EFFECTIVE SURFACE PREPARATION FOR ADHESIVE BONDING

White Paper

BUILDING TRUST

SURFACE QUALITY AND TREATMENT

MANY ENGINEERS, PRODUCTION MANAGERS, BUYERS, AND OTHER STAKEHOLDERS mention simple surface preparation when they are asked about their wish lists related to adhesive bonding. For most, a simplified surface preparation process ranks relatively high as it reduces cumbersome work steps and thus is an area to improve overall process efficiency.

Surfaces can alter during manufacturing, transport, handling, aging, exposure to sunlight and weather, etc. Therefore, surface preparation is advisable to ensure stable surface quality for adhesive bonding. Some methods also stabilize the surface quality and offer limited protection from natural forces. Compared with alternative measures to ensure a consistent quality of the material surfaces, like surface quality control and specification or protection from picking up dirt and dust, **surface preparation is a cost-efficient method to assure the final quality of the bond**.

ABOUT THE AUTHOR

David has more than 20 years of experience in the adhesive industry, focusing on industrial manufacturing and commercial transportation. With his team, he takes care of generating value for Sika's customers by simplifying assembly processes and increasing performance and output.

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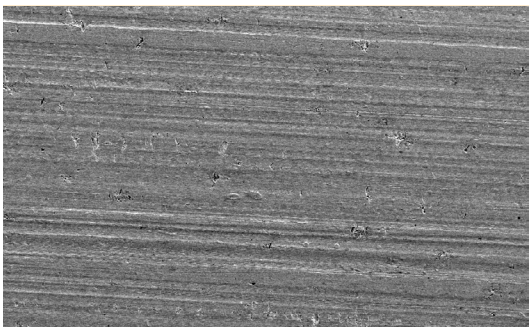
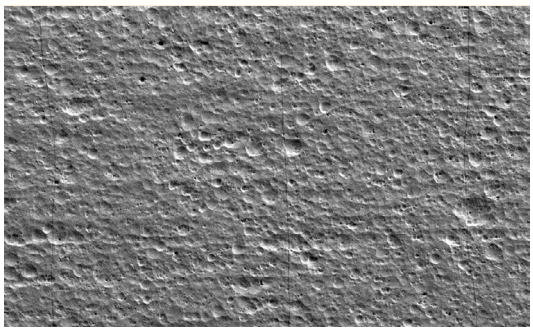
IT IS ABOUT SURFACE QUALITY!

When materials are joined with adhesives, the material's surface quality and consistency are vital. Industry standards are used to reflect certain commodities like steel. Most of the commonly used steel alloys are categorized into various grades, which define mechanical performance, composition, and corrosion resistance. They do not include specific information about the quality of the surface relevant for adhesive bonding.



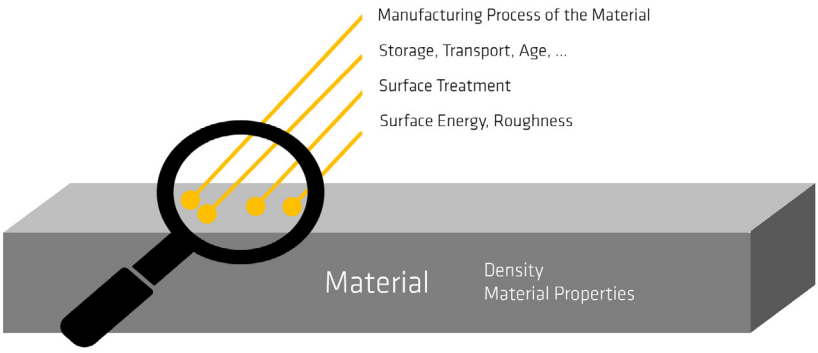
Aluminum Sheet Cleaning x 500



Anodized Aluminum Cleaning x 500

Pictures: These Scanning Electron Microscope (SEM) photos show the surface of regular aluminum vs. anodized aluminum after cleaning with n-heptane. The surface texture is entirely different.

For plastics or coatings, manufacturers might specify the surface to some extent. Still, specifications cover visible aspects like color, gloss, and UV resistivity and not the microscopic surface characteristics.



It is common in manufacturing to use more than one source for materials. Even though the material specification may look the same, there can be significant differences in surface quality which is relevant for adhesive bonding.

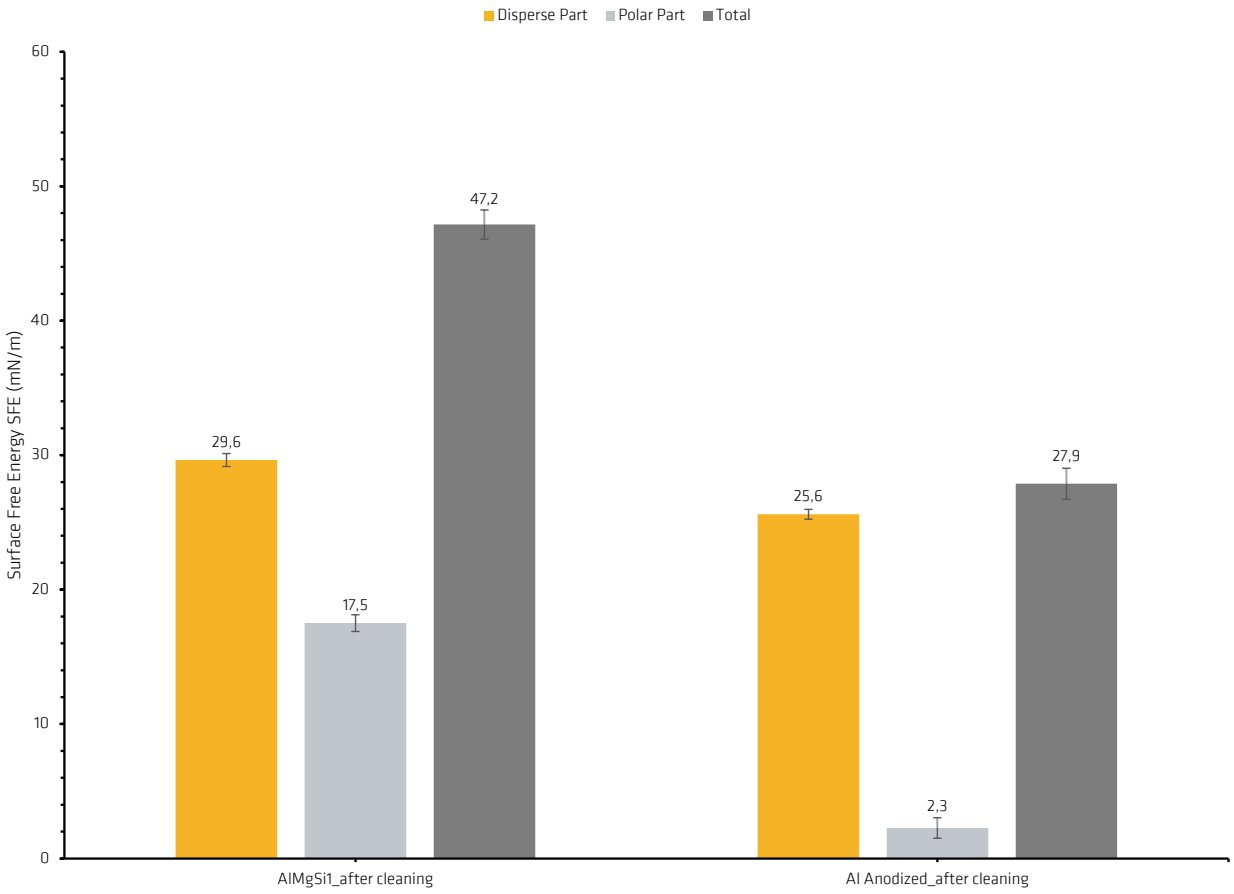
"WE RECOMMEND A REQUALIFICATION OF ADHESIVE BONDING PERFORMANCE WHENEVER THERE IS A CHANGE TO YOUR MATERIAL (SUPPLIER, SPECIFICATION, ENVIRONMENT, PRODUCTION, ETC.)."

ADHESION

Choosing an adhesive and joint dimension that delivers the required material performance is essential for long-lasting adhesive joints. In addition, the adhesive only provides mechanical performance when the adhesion quality to the substrates is ensured. Adhesion can occur either mechanically or chemically, or as a combination of them.

A mechanical bond is mostly determined by the adhesive and substrate contact area. Sanding and degreasing the surface removes contaminants and, more importantly, increases the surface, resulting in better bonding strength.

Alternatively, the adhesive can attach chemically to the substrate. The surfaces must be free of dirt, oil, and other contaminants for optimal bonding performance. Because of the wettability factor, materials with high surface energy (e.g., glass and many metals) allow for easier bonding than lower surface energy substrates (e.g., PP, PE or PTFE). High surface energy is, therefore, a vital prerequisite for adhesive bonding.

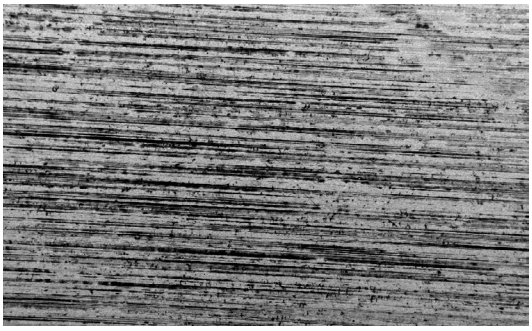


Picture: Regular Aluminum is generally easier to bond than anodized Aluminum also due to the higher surface energy as shown in this graph

METHODS OF SURFACE PREPARATION

CLEANING AND DEGREASING

Most adhesives require clean surfaces. Cleaning is essential to remove any loosely held dirt or other contaminants from the surface. Often solvent-based cleaners are used; acetone and heptane can remove oil and grease from metals, while alcohol or water-based cleaners may be better suited for sensitive substrates like plastics. Physical methods like plasma also act as a surface cleaner.



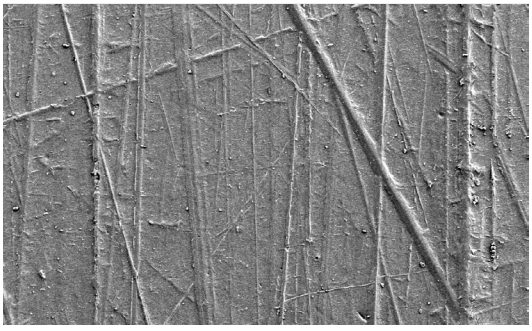
Aluminum Sheet Oiled x 100

Aluminum Sheet Cleaned x 100

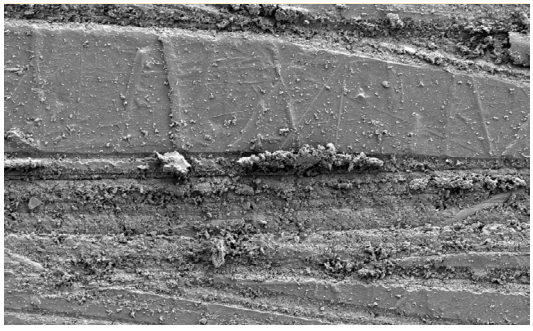
Pictures Cleaning: the Scanning Electron Microscope photos show the effect of cleaning on an aluminum sheet that was intently contaminated with oil and cleaned with n-Heptane afterward.

ABRADING

After degreasing, mechanical abrasion can be needed to remove heavy loose dirt or oxide layers from the surface. Another purpose for mechanical abrasion is the increase of surface area for bonding. Effective mechanical methods used by the industry include sandblasting, wire brushing, or abrasion with sandpaper or abrasive pads. **One must clean the surfaces before and after abrasion to remove pre-existing contaminants.**



SMC Sample Original x 500



SMC Sample Sanded x 500 (not cleaned afterwards)

Pictures Abrading: the SEM photos show the effects of sanding with 120 grit paper on an SMC sheet. The original indicates the glass fibers and that the resin was shrinking while curing. On the sanded part, it is well visible that there is dust on the surface which needs to be removed with a cleaning step.

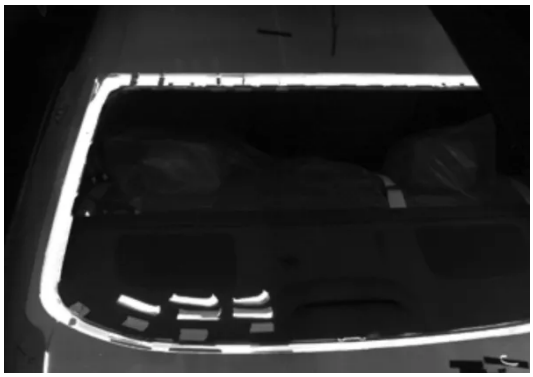
METHODS OF SURFACE PREPARATION

CHEMICAL TREATMENT

The use of chemical surface preparation is widespread throughout the industry and is a relatively simple but effective solution. Solutions range from chemical etching and "active cleaners" (at Sika we call them SikaAktivator) to film building primers.

Active cleaners contain adhesion promoters that chemically react with or change the surface energy. The layer typically remains invisible to the human eye. For in-process control, they often contain luminescent dye that can be detected in UV light.

Visual detection by eye



Detection with Cognex IN-Sight camera

Primers are typically forming a layer that can better interlock with the surface of the substrate, close cavities, and offer compatible surface chemistry to the adhesive. In simplified terms, a primer is usually a dilute solution of an adhesive in an organic solvent.

Download Sika Pre-treatment Charts

- for **Sikaflex-500 Series STPs**
- for **Sikaflex-200 Series PURs**

METHODS OF SURFACE PREPARATION

PHYSICAL TREATMENT

With some materials, particularly plastics, chemical treatment or mechanical abrasion are not effective enough. Physical methods like flame, corona, or plasma are widely used to modify the surface chemistries of plastics to achieve better adhesion.

Flame Treatment involves exposing the surface to a gas flame for a few seconds. The flame oxidizes the surface and increases the surface energy. The heat of the flame may lead to visible deformation, and users are sometimes reluctant to install flame treatment due to risk of fire.

Plasma Treatment: With plasma treatment, a gas plasma is activated to produce a highly excited, ionized gas that reacts with the plastic substrate. The latest plasma technologies allow a surface enhancement with the combination of plasma and adhesion promoters/surface modifiers in one step. The plasma activates both the surface and the molecules, which are then covalently bonded to the surface, resulting in a long-term modification of the treated surface's chemical functionality, which remains stable for a very long time.

More about Plasma Treatment from Plasmatreat and Molecular Plasma Group.

HOW TO ASSURE SURFACE QUALITY AND BONDING PERFORMANCE

Adhesive bonding is a well-established joining technology throughout the industry; it is, however, not much different than welding and needs qualified staff who is paying attention to correct execution as well as control measures. Claims reveal that critical parameters such as consistent execution of the working steps or changes in materials and surface quality are predominantly the root cause of failures.

The steps below shall help process and quality engineers to avoid costly mistakes.

1 QUALIFICATION OF AN APPLICATION

It is essential to test the combination of substrate material, surface prep, and adhesive for compatibility and performance. For elastic adhesives, adhesion peel testing acc ISO 21194 is the easiest method; for more rigid adhesives, using tensile lap shear testing acc ISO 4587 is typical; different aging conditions may be applied too. A cohesive failure mode, or break of the adhesive or substrate itself, is what one is looking for.

2 IMPLEMENT CLEAR WORK INSTRUCTION

For consistent execution, it is paramount to establish clear bonding process guidelines and train staff accordingly. The implementation of step-by-step assembly instructions is the best practice.

3 PROCESS CONTROL

It is also vital to control correct execution. With colored primers, surface treatment steps can easily be controlled by the eye. Sika offers active cleaners that can be detected by UV light for better in-process control. The consistent use of standard cleaners or sanding steps is more difficult to control. It is recommended to implement process integrated testing e.g. by taking samples of the materials and bonding them along the actual bonding process.

4 REQUALIFY IN CASE OF ANY MATERIAL CHANGES

The materials used in manufacturing are often changing, e.g. by changing the supplier and because manufacturers might change their processes or locations. Changes might have an impact on the surface quality and, ultimately, the quality of the bond. It is recommended to ask suppliers to be informed about such changes and execute requalification tests. Again adhesion peel testing or tensile lap shear testing are the recommended methods.

Sika Technical Services is supporting customers in this process. By doing the qualification test work, providing support on establishing work instructions, or training operators. Some Sika surface prep agents contain luminescent dye that can be detected in UV light for better in-process control.

SIKA SURFACE SCIENE LAB

For Sika, a leading adhesive manufacturer, knowledge about materials surfaces is vital for product development, customer support, and failure analysis.

Sika's Surface Science Lab in Switzerland is equipped with various methods of surface characterization, from optical microscopy to Scanning Electron Microscopy (SEM) and contact angle measurement. Sika Experts provide in-depth surface analytics support. Use cases range from the analysis of material homogeneity, layer thickness, chemical element mapping, morphology, and many more. I also thank the team for helping me with pictures for this article.

Sika is present in more than 100 countries all over the world. We employ local experts to talk your language and provide access to our vast network of global experts.

SIKA - YOUR PARTNER FROM ENGINEERING TO SERIAL PRODUCTION

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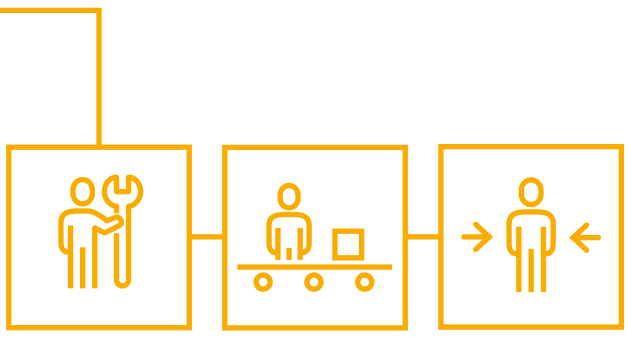
Support implementation and validation on the right equipment for efficient processes

AUTOMATION & PROCESS
expertise through a global network of experts and partnership with leading equipment manufacturers



Providing tailored customer application trainings

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LEGAL NOTE

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