Advanced Materials

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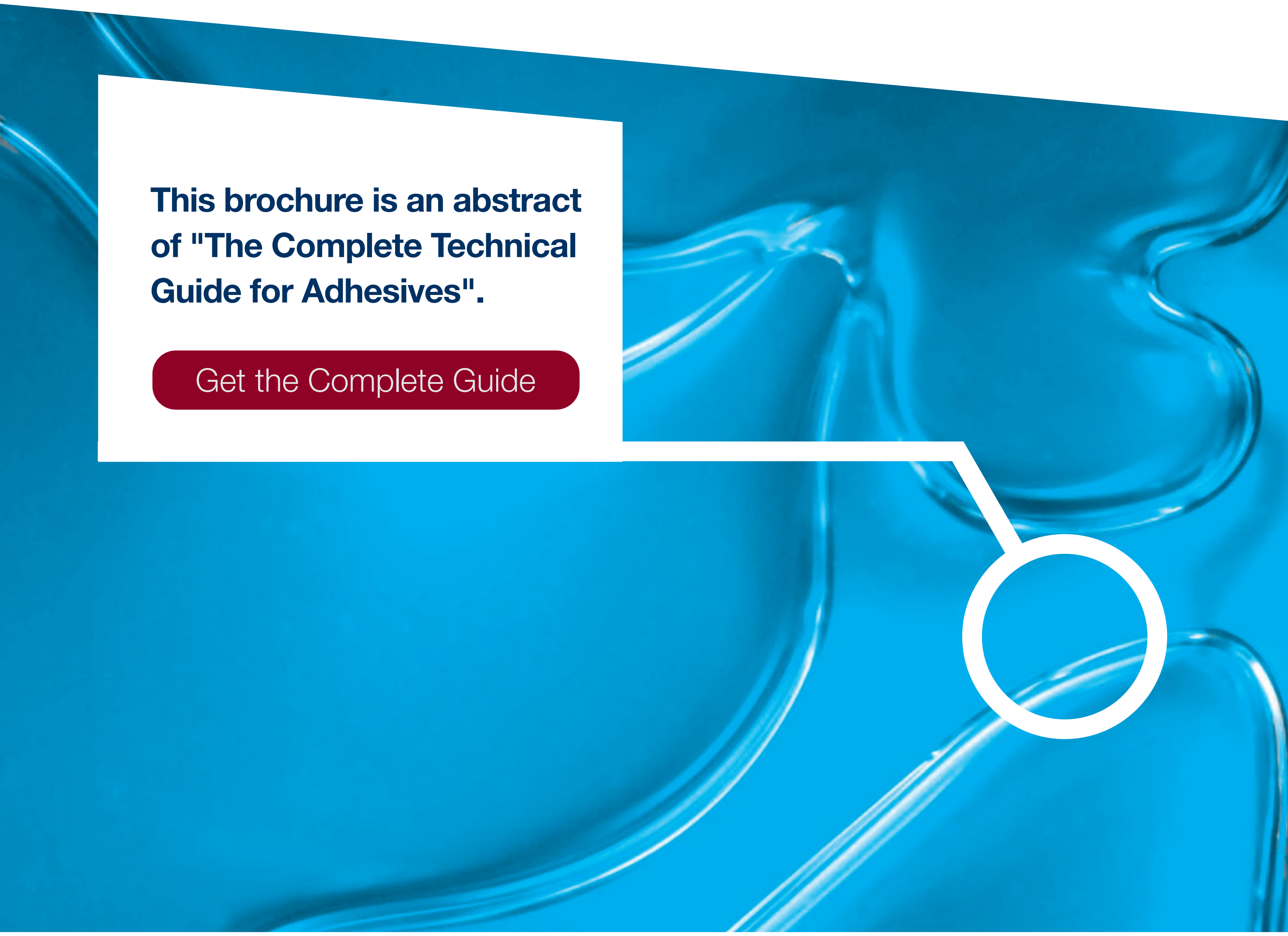
SURFACE PREPARATION AND PRETREATMENTS

The Technical Guide for Adhesives



This brochure is an abstract of "The Complete Technical Guide for Adhesives".

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3.0 SURFACE PREPARATION AND PRETREATMENTS

Bonding performance is always a combination of multiple factors, including mechanical, chemical and physical interactions.

Bonding is an interfacial phenomenon, as the adhesive forms an interface with the substrates to be bonded.

The surface conditions of the parts to be bonded are therefore a critical factor in achieving a dependable quality bond.

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3.1 INTRODUCTION

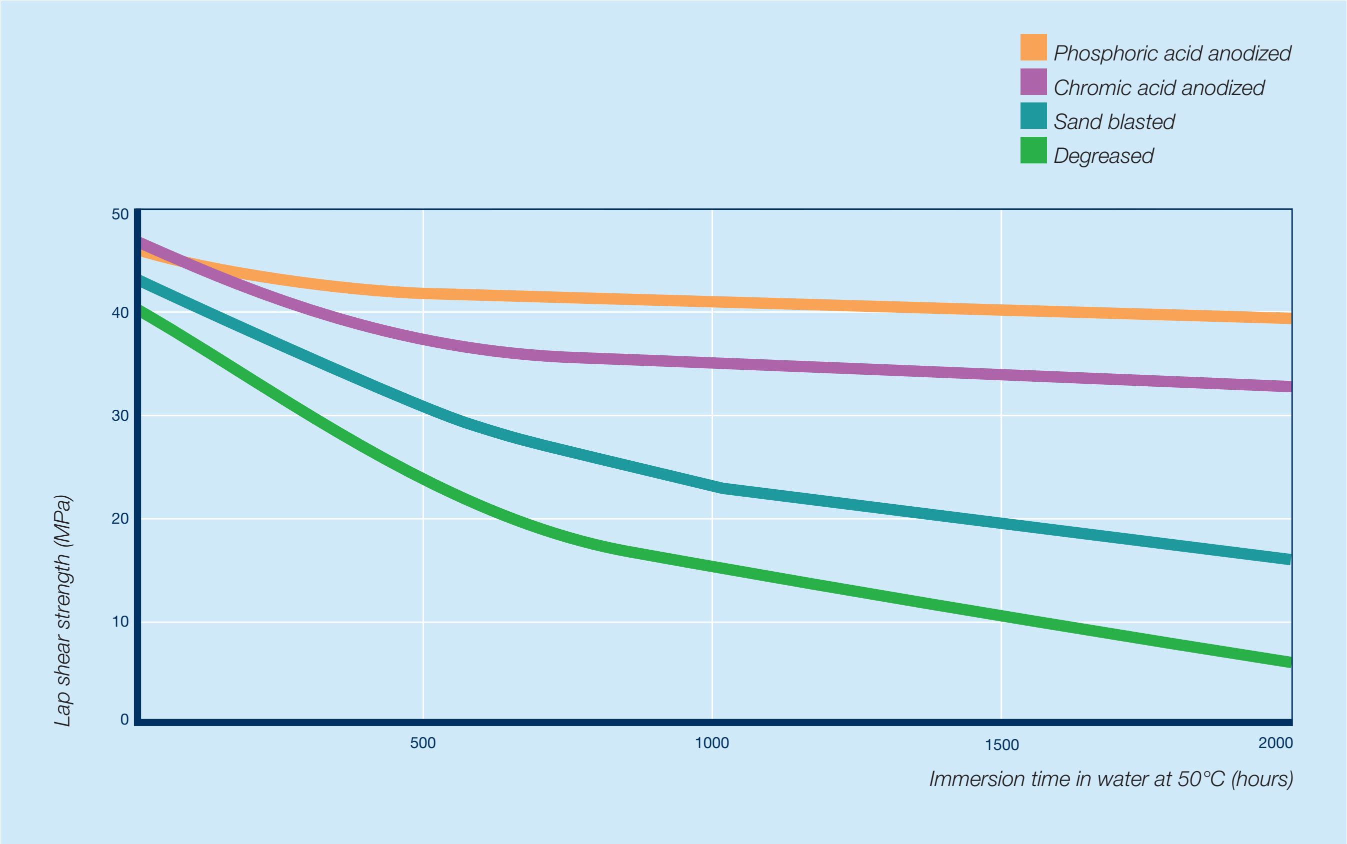
GENERAL CONSIDERATIONS

Proper surface preparation is essential for optimum adhesion between structural materials bonded with ARALDITE® adhesives.

Huntsman industrial adhesives are high performance products which adhere firmly to most materials. High strength bonds can be obtained after removal of grease and loose particles, e.g. rust, from the surfaces to be joined. However, when maximum strength and long-term durability are required, a more thorough mechanical or chemical surface pretreatment is highly recommended.

The type of surface preparation to be carried out prior to bonding depends on the required performance level (Figures 18, 19 and 20), the service conditions of the assembly and economic considerations (ratio cost vs benefit).

FIG. 18 EFFECT OF DIFFERENT SURFACE PREPARATIONS ON BOND STRENGTH DURING WATER IMMERSION FOR AN ALUMINUM ASSEMBLY BONDED WITH A ONE-COMPONENT EPOXY ADHESIVE

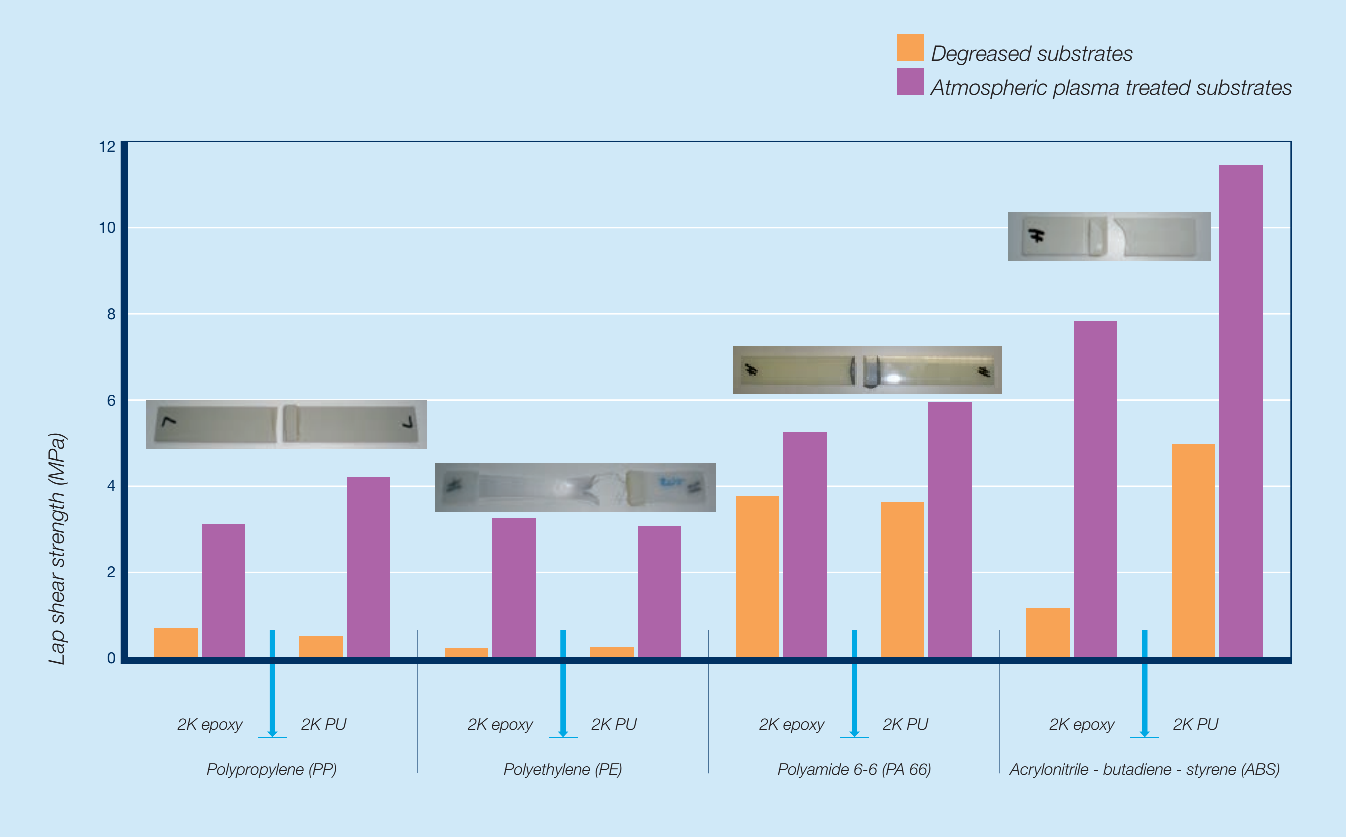


3.1 INTRODUCTION

GENERAL CONSIDERATIONS

FIG. 19 EFFECT OF PLASMA SURFACE TREATMENT ON PLASTIC BONDING

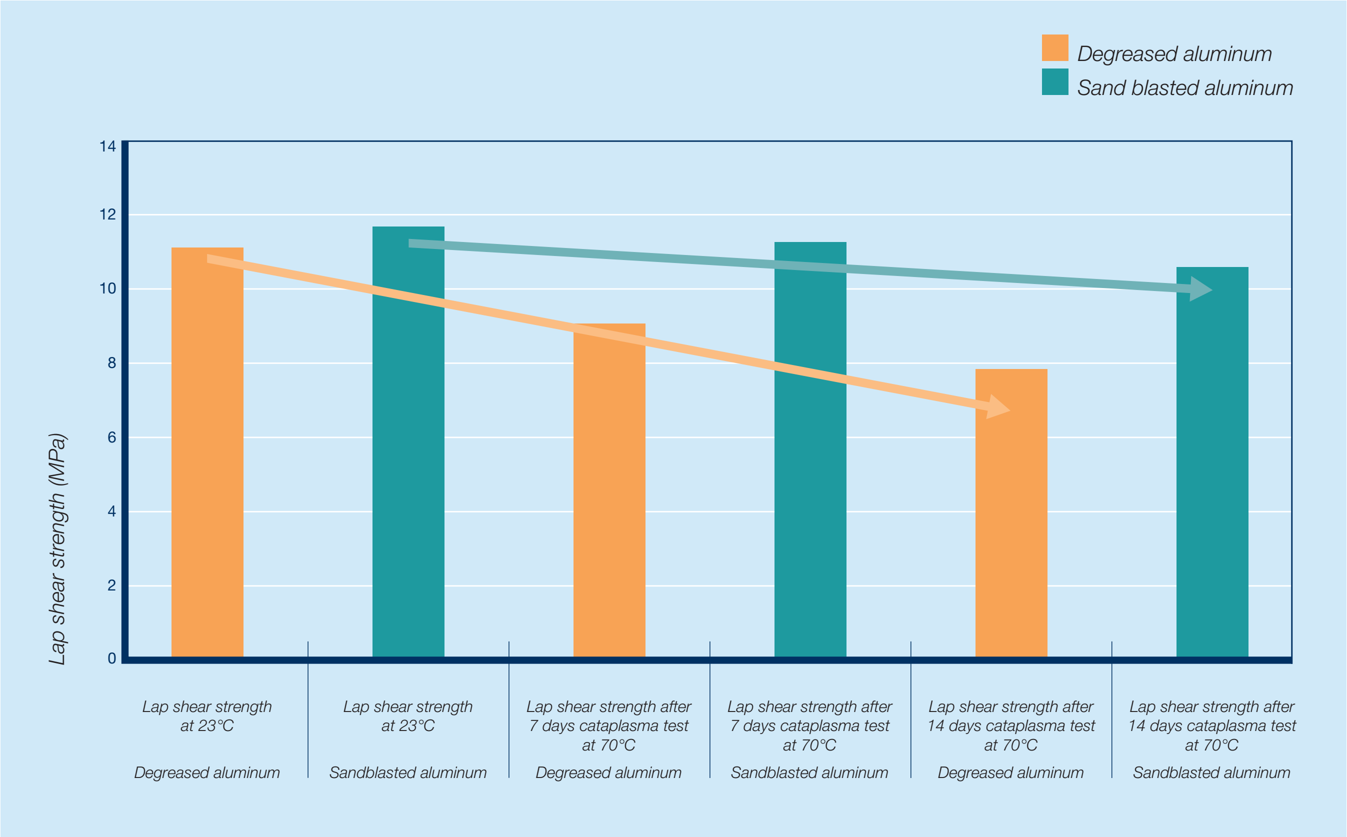
(Two-component toughened epoxy adhesive - Two-component polyurethane adhesive)



Note: systematic substrate failure on plasma-treated specimens

FIG. 20 EFFECT OF SURFACE PREPARATION ON AGEING PERFORMANCE OF ALUMINIUM BONDED WITH TWO-COMPONENT TOUGHENED EPOXY ADHESIVE

(Wet cataplasma aging)



Cataplasma test: 70°C with high humidity + thermal shock at -20°C

3.1 INTRODUCTION

WHY USE SURFACE PREPARATION?

In order to ensure an optimum wetting and a satisfactory adhesion on the substrate, a thorough surface preparation is required:

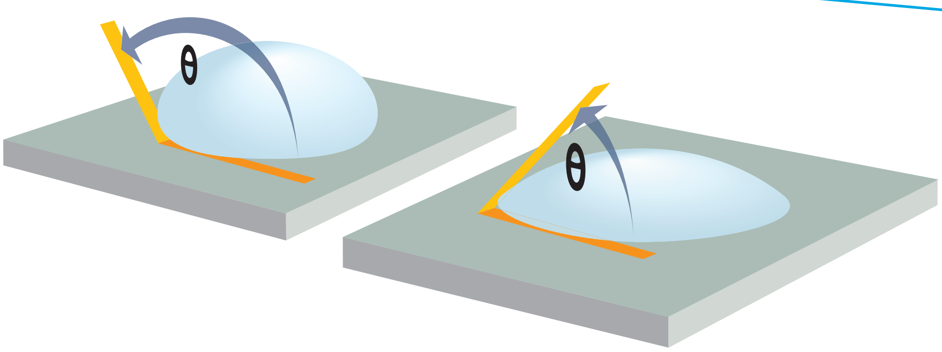
- To remove contaminants and/or low cohesion layers (oxides)
- To offer a clean surface for bonding
- To increase the bonding area
- To ensure that the substrate surface is fully wetted by the adhesive (e.g. by increasing the surface energy of the substrate)

Care must be taken to avoid contaminating the surfaces during or after pretreatment. Contamination may be caused by skin contact (clean gloves should be worn), using contaminated cleaning rags, by oil contaminated abrasives, by substandard degreasing or chemical solutions.

Contamination may also be caused by other work processes taking place around the bonding area. Oil vapors from machinery, spraying operations (paint, mold release-agent, etc.) and processes involving powdered materials must be particularly avoided.

Whatever the pretreatment procedure used, it is good practice to bond the surfaces immediately after the pretreatment has been performed i.e. when surface properties are at their best.

Note: If a delay between pretreatment and bonding cannot be avoided, optimum surface properties may be preserved by applying a suitable primer to the bond surfaces immediately after pretreatment.



WETTING ANGLES BEFORE SURFACE PREPARATION (LEFT) AND AFTER (RIGHT)

3.1 INTRODUCTION

TEST FOR A CLEAN BOND SURFACE

If a few drops of distilled water applied to a surface spread over it – or if, on drawing the surface from distilled water, the water film does not break up into droplets – then the surface may be assumed to be acceptably free of contamination. Uniform wetting of the surface by distilled water indicates that it will probably be likewise wetted by an adhesive.

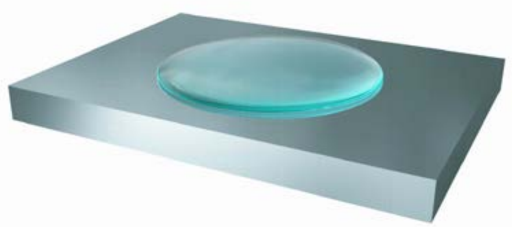
It must be borne in mind that certain plastics, even when clean, may not be wetted by distilled water, but will be wetted by suitable adhesives. Furthermore, it should be noted that a satisfactory wetting provides no information with regards to the potential bond strength and durability of the bonded assembly. At most it is a necessary – but not sufficient – requirement for the achievement of high bond strengths.

The surface tension of plastic materials cannot be directly measured and is therefore usually determined indirectly by contact angle methods or using testing inks. Several standard methods have been developed to respond to the different types of substrates being evaluated (see literature, e.g. Adhesives Technology Handbook – W. Andrew Editions).

The water droplet test is a simple method to determine whether the surface to be bonded is clean. It is best suited to metals.

BAD WETTING

GOOD WETTING



3.2 SURFACE PREPARATION METHODS

DEGREASING METHODS

The removal of all traces of oil, grease or release agents from the surfaces to be bonded is essential. Degreasing by one of the methods given below should be carried out even when the surfaces to be bonded appear clean.

VAPOR DEGREASING

The parts are suspended in a vapor degreasing unit, using common degreasing solvent such as acetone, methyl ethyl ketone (MEK), ethanol or isopropanol. The unit may include a compartment to enable initial washing in the liquid solvent.

SOLVENT IMMERSION

Where a vapor degreasing unit is not available, immerse successively in two tanks each containing the same degreasing solvent. The first tank acts as a wash, the second as a rinse. When the solvent in the wash tank becomes heavily contaminated, the tank is cleaned out and refilled with fresh solvent. This tank is then used for the rinse, and the former tank for the wash.

BRUSH OR WIPE

Brush or wipe the joint surfaces with a clean brush, cloth or lint-free paper soaked in a commercial degreasing solvent. For fine work, cleaning with solvent applied by aerosol spray may be a more suitable alternative; this technique also ensures that the solvent used is perfectly clean. Allow to stand for a minute or two to allow complete evaporation from the joint surfaces. A wide range of proprietary solvent degreasing agents with low hazard ratings are now available. These should be used in accordance with the manufacturer's instructions.

Removal of oil or grease residues is key but should be combined with other surface preparation method for optimal bonding:

- Degreasing only (good)
- Degreasing, mechanical abrasion followed by loose particle removal (very good)
- Degreasing and chemical pretreatment (excellent)

Want to remove all traces of oil and grease from the surfaces to be bonded?

Watch the video

ALKALINE DEGREASING

Alkaline degreasing is an alternative method to detergent degreasing. Sodium or potassium hydroxide, carbonates, phosphates, borates, complexing agents and organic surfactants are all used for this application. This method can be carried out hot or cold, with or without applied electrical current. Thorough washing, and possibly neutralization, is required to remove residual traces of alkaline cleaners. It is recommended to use proprietary products and to follow the manufacturer's instructions for use.

ULTRASONIC DEGREASING

Ultrasonic degreasing may also be employed and is typically used for the preparation of small specimens (by ultrasonic vapour degreasing or solvent immersion).

DETERGENT DEGREASING

Scrub the joint surfaces in a solution of liquid detergent. Non-ionic detergents generally give good results. Wash with clean hot water and allow to dry thoroughly – preferably in a stream of hot air from, e.g. a forced-air heater.

ABRADING METHODS

Lightly abraded surfaces provide better anchoring to adhesives than highly polished surfaces.

If substrates are abraded, this must be followed by cleaning to ensure complete removal of any dust or particles. Cleaning methods following abrasion:

- Repeat the degreasing operation, degreasing liquids must be clean (good)
- Lightly brush with a clean soft brush (very good)
- Clean the surface with a suitable industrial vacuum cleaner (excellent)

PLASTICS AND COMPOSITES SURFACES

Remove the top layer of molded plastic surfaces to ensure elimination of all traces of release agent. As with metals, abrasion is in general the best method, but grit blasting is often replaced by sanding, either manually or with a sanding machine. After abrasion, all loose particles must be removed. Use of peel (or tear) plies is often used on composite parts to produce a ready-to-bond surface: peel plies are special fabrics applied on the surface of the composite during molding and peeled off immediately prior to bonding, leaving a roughened, clean surface suitable for bonding.

NOTE

Removal of loose particles from plastic surfaces is best carried out by brushing, tack cloths or vacuum cleaning. Since plastics often carry static electrical charge, care is needed to avoid recontamination after cleaning, and parts should be bonded as soon as possible. Use of degreasing liquids on certain plastics may impair the abrasion treatment. Since plastics are poor heat conductors, care must be taken to keep grit blasting or sanding times as short as possible to avoid overheating. For composites pretreatment, cryoblasting may also be used, which employs solid carbon dioxide pellets as the blasting medium. This leaves a clean, abrasive-free surface and avoids heating.

METAL SURFACES

Remove surface deposits, e.g. oxidation, corrosion or mill scale, preferably by grit blasting using a suitable abrasive media. For most materials the preferred grits are fused alumina and, less commonly, silicon carbide (ferrous grits such as chilled iron must be restricted to mild steels and cast irons; their use on other metals may promote corrosion). Fused alumina is the most common abrasive for aluminum alloys and stainless steels. Silicon carbide is sharper, but it is more expensive and also more friable. Silicon carbide is used on certain special alloys likely to react adversely with any residual fused alumina at temperatures they may be exposed to under service conditions. The use of silicon carbide may be preferable when the materials to be abraded are either soft or extremely hard.

Choice of grit size depends on various factors: metal to be grit blasted, type of grit blasting equipment, pressure and angle of blast impact, and time of treatment.

Grits from 46 to 120 mesh (350 to 125 μm) are usually adequate for most applications, however the optimum grit size for specific applications may have to be determined by trials. In general, for soft materials the optimum grit size will be towards the fine end of the range.

If grit blasting equipment is not available or the metal is too thin to withstand blasting treatment, joint surfaces may be cleaned with a wire brush, or with abrasive cloth or paper (alumina or silicon carbide abrasive). Wetting the wire brush – or the abrasive cloth or paper – assists removal of contaminants and reduces dust. Dry, if necessary, and remove all loose particles.

NOTE

Painted surfaces should be stripped of paint; otherwise the strength of the joint may be limited by the comparatively low adhesion of the paint to metal.

3.2 SURFACE PREPARATION METHODS

SPECIAL PRETREATMENTS FOR METALS

The surface preparations previously described (degreasing alone or degreasing followed by abrasion and removal of loose particles) is sufficient for most adhesive bonding.

However in order to obtain maximum strength, reproducibility and long-term durability of a bond, a chemical or physical pretreatment may be required. Examples of these special pretreatments are described in this section and some additional details can be found in the annexes.

ACID ETCHING

The visible surface of any metal substrate is rarely made of pure metal and is far more likely to be a combination of oxides, sulfides, chlorides and other atmospheric contaminants resulting in a surface which is mechanically weak. Acid etching is a well-established method of removing surface oxidation layers, generally weakly attached to the metal surface, and replace them with a strongly bonded layer which is mechanically and chemically compatible with the adhesive. Different acid treatments are applied to different metal adherends, for example, chromic acid for aluminum, sulfuric acid for stainless steel, and nitric acid for copper.

ANODIZING

Anodizing is used extensively by the aerospace industry as a surface pretreatment for aluminum and titanium alloys. The purpose of anodizing is to deposit a porous oxide layer on top of the oxide layer formed after etching. The porous oxide layer enables adhesive (or primer) to penetrate the pores readily to form a strong bond. To be suitable for bonding, the oxide layer generated by anodization should remain unsealed. Hard anodized aluminum alloy requires stripping either by abrasive blasting or by etching: the hard anodize finish offering only poor bonding.

APPLICATION OF A PRIMER

Primer application is another form of surface pretreatment mainly used for materials such as metals, glass and ceramics. Generally, the primer is the final stage of a multistage pretreatment process.
Some substrates have "difficult to bond" surfaces (e.g. copper), meaning that they are not easily wetted. The primer, which is often a similar composition to the adhesive with additional solvent, readily wets the substrate. Once the adhesive is applied to a chemically compatible surface, it will form a strong bond after curing.

Care must be taken in the preparation of chemical pretreatment solutions, not only because of the handling hazards, but because incorrect preparation could lead to lower bond strengths compared to no chemical treatment. Time of application is also important: too short an application may not sufficiently activate surfaces, whereas an excessively long exposure to the chemical(s) may result in chemical reaction products which will interfere with adhesion.

Upon completion of a chemical pretreatment, a thorough washing of the surfaces with sufficient clean water is standard practice. For the final rinse, the use of de-ionized (demineralized) water is strongly recommended.

Want to achieve a good preparation for metals?

Watch the video

3.2 SURFACE PREPARATION METHODS

SPECIAL PRETREATMENTS FOR PLASTICS AND COMPOSITES

The type of polymer and the manufacturing process used to make the substrates to be bonded may influence the effectiveness of the physical pretreatment.

It is also advisable to test whether the quality of the pretreatment is dependent on the specific treatment time. Acid pretreatment can also be applied to certain plastics, e.g. chromic acid is used to surface treat polyolefins.

LOW PRESSURE PLASMA

A plasma is formed by applying a high frequency voltage to a gas using electrodes in a low-pressure chamber. If substrates, in particular plastics, are placed in the plasma, their surface energy is increased. A higher surface energy enables full wetting of the substrate surface by an adhesive, forming a strong, durable bond. Different plasmas can be formed, e.g. by argon, ammonia, oxygen or nitrogen gas, making the process suitable for a range of substrate types.

This method is usually preferred for the treatment of small parts with a complex geometry or for parts on which the surface to be bonded is difficult to access.

ATMOSPHERIC PLASMA

A plasma is created in air at atmospheric pressure (without additional gases), and the beam generated does not have any electrical potential. The benefits of this method are similar to the previous one. This method is usually preferred for larger plane surfaces. The parameters which can influence the quality of the treatment are the exposure time and the distance between the surface and the plasma nozzle.

FLAME TREATMENT

The effect of a flame treatment is to oxidize the surface layer to produce polar groups ; the increased polarity of these groups leads to increased surface energy and thus improved wetting by the adhesive. This method of surface pretreatment has been applied successfully to polyethylene and polypropylene. The parameters which can influence the quality of the flame treatment include type of gas to air (oxygen)-ratio, flow rate, exposure time and distance between flame and substrate.

CORONA TREATMENT

Under normal atmospheric pressure, a high voltage discharge creates oxgen and ozone molecules which will lead to the activation of the plastic surface by oxidation.

All these methods have limited stability which can vary from hours to weeks according to substrate.

Want to achieve a good preparation for plastics ?

Watch the video

PREPARING METALS

Preparation methods for most common metals are shown in the table on the following page.

Engineers wishing to bond materials not covered in this manual should discuss with our technical team.

Contact

The wide range of individual alloys (and the variety of surface structures caused by heat treatments) within each metal group precludes standardizing on one pretreatment for each.

The following pretreatments are well established, but on occasion a different pretreatment (not described in this manual) may prove more effective. This can be shown only by comparative testing – using materials from the batch of metal components to be bonded and the type of adhesive specified for the work.

Want to achieve a good preparation for metals?

Watch the video

Substrate	Preferred pretreatment (state of the art)	Alternative solution	Remarks
Aluminum and alloys non-anodised	Degreasing, Special pretreatment	Degreasing, Abrading	Special pretreatment: anodise with chromic or phosphoric acid.
Aluminum and alloys anodised / unsealed	None	None	Chromic acid or phosphoric acid anodised material has the optimum surface properties for bonding directly after completion of the anodising process. No pretreatment is needed, but the material must be bonded within a few hours after anodising.
Aluminum and alloys hard anodised / anodised and sealed	Degreasing, Special pretreatment	Degreasing, Abrading	Special pretreatment: requires stripping either by abrasive blasting or by etching (annex Etchant 1). The unstripped metal is unsuitable for bonding. Aluminum alloy anodised by the normal chromic acid or sulphuric acid methods and sealed, may be bonded after degreasing and light abrasion.
Cadmium	Degreasing, Special pretreatment	Degreasing, Abrading	Special pretreatment: electro-plate with silver or nickel.
Cast iron	Degreasing, Abrading	—	—
Copper and copper alloys	Degreasing, Special pretreatment	Degreasing, Abrading	Special pretreatment: etching solution (annex Etchant 2).
Chromium	Degreasing, Special pretreatment	Degreasing, Abrading	Special pretreatment: etching solution (annex Etchant 3).
Galvanised surfaces	—	—	See zinc and zinc alloys.
Gold	Degreasing	—	—
Lead	Degreasing, Special pretreatment	Degreasing, Abrading	Special pretreatment: etching solution (annex Etchant 4).
Magnesium and magnesium alloys	Degreasing, Special pretreatment	Degreasing, Abrading	Special pretreatment: etching solution (annex Etchant 5).
Nickel and nickel alloys	Degreasing, Special pretreatment	Degreasing, Abrading	Etch for 5 seconds in concentrated nitric acid. Wash with clean cold running water, followed by clean hot water, and dry with hot air.
Silver	Degreasing, Abrading	—	—
Steel mild	Degreasing, Special pretreatment	Degreasing, Abrading	Special pretreatment: etching solution (annex Etchant 6).
Stainless steel	Degreasing, Special pretreatment	Degreasing, Abrading	Special pretreatment: etching solution (annex Etchant 7).
Tin	Degreasing, Abrading	—	—
Titanium and titanium alloys	Degreasing, Special pretreatment	Degreasing, Abrading	Special pretreatment: etching solution (annex Etchant 8).
Tungsten and tungsten carbide	Degreasing, Special pretreatment	Degreasing, Abrading	Special pretreatment: etching solution (annex Etchant 9).
Zinc and zinc alloys	Degreasing, Abrading	—	Apply the adhesive immediately after surface preparation.

Degreasing *Abrading* *Special pretreatment*

PREPARING PLASTICS AND COMPOSITES

Most common plastics and composites likely to be bonded are covered in the table on the following page.

Engineers wishing to bond materials not covered in this manual should discuss with our technical team.

Contact

THERMOSETS

Moldings, castings, laminates and the like can usually be bonded without difficulty. However in order to ensure good bond strength, all surface contaminants (e.g. residual release agent) must be removed from the joint surfaces before the adhesive is applied. The surfaces must be either abraded, e.g. with emery cloth or sand paper, or they must be cleaned with an organic solvent such as acetone, methyl ethyl ketone (MEK) or isopropanol. Abrading, bead blasting or peel ply is highly recommended for molded parts since their surfaces may otherwise repel the adhesive.

THERMOPLASTICS

Although thermoplastics are often difficult to bond, the wide range of Huntsman industrial adhesives provides a solution for many common plastics. Pretreatment, such as plasma, flame and corona discharge, are especially effective for bonding of thermoplastics. Some types of thermoplastic, such as polyethylene and polypropylene, are particularly difficult to bond, and will produce only limited bond strength even after surface treatment.

Want to achieve a good preparation for plastics?

Watch the video

Want to achieve a good preparation for composites?

Watch the video

Substrate	Preferred pretreatment (state of the art)	Alternative solution	Remarks
ABS	Degreasing, Special pretreatment	Degreasing, Abrading	Special pretreatment: etching solution (annex Etchant 10) or plasma treatment.
Cellulose based polymers	Degreasing, Abrading	—	Warm preferably for 1 hour at 100°C and apply the adhesive before the material cools completely down to room temperature.
Composites (fiber reinforced thermosets)	Degreasing, Abrading	Degreasing, Special pretreatment	Alternatively, design the laminate in such a way that a 'peel ply' of special close-weave fabric is placed at the surface to be bonded. The ply becomes part of the laminate on curing and is 'peeled' off prior to bonding, exposing a roughened, clean bonding surface on the laminate. Special pretreatment: plasma treatment.
Decorative and industrial laminates	Degreasing, Special pretreatment	Degreasing, Abrading	Special pretreatment: pretreat using corona / plasma treatment.
Polyacetal (POM)	Degreasing, Special pretreatment	—	Special pretreatment: etching solution (annex Etchant 10).
Polyamides (Nylon)	Degreasing, Special pretreatment	Degreasing, Abrading	Special pretreatment: pretreat using corona / plasma treatment.
Polyacrylics (PMMA…)	Degreasing, Abrading	Degreasing, Special pretreatment	For optimal results, it is recommended to stress relieve the material by annealing. Special pretreatment: plasma treatment.
Polycarbonate	Degreasing, Special pretreatment	Degreasing, Abrading	Special pretreatment: pretreat using corona / plasma treatment.
Polyesters (unsaturated thermosets)	Degreasing, Abrading	—	See composites (fibre reinforced thermosets).
Polyesters thermoplastic moldings and films	Degreasing, Special pretreatment	Degreasing, Abrading	Special pretreatment: etching solution (annex Etchant 11). Alternative: corona / plasma treatment.
Polyetheretherketone (PEEK)	Degreasing, Special pretreatment	Degreasing, Abrading	Special pretreatment: Pretreat using corona / plasma treatment.
Polyimide	Degreasing, Special pretreatment	Degreasing, Abrading	Special pretreatment: pretreat using corona / plasma treatment.
Polyolefin (PP, PE)	Degreasing, Special pretreatment	—	Special pretreatment: pretreat using flame / plasma treatment. Lightly flame treat with a waving motion in an oxidising gas flame until the surface is shiny. Proprietary primers for polypropylene are available which provide an alternative to flame and plasma pretreatments.
Polyphenylene oxide (PPO)	Degreasing, Special pretreatment	Degreasing, Abrading	Special pretreatment: pretreat using corona / plasma treatment.
Polystyrene	Degreasing, Abrading	—	—
Polyurethane	Degreasing, Special pretreatment	Degreasing, Abrading	Special pretreatment: pretreat using corona / plasma treatment.
PTFE and similar fluorocarbon plastics	Degreasing, Special pretreatment	—	Fluorocarbon based polymers cannot normally be bonded in the untreated condition. There are, however, specialised processes (involving flame oxidisation or exposure to dispersions of metallic sodium) for treating the surfaces of fluorocarbon polymers. Pretreated PTFE using such processes is available from various suppliers.
PVC	Degreasing, Abrading	—	—
SMC / BMC	—	—	See composites (fibre reinforced thermosets).

Degreasing *Abrading* *Special pretreatment*

PREPARING OTHER INDUSTRIAL MATERIALS

Most other common industrial materials likely to be bonded are covered in the table on the following page.

Engineers wishing to bond materials not covered in this manual should discuss with our technical team.

Contact

For non-metallic or non-plastic substrates, surface preparation may also be required for optimum bonding. The table hereafter provides solutions for mineral materials, rubbers, leather and wood.

Substrate	Preferred pretreatment (state of the art)	Alternative solution	Remarks
Bricks and other fired non-glazed building materials	Degreasing, Abrading	—	Brush with a wire brush and remove dust.
Carbon	Degreasing, Abrading	—	Abrade with fine abrasive cloth or paper and remove dust.
Ceramics	Degreasing, Abrading	—	Abrade with a slurry of silicone carbide powder and water.
Concrete and mortar	Degreasing, Abrading	Degreasing, Special pretreatment	Even where concrete is sound, it should be pretreated wherever practical by one of the following methods. Method 1 is more effective than 2, and 2 is more effective than 3. 1. Remove by mechanical scarification 3mm - or more - of all surfaces to be bonded, then remove dust preferably by vacuum cleaner; or 2. Sand-blast about 1.5mm off all surfaces to be bonded, then remove dust preferably by vacuum cleaner; or 3. SP: etching solution (annex Etchant 12).
Earthenware	Degreasing, Abrading	—	—
Friction materials (brake pads and linings)	Degreasing, Abrading	—	—
Glass	Degreasing, Special pretreatment	Degreasing, Abrading	Special pretreatment: pretreating the surface with a silane based primer will increase the bonding performance. Alternatively warm for 1/2 hour at 100°C and apply the adhesive before the glass cools down completely to room temperature.
Graphite	Degreasing, Abrading	—	Abrade with fine abrasive paper or cloth and remove dust.
Precious stones	Degreasing	—	—
Leather	Degreasing, Abrading	—	Roughen with abrasive paper & remove loose particles
Paints (cataphoretic / powder coatings)	Degreasing, Abrading	—	—
Plaster	Degreasing, Abrading	—	Allow the surfaces to dry thoroughly. Smooth with fine abrasive paper or cloth and remove dust.
Rubber	Degreasing, Special pretreatment	Degreasing, Abrading	Special pretreatment: etching solution (annex Etchant 13).
Stonework	Abrading	—	Allow the surfaces to dry thoroughly. Brush with a wire brush and remove dust.
Wood	Abrading	—	Ensure the wood is dry. Plane or abrade with abrasive paper and remove dust.

Degreasing *Abrading* *Special pretreatment*

ETCHANT COMPOSITIONS

ETCHANT 1
(ALUMINUM ETCHING)

Composition

Potassium dichromate or sodium dichromate	2 kg
Concentrated sulfuric acid (specific gravity 1.84)	10 liters
Distilled/de-ionized water	30 liters

Solution preparation: Stir continuously whilst adding the concentrated sulfuric acid to 60% of the total water volume. Add dichromate. Stir to create a solution. Finally add the remaining water.

ETCHANT 2
(COPPER AND COPPER ALLOY ETCHING)

Composition

Concentrated nitric acid (specific gravity 1.42)	5 liters
Distilled/de-ionized water	15 liters

Etch for 30 seconds at room temperature in the etching solution described above. Rinse with clean, cold running water. Do not allow to dry. Immerse for 2-3 minutes at 95-100°C in a solution of:

Composition

Sodium hydroxide	0.1 kg
Sodium chlorite (NaCl technical)	0.6 kg
Trisodium phosphate (Na_3PO_4 anhydrous)	0.2 kg
Distilled/de-ionized water	20 liters

Rinse with plenty of clean cold water and dry promptly with a room temperature air stream (the use of hot air may cause staining of the surfaces).

The two-stage chemical pretreatment above gives, in general, better bond strengths than the ammonium persulphate pretreatment below. This however offers the advantage of simplicity and the achievable bond strength may be adequate for some applications.

Etch in a 25% solution of ammonium persulphate: Immerse for 30 seconds at room temperature, wash with plenty of clean cold water and dry promptly with a room temperature air stream. (The use of hot air may cause staining of the surfaces).

ETCHANT 3
(CHROMIUM ETCHING)

Composition

Concentrated hydrochloric acid (specific gravity 1.18)	4.25 liters
Distilled/de-ionized water	5 liters

Immerse for 1-5 minutes at 90-95°C, rinse with clean cold running water, followed by clean hot water, and dry with hot air.

ETCHANT 4
(LEAD ETCHING)

Composition

Concentrated nitric acid (specific gravity 1.42)	1 liters
Distilled/de-ionized water	9 liters

Immerse for 10 minutes at 45-55°C, rinse with clean running water, followed by clean hot water, and dry with hot air.

ETCHANT 5
(MAGNESIUM AND MAGNESIUM ALLOY ETCHING)

Composition

Sodium sulfate anhydrous	0.2 kg
Calcium nitrate	0.2 kg
Chromium trioxide	2.2 kg
Distilled/de-ionized water	12 liters

Immerse in sodium hydroxide solution (1 part to 12 parts) for 10 minutes at 70-75°C, wash thoroughly in cold tap water. Immerse in etchant 5 for 10 minutes at room temperature. Rinse thoroughly with cold tap water. Final rinse with distilled or de-ionized water. Dry in hot air and bond immediately.

ETCHANT 6
(STEEL-MILD ETCHING)

Composition

Orthophosphoric acid (specific gravity 1.7)	10 liters
Industrial methylated spirit	20 liters

Immerse for 10 minutes at 60°C, remove from the solution and then, under clean cold running water, brush off the black deposit with a stiff-bristle nylon brush. Absorb residual water by wiping with a clean cloth soaked with clean industrial methylated spirit or isopropanol. Heat for 1 hour at 120°C.

ETCHANT COMPOSITIONS

ETCHANT 7
(STAINLESS STEEL ETCHING)

Composition

Oxalic acid (HOOC-COOH, $2H_2O$)	5 kg
Concentrated sulphuric acid (specific gravity 1.84)	16 liters
Distilled/de-ionized water	35 liters

Etch for 5-10 minutes at 55-65°C.
Prior conditioning (e.g. passivation) of the steel surface may delay the reaction between steel and etch solution. The etch treatment should be timed from the onset of the reaction. Rinse with clean cold running water, then remove the black deposit by immersing for 5-20 minutes at 60-65°C in the sulfuric acid + sodium dichromate (or chromium trioxide) etch specified for aluminum and aluminum alloys.

*Alternatively, remove the black deposit by brushing, under clean cold running water, with a stiff-bristle nylon brush, and dry with hot air.

Note: As wide variations in the composition of stainless steel can be encountered, prior testing should be performed to determine the optimum immersion conditions and etching solution component concentration. Etching baths used for the pretreatment of aluminum alloys must not be used concurrently for the pretreatment of steel.

ETCHANT 8
(TITANIUM AND TITANIUM ALLOY ETCHING)

Composition

Concentrated nitric acid (specific gravity 1.42)	9.5 liters
Hydrofluoric acid (specific gravity 1.17)	0.85 liter
Distilled/de-ionized water	40 liters

Etch for 1-2 minutes at room temperature. Wash with clean cold running water, then immerse for 2-3 minutes at room temperature in a solution of:

Composition

Trisodium phosphate (Na_3PO_4, $2H_2O$)	1.75 kg
Potassium fluoride (KF, $2H_2O$)	0.68 kg
Hydrofluoric acid (specific gravity 1.17)	1 liter
Distilled/de-ionized water	40 liters

Rinse with clean cold running water, immerse in clean de-ionized water at 55-65°C for 15-20 minutes, remove, rinse with clean cold running water (brush off any remaining deposit with a clean stiff-bristle nylon brush) and dry with hot air. The temperature of the hot water and air must not be greater than 65°C.

Frequent renewal of the de-ionized water is highly recommended. Renewing is essential if turbidity appears.

ETCHANT 9
(TUNGSTEN AND TUNGSTEN CARBIDE ETCHING)

Composition

Caustic soda (sodium hydroxide)	15 kg
Distilled/de-ionized water	35 liters

Use a stress-relieved mild-steel container: aluminum, tin and zinc-coated, galvanised or tinned ware are unsuitable for caustic soda. Mixing procedure: slowly sprinkle while stirring, flake or pearl caustic soda onto the cold water. Continue stirring until the caustic soda is dissolved. Immerse for 10 minutes at 80-90°C, rinse with clean cold running water, followed by clean hot water and dry with hot air.

ETCHANT 10
(ABS ETCHING)

Composition

Potassium dichromate or sodium dichromate	1 kg
Concentrated sulfuric acid (specific gravity 1.84)	10 liters
Distilled/de-ionized water	30 liters

Immerse for 15 minutes at room temperature, rinse with clean running water, followed by clean hot water, and dry with hot air.

ETCHANT 11
(THERMOPLASTIC POLYESTER ETCHING)

Composition

Caustic soda	2 kg
Distilled/de-ionized water	8 liters

Immerse for 6 minutes at 75-85°C, wash with clean running cold water, followed by clean hot water, and dry with hot air.

ETCHANT 12
(CONCRETE / MORTAR ETCHING)

Composition

Hydrochloric or sulfamic acid	1 liter
Distilled/de-ionized water	10 liters

Etch (1 liter per square meter, spread by stiff-bristle brooms) until bubbling subsides (about 15 minutes). Wash with clean water by high-pressure hose until all slush is removed and the surface is neutral to litmus. A final rinse with 1% ammonia solution followed by clean water is a good practice to ensure thorough neutralisation. Allow the surface to dry thoroughly. Remove dust preferably by vacuum cleaner.

ETCHANT COMPOSITIONS

ETCHANT 13
(RUBBER BLEACHING)

Composition modified bleach solution

Sodium hypochlorite (standard household bleach):	300 ml
Concentrated hydrochloric acid (specific gravity 1.18)	50 ml
Distilled/de-ionized water	10 liters

Prepare the modified bleach solution by pouring the water into a clean container made of plastic, glass or similar inert ware. While stirring the water, add the concentrated hydrochloric acid in a slow steady stream, followed by the household bleach, continuing to stir thoroughly. Never mix the household bleach and acid without adding the water first, as toxic chlorine gas will be formed. Immerse for 1-3 minutes at room temperature, wash with cold, clean water, followed by clean, hot water, and dry with hot air.

An alternative solution is to use concentrated sulfuric acid (specific gravity 1.84). Immerse for 2-10 minutes at room temperature, rinse with clean cold running water, followed by clean hot water, and dry with hot air.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Ref. No. AdMat_TechGuide_SurfacePreparation_EN_EU_April 2022

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