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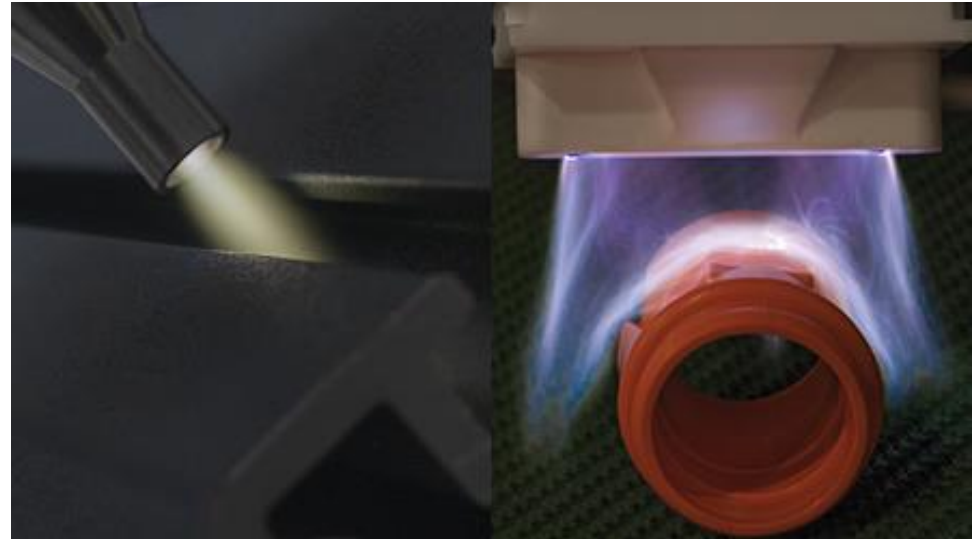
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Getting Started with Atmospheric Plasma Surface Treatment

DIGITAL BOOK SERIES



Table of Contents

1. **Why inks, coatings & adhesives need help bonding to surfaces**
2. **How does surface treatment promote adhesion?**
3. **What types of surfaces can be treated?**
4. **How can I determine if surface treatment is successful?**
5. **Plasma Technology Comparison**
6. **Next Steps : Review, Integration Options, Free Lab Trials**

Introduction

One of the most important requirements for adhesion is the condition of the surface prior to **bonding with inks, coatings & adhesives**.

In-line atmospheric plasma treating systems are proven to **improve adhesion** properties on a wide variety of surfaces.

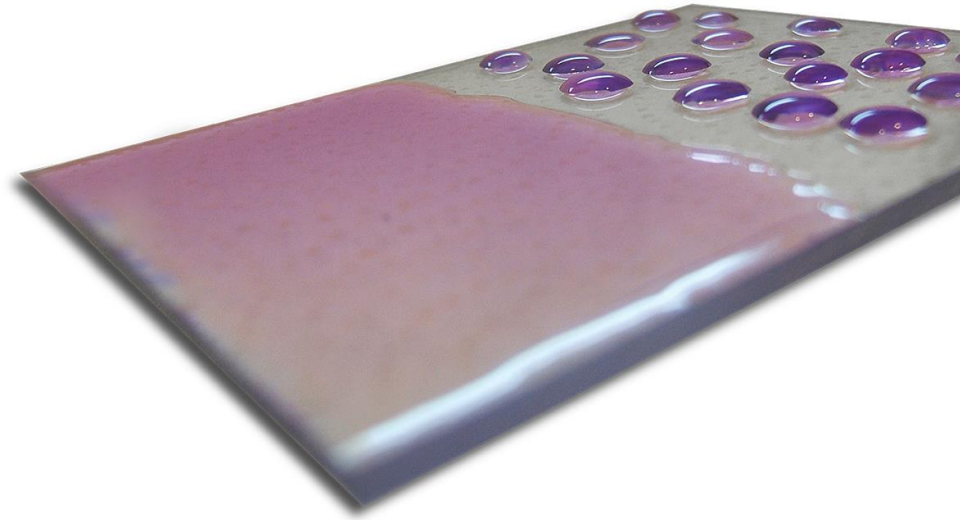
Benefits of in-line surface treatment include **stronger bonds**, faster line speeds, and improved product quality.

This eBook covers the basics of **plasma surface treatment** and the technologies available for specific applications.

Chapter 1

**Why Inks, Coatings &
Adhesives need help
bonding to surfaces**

**Controlling surface variables is
key for successful adhesion**



Factors Affecting Adhesion Dynamics

Material type

Performance-aiding additive load

Adhesive chemistry

Bond stress

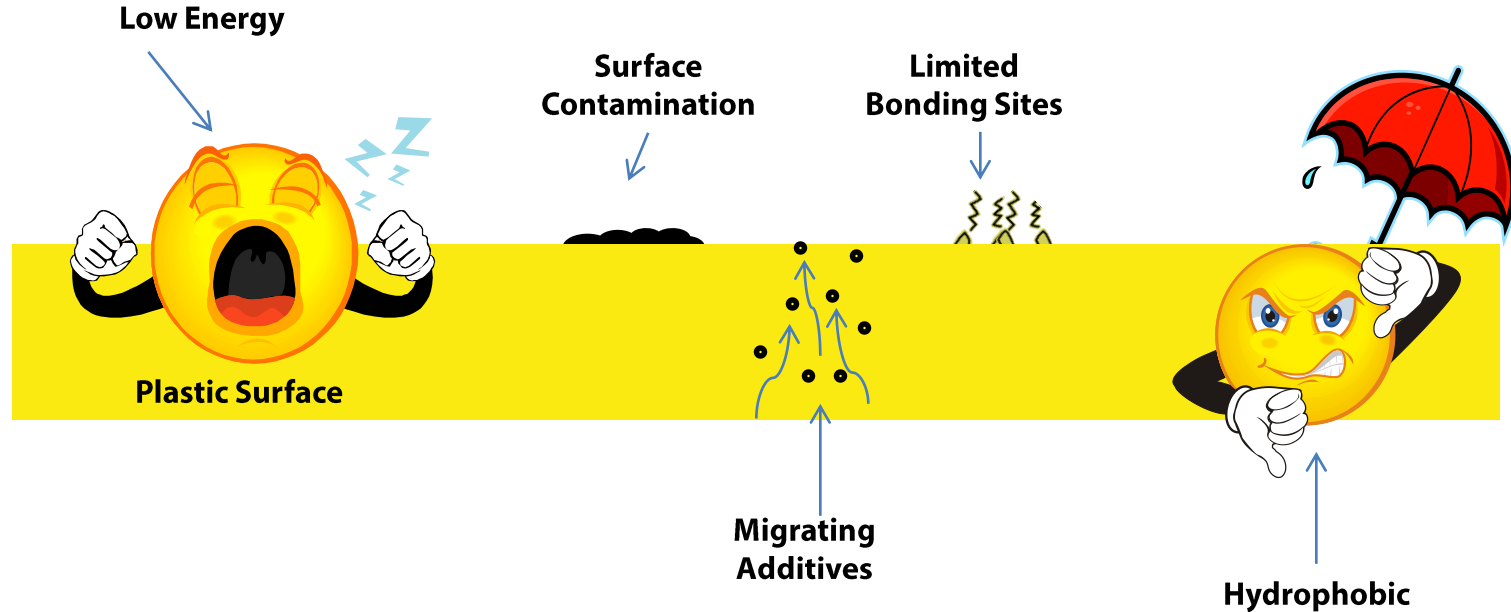
Surface contaminants

Surface roughness

Surface chemistry

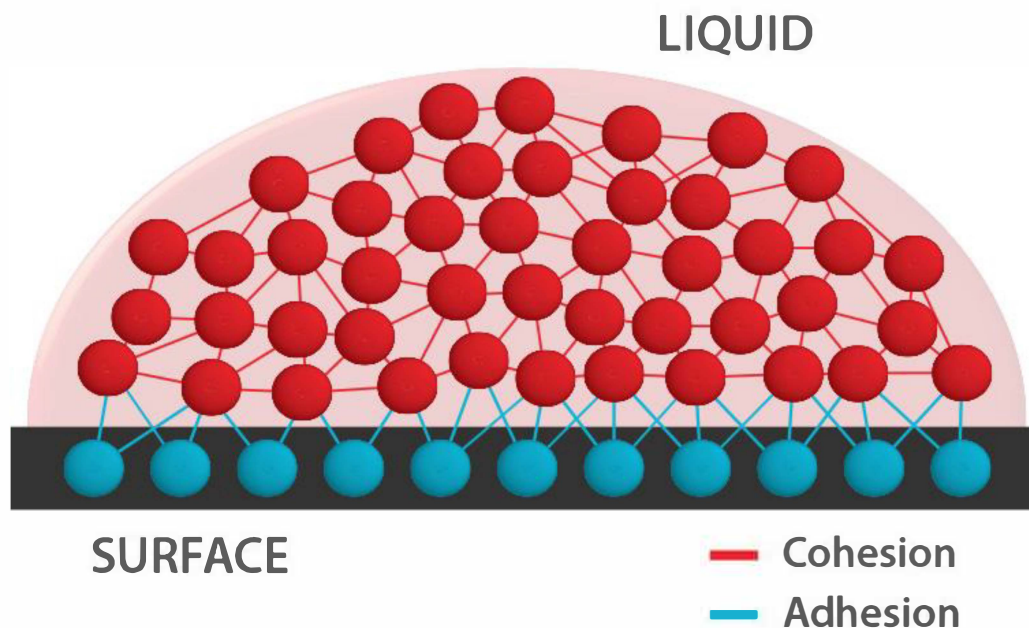


Common Adhesion Impediments Found on Plastic Surfaces



Plastics are generally composed of non polar, long-chain molecules, non porous, hydrophobic, & offer only a small amount of free energy. As such, plastics have few available bonding sites due to low levels of charged ions on the surface. Any type of surface contamination will have a negative effect on adhesion. This includes material additives & release agents which can migrate to the surface

How the Forces of Cohesion & Adhesion Affect Wetting Out



Low energy, lack of bonding sites, and surface contamination have a negative impact on molecular attraction, causing liquids to fail to wet the surface.

In simple terms:

When you observe a liquid beading up on a surface you are witnessing **the forces of cohesion** (the property of the liquid's like molecules to remain attracted) being stronger than the **forces of adhesion** (the property of unlike molecules to attract.)

Examples of Poor Adhesion



Poor adhesion resulting from surface issues appear in a variety of ways:

- **Inconsistent ink adhesion**
- **Label adhesive failures**
- **Failure of coatings to wet out**
- **Bond strength failures**

Chapter 2

How Atmospheric Plasma Treatment Improves Adhesion

Getting Started with Atmospheric Plasma Surface Treatment

Atmospheric plasma discharges clean, etch and functionalize surfaces to improve adhesion.



What is atmospheric plasma?

plasma : n ; “Fourth state of matter”, (Solid, Liquid, Gas, Plasma.)

Mixture of charged ions & energetic electrons generally in equilibrium.

Atmospheric plasma surface treaters generate plasma to impart adhesion promotion onto a wide range of surfaces.

Adhesion Promoting Surface Effects

Cleans Surfaces

Etches Surfaces

Functionalizes
Surfaces

Atmospheric plasma is highly effective at **cleaning, etching & functionalizing** a variety of surfaces.

The following pages will provide insights into how atmospheric plasma achieves these effects and how they help promote adhesion.



Plasma Cleaning



Plasma treatment **removes organic and inorganic impurities & contaminants** from the surface.

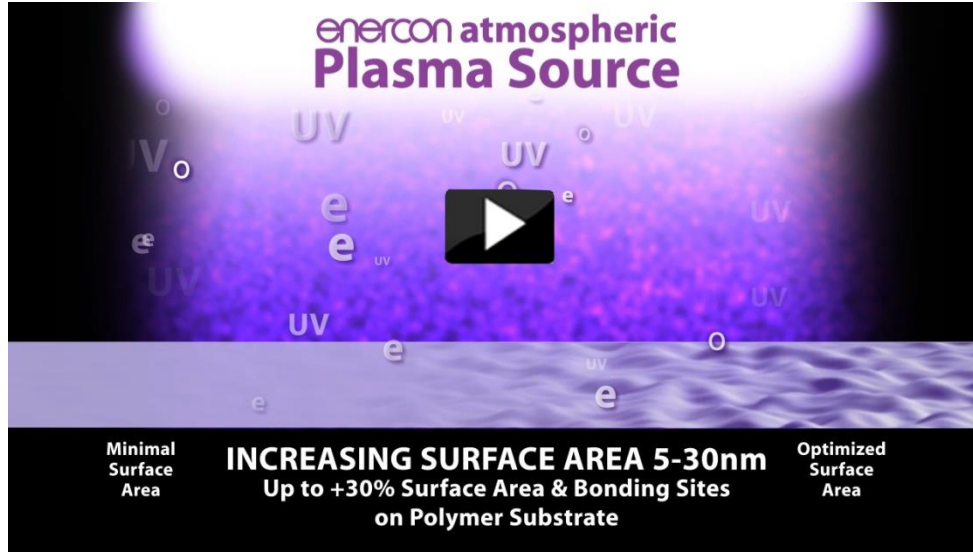
Plasma species react with the surface and decompose, volatilize & vaporize low molecular weight contaminants to expose a clean, fresh surface to promote adhesion.

Click the image above to see an animation of plasma cleaning.

Cleans Surfaces



Plasma Etching



Micro etching of a polymer surface is accomplished as charged ions, neutral atoms and radicals, in both the plasma forming gas and the reactive process gas, bombard the surface.

Increasing surface area creates more bonding sites which promotes adhesion success.

Click the image above to see an animation of plasma etching.

Etches Surfaces

Plasma Functionalizing and Activation



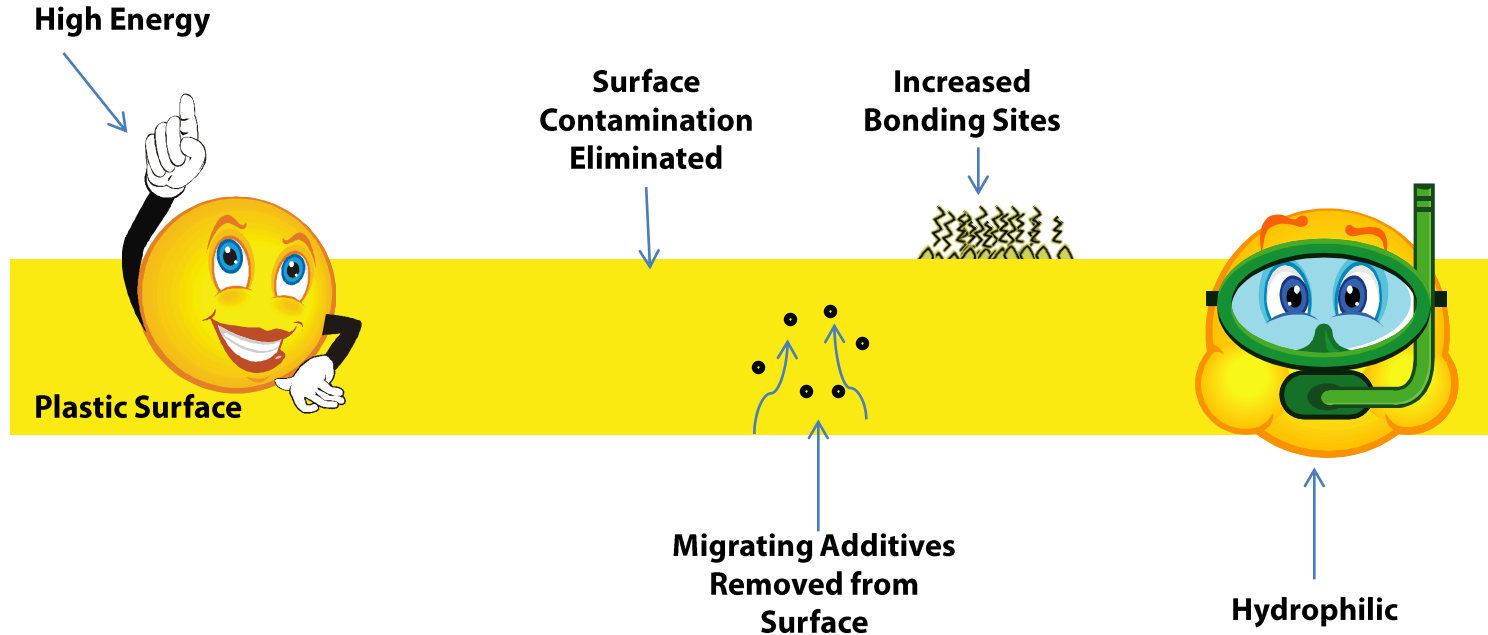
Click the image above to see an animation of plasma functionalizing.

Plasma activation or functionalization is the concurrent process of using radicals & small amounts of UV radiation to break up surface polymer bands to create cross linking of surface molecules.

This process **increases polar groups** which directly contributes to the surface's adhesion properties.

Functionalizes Surfaces

The Transformation of a Surface Prepared for Adhesion

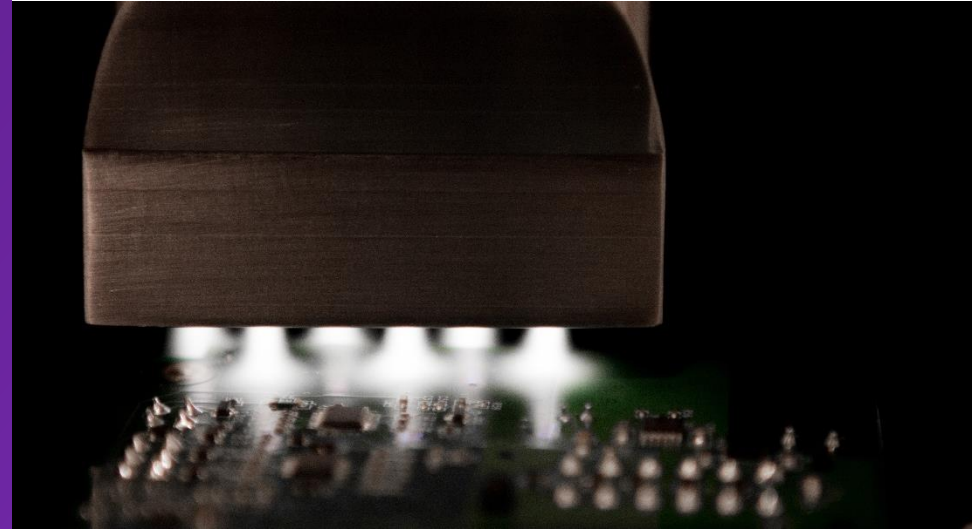


Chapter 3

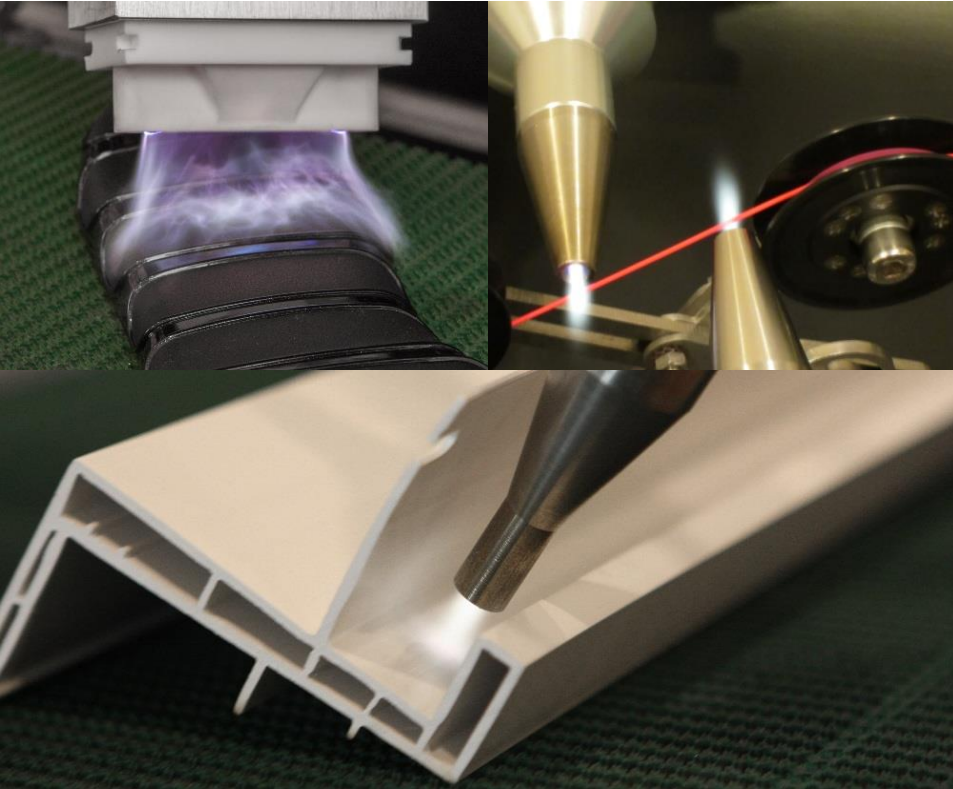
**What type of surfaces
can be treated?**

**Getting Started with Atmospheric
Plasma Surface Treatment**

**Atmospheric Plasma Treatment
effectively treats glass,
plastics and metals.**



Surface Treatment Plastics

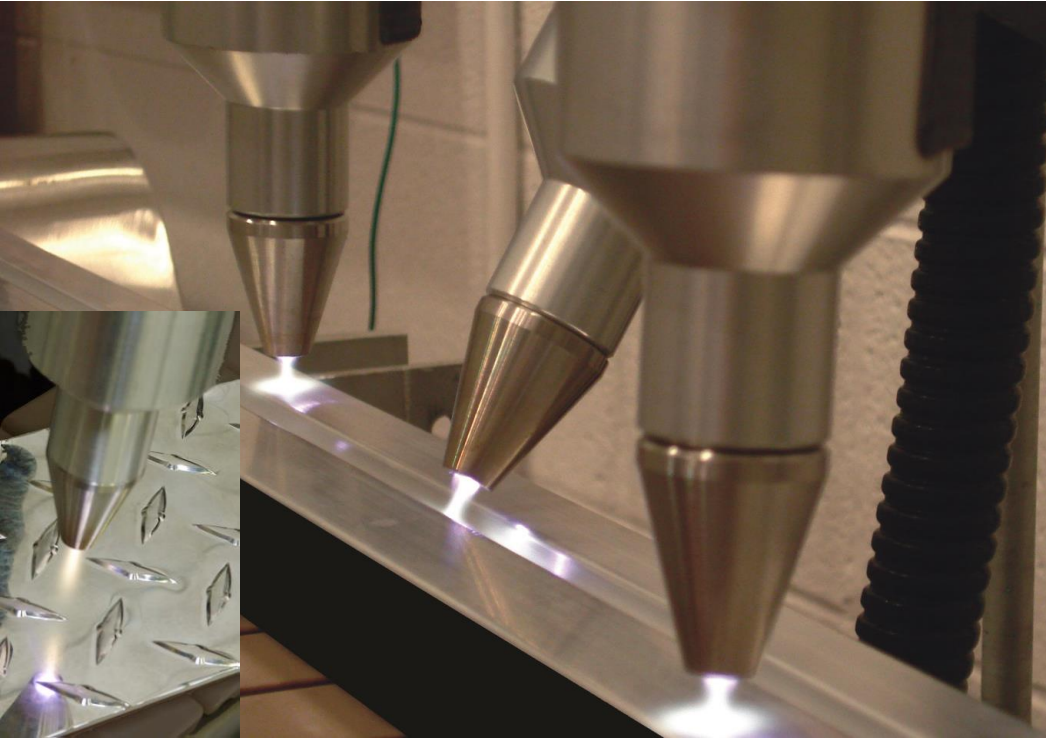


Atmospheric plasma surface treatment is effective at treating a wide variety of plastics and polymers.

Some of the more common plastics requiring treatment include:

**ABS, ASA, EPDM, EVA, HDPE, LDPE,
PC, PE, PET, PMMA, PP, PS,
PU, PVC, PBT, TPU**

Surface Treatment Metals



Atmospheric plasma surface treatment is effective at treating metals for **cleaning and removing oils.**

For large areas flame treatment is often used to treat metals as well.

(note: not all atmospheric plasma treaters are suitable for treating metal, please consult with your treater supplier to verify the capabilities of your system.)

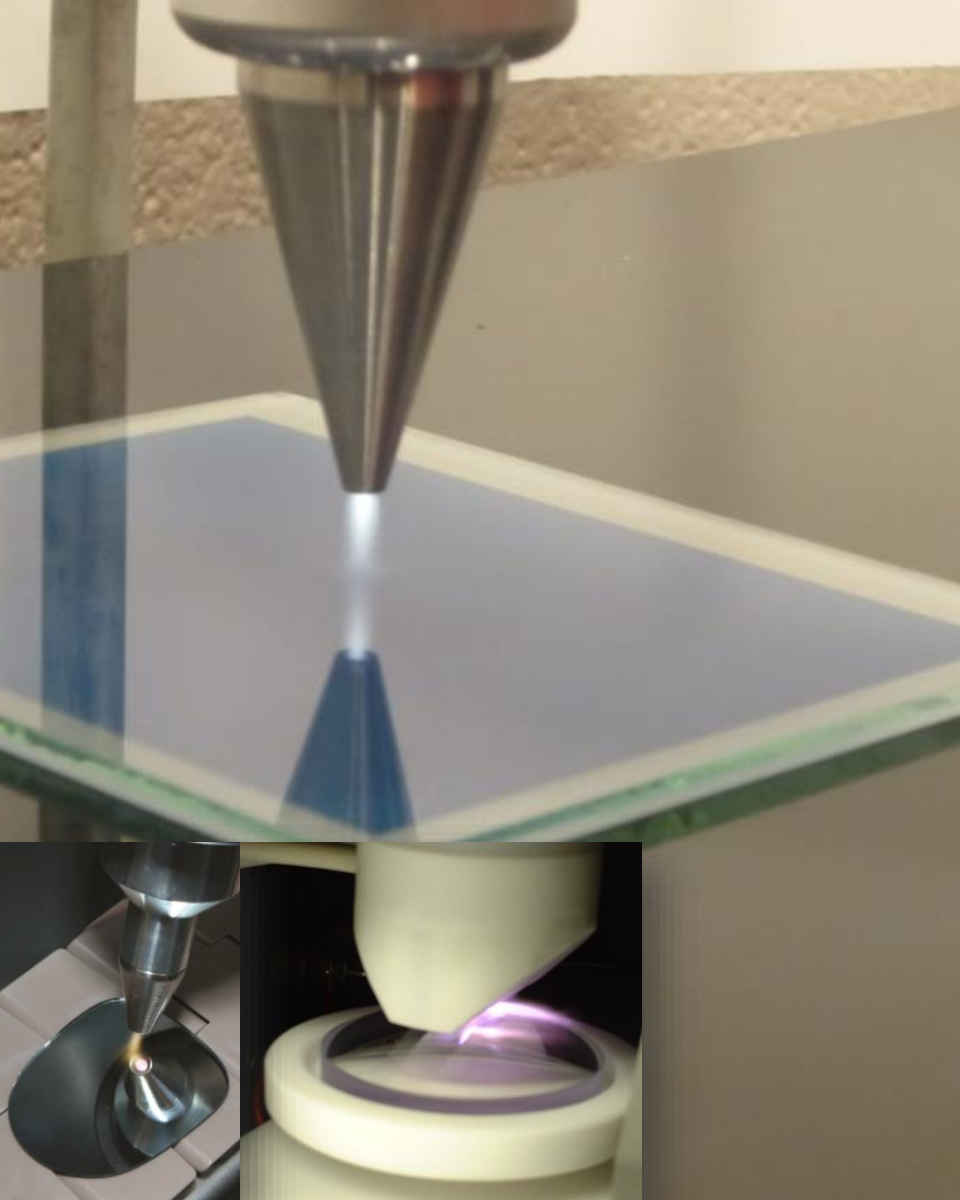
Surface Treatment Glass

Atmospheric plasma surface treatment is effective at **treating glass for the purposes of cleaning and sterilization.**

In some cases flame treatment may be used to treat glass as well.



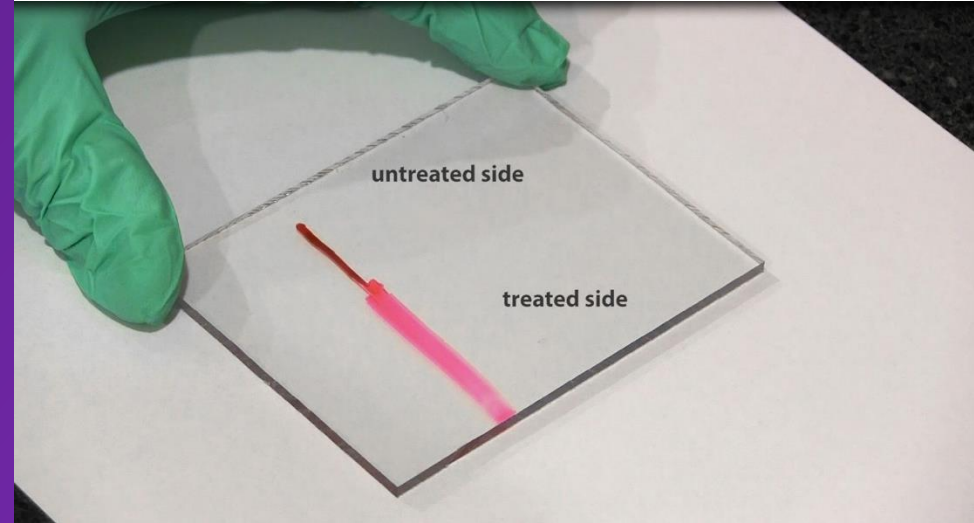
**Is Plasma right for you?
Ask an application expert
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Chapter 4

How can I tell if surface treatment changed the surface?

There are number of methods to determine the effectiveness of surface treatment.



Determining the Effects of Surface Treatment

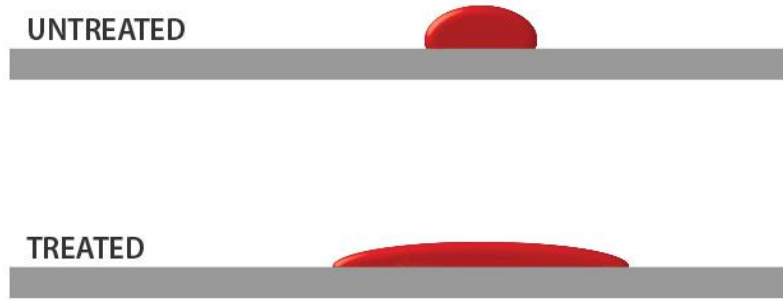


In most cases a surface that has been plasma treated will show no change to the human eye.

We'll review a number of different test methods designed to determine the effectiveness of surface treatment.

Its important to remember **the most important test is the success or failure of your ultimate bonding process**, whether that be printing, painting, coating or bonding.

Visually Seeing Results of Plasma Surface Treatment



Instant examples of improved adhesion from surface treating can be observed by watching an ink or adhesive droplet wet out on a surface as shown in the examples to the left.



The liquid on the untreated surfaces fails to wet out whereas the treated surface enables wetting out.



Measuring Surface Energy in Dynes



A popular way of determining the effect of surface treatment is to **measure its change in surface energy with dyne solutions.**

Dyne solutions are calibrated liquids that measure surface energy. They are available in bottles and pens.

Often your ink or adhesive supplier will recommend a specific minimum surface dyne level for adhesion success.



[Click here for more information on dyne testing](#)

Considerations Regarding Dyne Levels

42 Dyne Pen



38 Dyne Pen



The solid line created by the 38 dyne pen indicates a surface energy of at least 38 dynes. The 42 dyne pen's ink did not wet out indicating a dyne level less than 42 dynes.

Dyne level readings are subjective
 ± 2 dynes is a safe margin of error.

Higher dyne levels and adhesion
In general higher dyne levels are better for adhesion, but once the dyne level threshold for successful adhesion is reached, there are not significant benefits to striving for even higher levels.

Dyne levels do not guarantee adhesion
Dyne level is one of many factors that contribute to adhesion, therefore it is only an indicator of your chances of success.



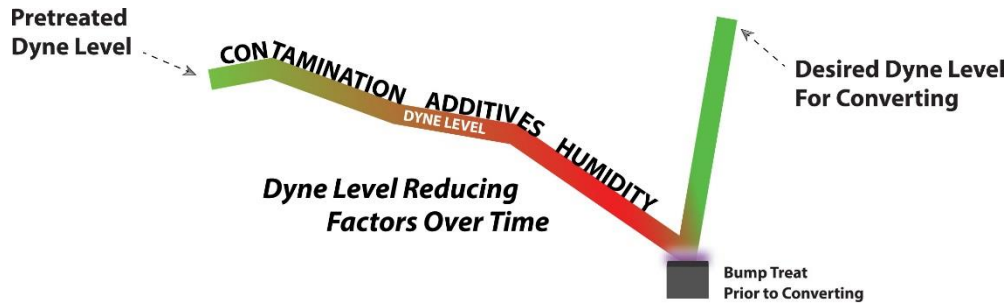
Surface Treatment Plastics Typical Starting Dynes

Material	Initial Dyne Level	Post Treatment Dyne Level
ABS	31-35	44-72
ETFE	30>	50
ETFE	30>	50
Flexible PVC	33-36	40-56
PEEK	30	>72
PET	35	44-60

Material	Initial Dyne Level	Post Treatment Dyne Level
Polycarbonate	37	56-72
Polyethylene	32-34	42-60+
Polypropylene	30-34	45-60
Polystyrene	36	52-70
PTFE	30>	50
Rigid PVC	33-36	42-60+
TPU	34	48

Several factors can impact initial and post treatment dyne level readings.
The chart above is provided as a general guideline of typical results.

Considerations Regarding Dyne Levels



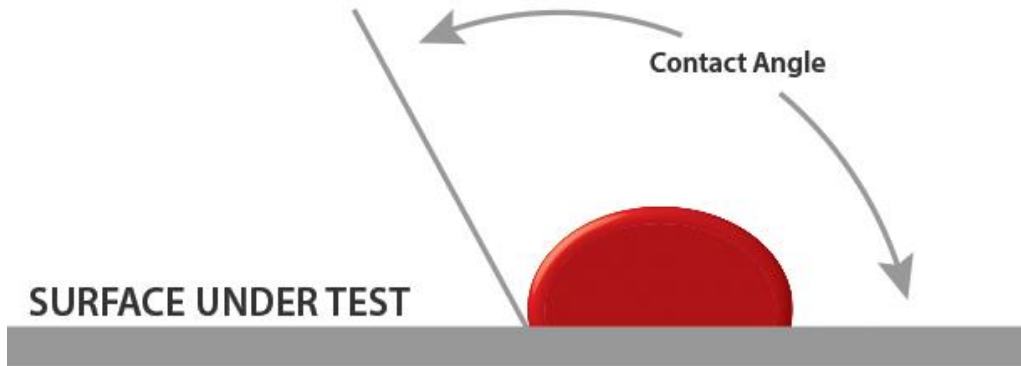
Dyne level decay rate vary based on environmental and material factors.

Treatment life may vary from hours to several months.

Special care should be taken when handling any surface after it has been treated to not contaminate the surface.

Since dyne levels decay over time it is a best practice to print, coat, paint, laminate or bond to a surface as soon as possible after treatment.

Contact Angle Measurement



Contact angle measures the interaction of a liquid with a solid.

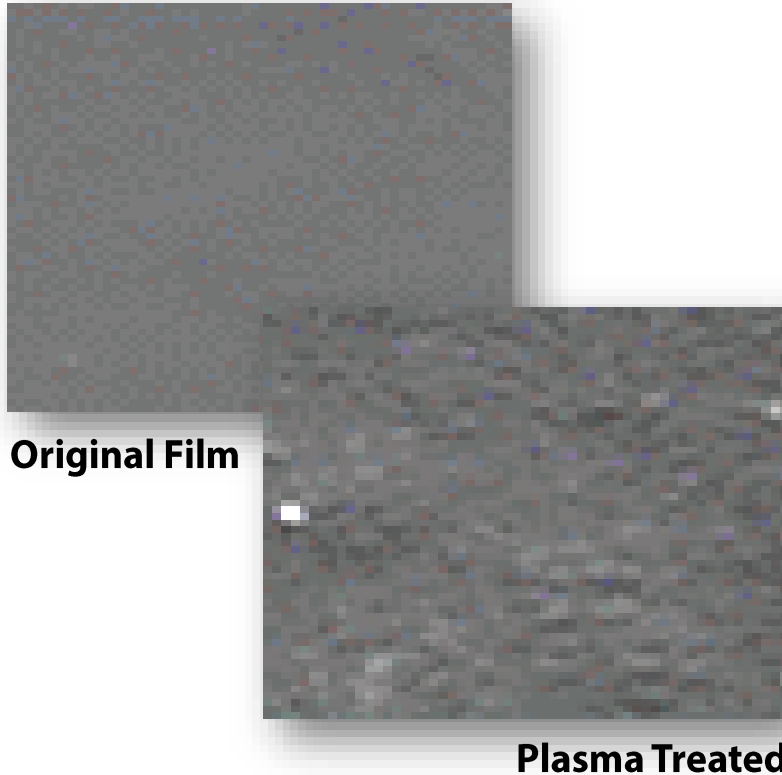
In general, a water droplet which “runs” to the base of the incline surface at a low incline angle indicates that the material has a low surface tension.

Water droplets which do not run at low angles indicate the material has a high surface energy.



Surface Analyzers

Advanced Analysis of Surface Treatment



Another example of how plasma treatment can affect a surface is shown to the left.

The images are of a Polyethylene film captured by a Scanning Electron Microscope (SEM) at 30,000 magnification.

The plasma treated surface has an increase in surface area & bonding sites which promotes adhesion.

Chapter 5

Atmospheric Plasma Treater Technology Comparison

Getting Started with Atmospheric Plasma Surface Treatment

**Understanding the capabilities of
your plasma treater is key to success.**



Blown-arc Air Plasma Characteristics



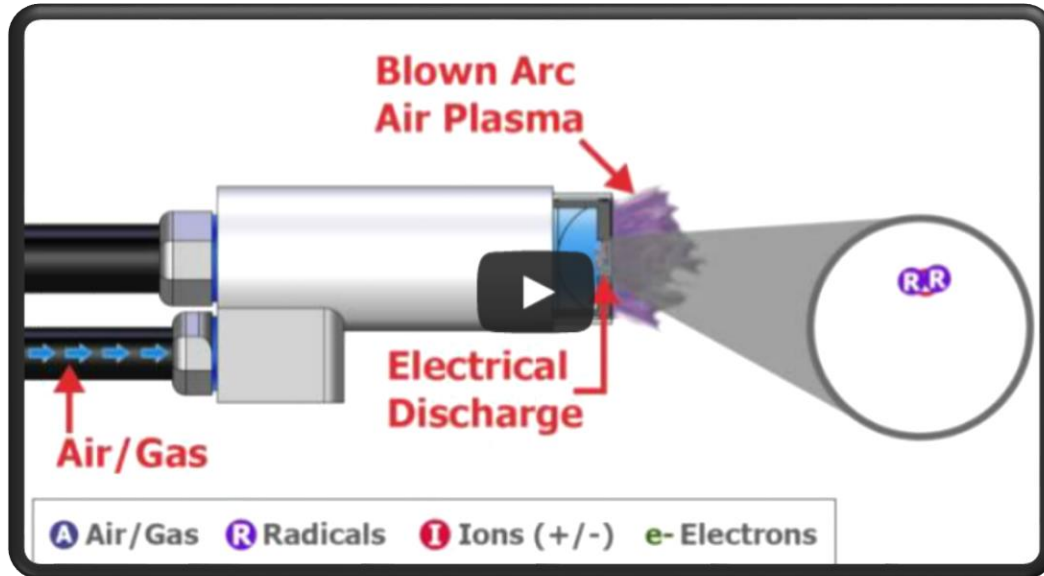
Ideal for a wide range of applications

Treats extruded, molded and
formed materials

Treats non-conductive materials

Wide Treatment Pattern – 2" or 3.5"

How Blown-arc™ Air Plasma Treatment Works

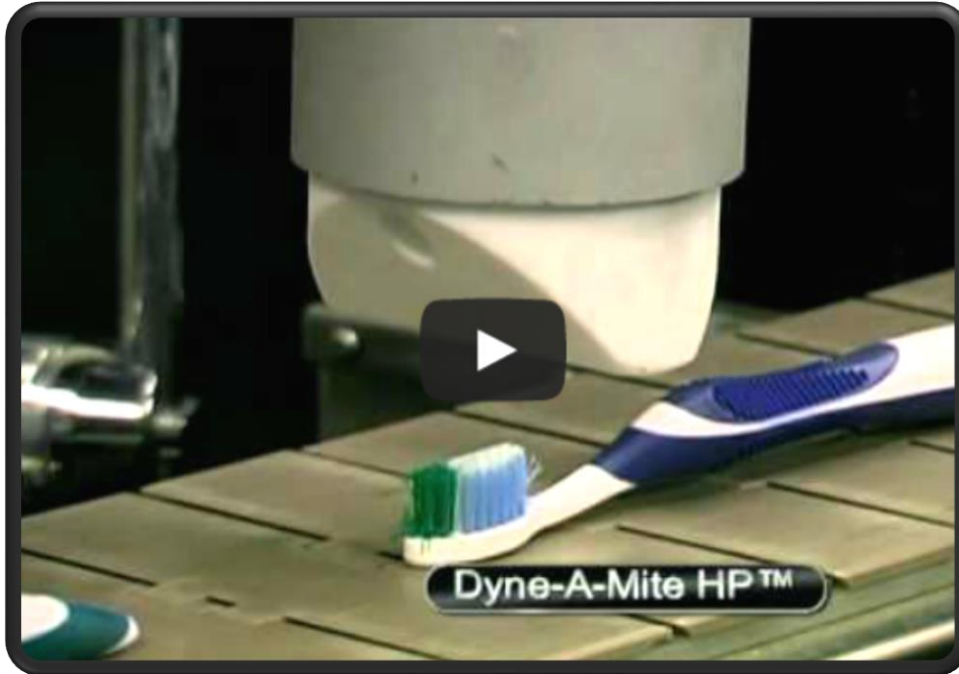


Click the image above to see an animation of how blown arc plasma treatment is created.

Blown arc air plasma is formed by blowing air past two high voltage power electrodes and is sometimes referred to as corona treatment.

The electrical discharge positively charges the ion particles surrounding it. Through direct contact, these **particles positively charge the treated area** making the surface more receptive to any applied substance.

Blown-arc™ Plasma Treatment in Action



Click the image above to see Enercon's Dyne-A-Mite™ HP plasma treater in action.

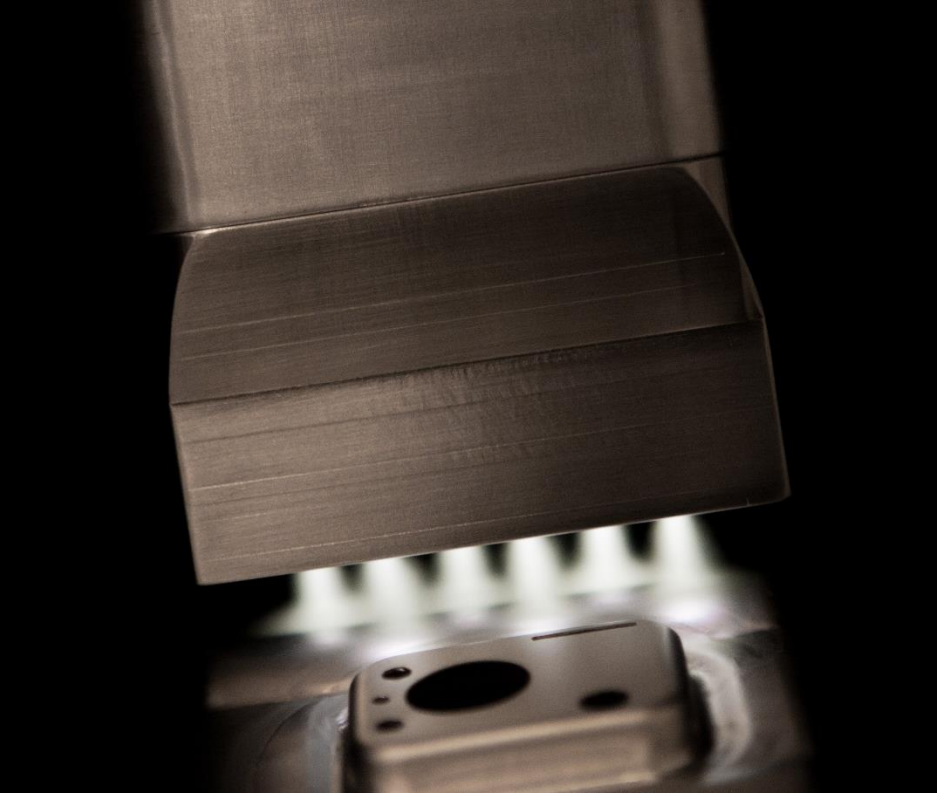
The video to the left shows a **lab trial of a blown arc plasma treater** treating toothbrushes prior to pad printing.

The resulting increase in surface energy enabled successful printing.



[Click here to see a story on this application on our website](#)

Blown-ion™ Air Plasma Characteristics



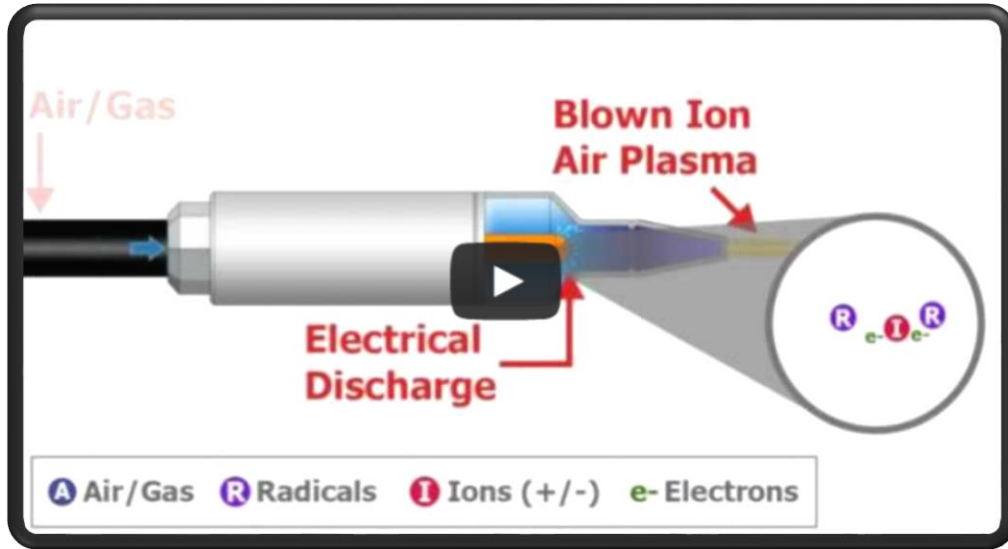
**Treats Conductive & non
conductive materials**

Focused treatment coverage:
3/8" – 2"

Precise pattern or spot treatment

Requires minimum dwell time
(enables high speed in-line
treatment)

Blown-ion™ Plasma Treatment



Blown ion air plasma pushes pressurized air past a single electrode which discharges inside the treater head. The electrode creates positively charged ions in the surrounding air particles.

The air pressure then forces the air particles to accelerate of the tip of the head as **a high velocity stream of charged ions directed toward the object's surface.**

Click the image above to see an animation of how blown ion plasma treatment is created.



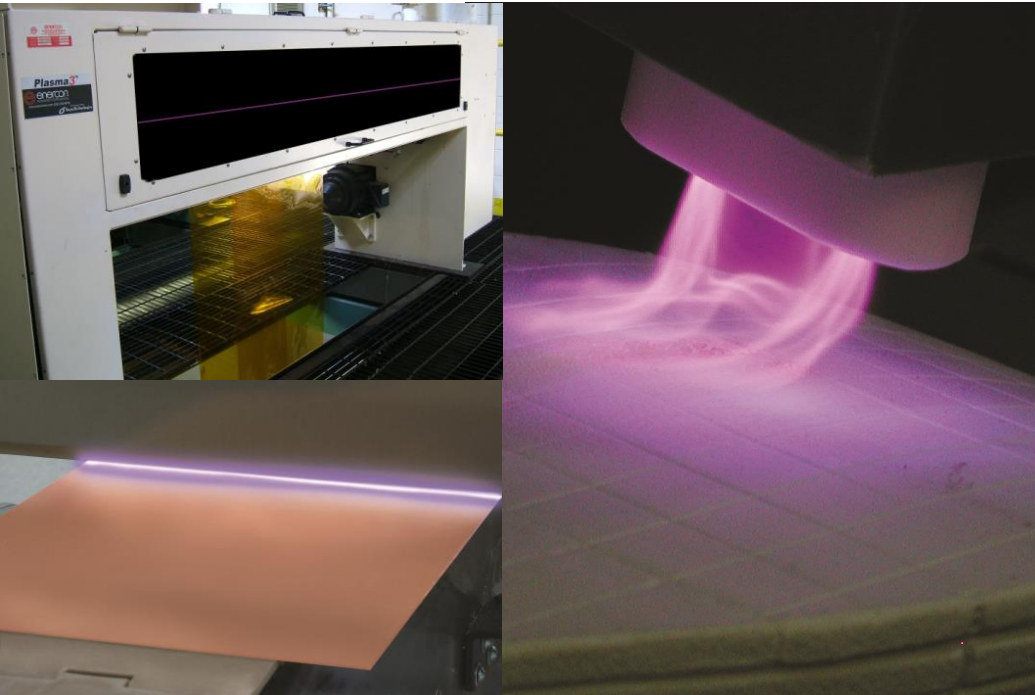
Blown-arc™ Plasma Treatment in Action



The video to the left demonstrates a blown ion **plasma treater integrated with an articulating robotic arm** for precise treatment patterns.

Click the image above to see a video of Enercon's Dyne-A-Mite™ IT plasma treater integrated with a robotic arm.

Variable Chemistry Air Plasma Characteristics



Variable gas chemistry plasma are available in a variety of discharge configurations and are **suitable for films, sheets and dimensional objects**.

By using specific gas chemistries these plasma treaters can generate treatment results on difficult to treat surfaces such as fluoropolymers.



Atmospheric Plasma Application Gallery



Chapter 6

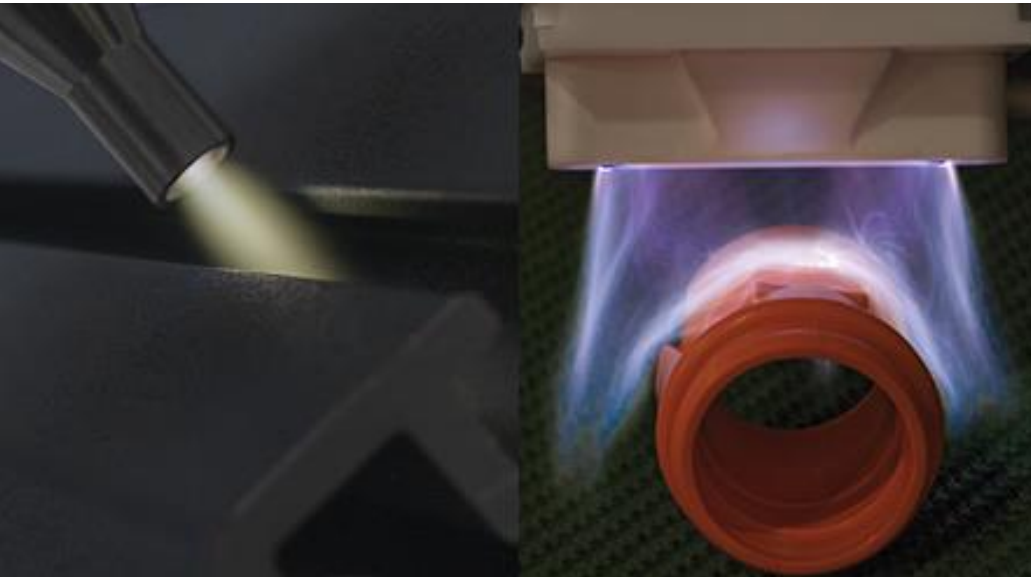
Getting Started... Review, Integration, & Free Lab Trials

Getting Started with Atmospheric Plasma Surface Treatment

**Putting your application to the test
is the best way to find the optimal
surface treating solution**



Atmospheric Plasma Surface Treating Review



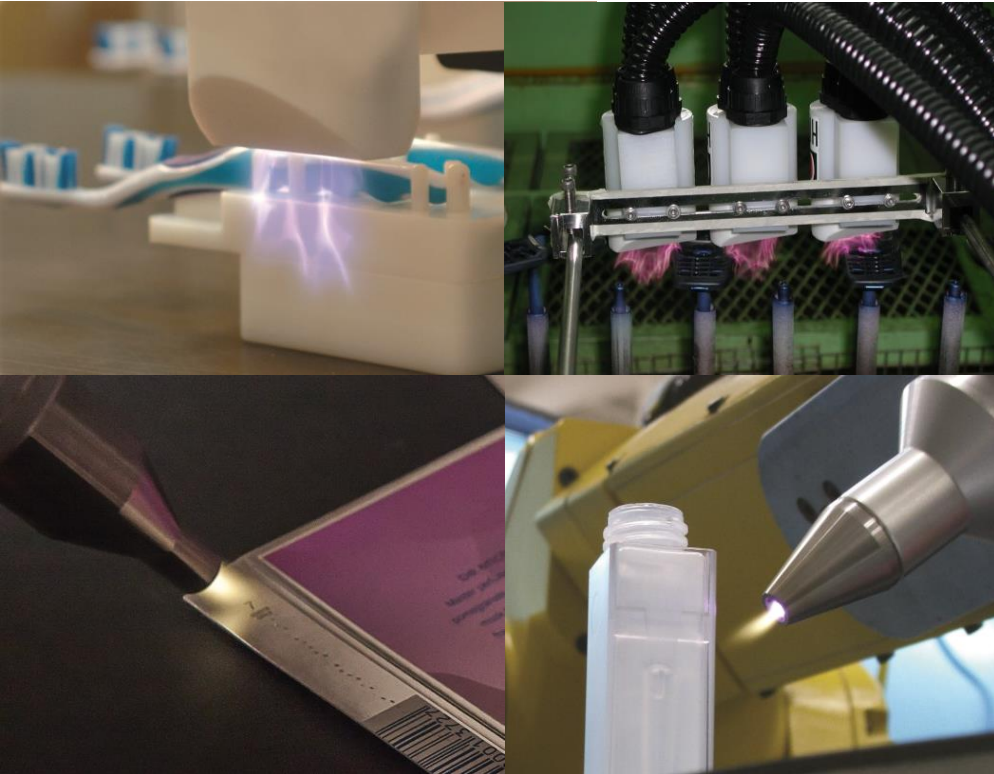
Plasma treatment cleans, etches and functionalizes surfaces to improve wettability & adhesion.

Plasma treaters are effective at treating plastics, glass and metals surfaces.

Treatment levels decay over time so it is best practice to use treated surfaces as soon as possible.

There are many factors that contribute to adhesion dyne level is one of them.

Integrating Atmospheric Plasma Treaters Into your Process



Fixed Location Treatment Head

Parts are conveyed, indexed or otherwise presented to the treatment head.

Moving Treatment Head

Head can be indexed or robotically controlled to follow precise treatment patterns.

Putting your application to the test



Enercon offers **free laboratory trials** with blown ion, blown arc and variable chemistry plasma systems.

We can also help you decide if flame plasma treatment might be better suited to meet your application requirements.



Contact an application expert.
Click or call 1-262 255-6070



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