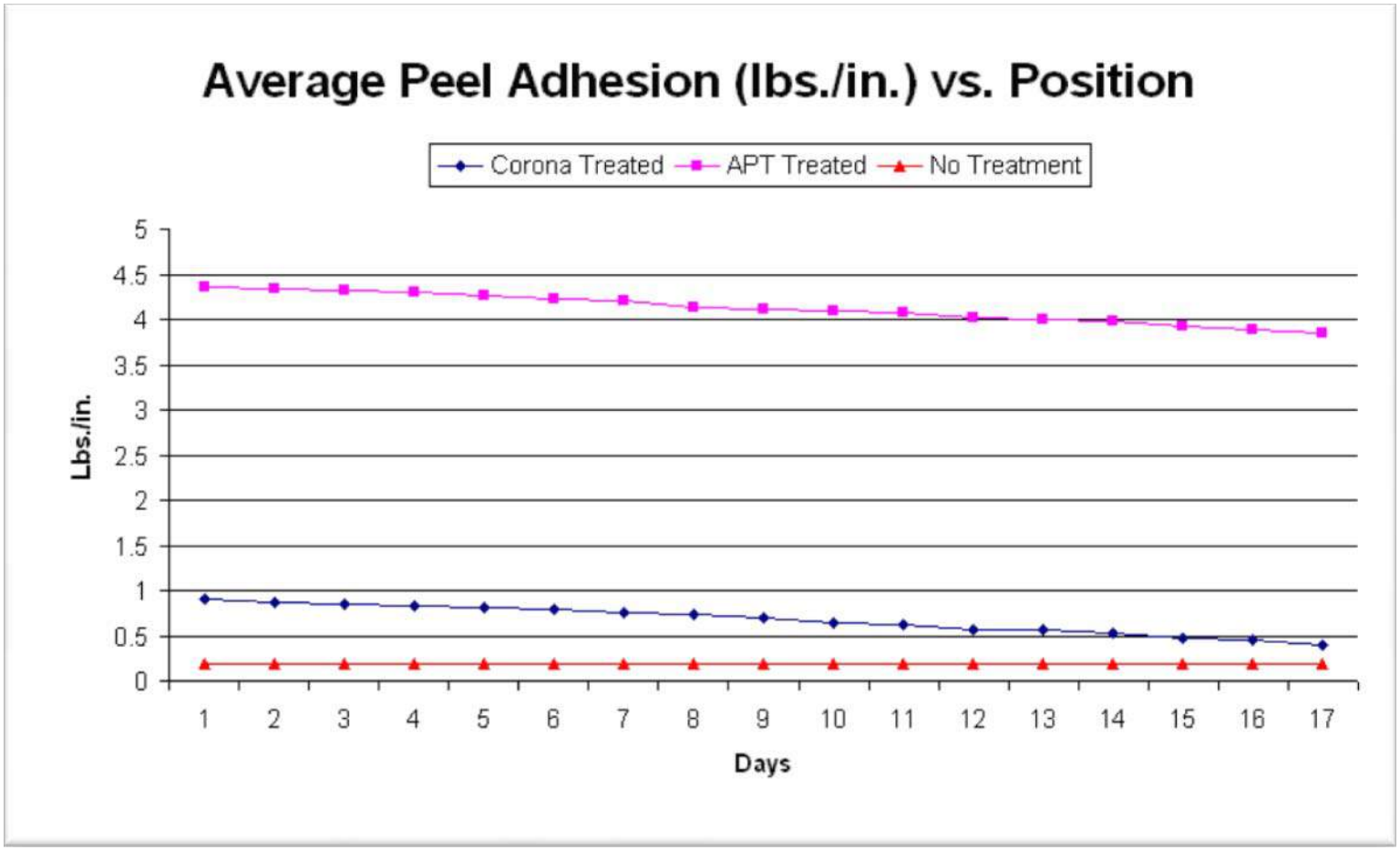
Flexible Packaging

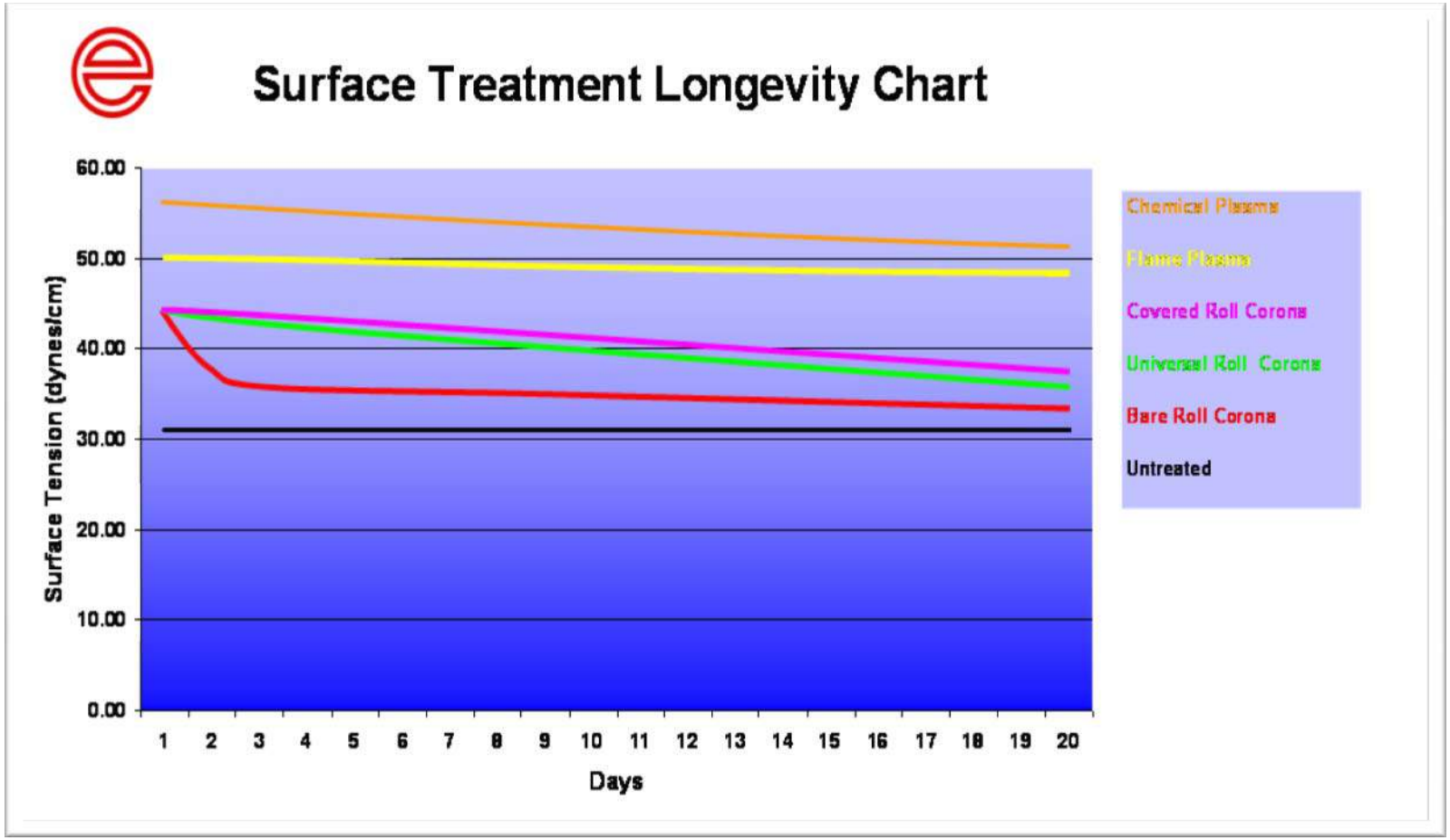


Current Plasma Application Markets

Flexible Packaging




Average Peel Adhesion (lbs./in.) vs. Position
Corona Treated
APT Treated
No Treatment
Lbs./in.
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
Days


Surface Treatment Longevity Chart
Surface Tension (dynes/cm)
60.00
50.00
40.00
30.00
20.00
10.00
0.00
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
Days
Chemical Plasma
Flame Plasma
Covered Roll Corona
Universal Roll Corona
Bare Roll Corona
Untreated

www.tappiplace.org

PLACE

POLYMERS • LAMINATIONS • ADHESIVES • COATINGS • EXTRUSIONS

Recommended Process Parameters - WD[1] / Tension[2]

	Corona	Flame[3]	APT	Ozone[4]
OPP, BOPP (water-base ink adhesion)	27.8-33.3 / 42 - 48	277.8 / 44	22.2-27.8 / 42 - 48	n/a
OPP, BOPP (polyolefin melt adhesion over water-base ink)	16.6 - 22.2 / 50 - 56	148.2 / 50	11.1 - 16.7 / 50 - 56	n/a
OPP, BOPP (solvent-base ink adhesion)	22.2-27.8 / 38 - 44	220.0 / 40	16.6 - 22.2 / 38 - 44	n/a
OPP, BOPP (polyolefin melt adhesion over solvent ink)	16.6 - 22.2 / 40 - 46	148.2 / 42	11.1 - 16.7 / 40 -46	n/a
PET, BOPET (water-base ink adhesion)	13.8-19.4 / 50 -56	148.2 / 52	8.8 - 11.1 / 50 - 56	n/a
PE (water-base ink adhesion)	27.8-33.3 / 42 - 48	277.8 / 44	22.2-27.8 / 42 - 48	n/a
PE (solvent-base ink adhesion)	22.2-27.8 / 38 - 44	220.0 / 40	16.6 - 22.2 / 38 - 44	n/a
PET, BOPET (polyolefin melt adhesion over water ink)	16.6 - 22.2 / 50 - 56	185.2 / 52	11.1 - 16.7 / 50 - 56	n/a
PET, BOPET (solvent-base ink adhesion)	11.1-16.7 / 54 -56	122.22 / 54	8.8 - 11.1 / 54-56	n/a
PET, BOPET (polyolefin melt adhesion over solvent ink)	16.6 - 22.2 / 40 - 44	185.2 / 42	11.1 - 16.7 / 40 - 44	n/a
SiOx-coated PET	88.9 - 111 / 38 - 44	Data limited	66.6 - 88.9 / 38 - 44	n/a
Metallized Films	33.3-55.6 / 42 - 46	Data limited	22.2 - 44.4 / 42 - 46	n/a
Aluminium Foil	36.6 - 54.5 / 60 - 70	Data limited	22.2 - 44.4 / 60 - 70	5 - 8 mg/m²
Paper, Paperboard (coated)	16.6 - 22.2 / 42 - 44	222.2 / 43	11.1 - 16.7 / 42 - 44	n/a
Extruded LDPE Coating (adhesion to paper/paperboard)	16.6 - 22.2	277.8	11.1 - 16.7	2 - 4 mg/m²

Note: 100% Ink coverage assumed for polymer melt adhesions over inks.

[1] Watts/m²/min. range

[2] Dynes/cm range

[3] 1kW = 3,412 BTUs/hr./lineal burner inch (Enercon PowerFlame burner), 11:1 stoichiometric ratio. Dyne data is minimum outcome.

[4] Assumes extrudate melt temperature of 300-320C.

www.tappiplace.org

PLACE

POLYMERS • LAMINATIONS • ADHESIVES • COATINGS • EXTRUSIONS

Thank you!

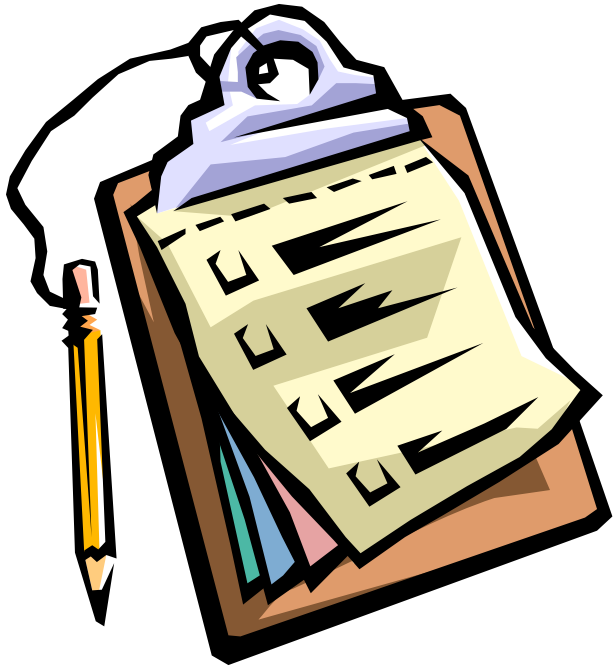
PRESENTED BY

Rory A. Wolf

VP Business Development

Enercon Industries Corp.

rwolf@enerconmail.com



Please remember to turn in your evaluation sheet...