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RPTU University of Kaiserslautern-Landau, Workgroup Materials and Surface Technologies
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QUALITY ASSURANCE OF SURFACES PRIOR TO ADHESIVE BONDING

Abstract
The quality of adherent surfaces prior to adhesive bonding has a strong impact on the bond performance in terms of strength and durability. The in-line quality control of cleaning and pre-treatment processes thus pursues the goal of monitoring the suitability of the surface to be bonded. Spectroscopic analysis methods are advantageous because they may be applied in a non-destructive manner. In addition to identifying and quantifying contaminations, IR spectroscopy also allows the detection of adhesion promoters, activators and primers. In these cases, process-integrated IR analysis can be used to verify the desired activation effect.

The range of FTIR analyzers available today extends from modular industrial instruments to hand-held mobile small spectrometers. High surface sensitivity is provided by measuring devices that use the grazing angle principle for the infrared analysis of superficial contaminations. In this talk, the performance of devices for diffuse reflectance (DRIFT), grazing angle (GA) and attenuated total reflectance (ATR) will be compared.

To determine the limit of detection (LOD) required for quality assurance, the influence of surface contaminations on the quality of adhesively bonded joints is first investigated experimentally using destructive mechanical testing methods and expressed as a quality parameter. When the chosen spectroscopic method meets the requirements of the detection limit, the result of the surface analysis can be used to infer whether the quality of the joint to be bonded is likely to meet the requirements. Assessment routines such as the FTIR spectroscopic integration methods can be tailored to a production-relevant issue and thus be implemented in a quantity-specific manner. By using process-integrated handheld FTIR tools for non-destructive surface analysis, adhesively bonded joints with poor quality can be avoided.

Plasmatreat Schweiz AG
Klaus Kresser

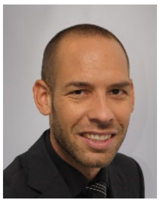
OPENAIR-PLASMA® TECHNOLOGY FOR WETTING, SEALING & BONDING IN BATTERY APPLICATIONS

Abstract
Why is it beneficial to use OpenAir® technology for wetting sealing and bonding in battery applications? For these applications a lot of different substrates made of metals and plastics are used for gluing and coating applications. This means that for the actual function - such as adhesion, corrosion protection, etc. efficient and environmentally friendly inline treatment solutions are needed. In addition, with every new car model, new battery designs are established and new legislations have to been taken into account. For this a universal and flexible treatment system is preferred.
Here, OpenAir®-Plasma technology simplifies the processes. All different types of materials like plastic, glass, metals like aluminum, etc. can be treated with OpenAir®.Plasma. This process is already being used successfully for surface treatments in a large number of different automotive battery applications and for other industries and applications. Herewith OpenAir®-Plasma technology assure long-term adhesion.

In the paper, the following topics will be introduced and discussed:
- Explanation of the basic principle of the OpenAir®-Plasma treatment on plastic and metals
- Distinction between different plasma technologies: Activation of surfaces and coating of surfaces via PECVD (Plasma Enhanced Chemical Vapor Deposition).
- Examples of substrate/adhesive combinations, where PECVD can be used for automotive battery applications.

- Examples of successful implementation and industrialization of green processes and new materials with PECVD technology
- Examples Lean pre-treatment solutions for bonding are industrialized.

Fracture Analytics
Dr. Martin Brandtner-Hafner



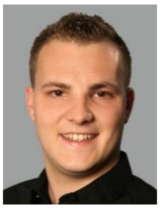
GAP FILLING EFFICIENCY OF ADHESIVE SEALANTS

Abstract

The performance of adhesive joints depends on a variety of influencing factors. These include external aspects, such as load type, load dynamics, and environmental influences, as well as internal ones, such as adhesive gap, adhesive surface, geometric shape, and substrate type. However, for adhesive selection, economic facet also plays a major role in addition to technical parameters. Hence, this technical paper will focus on the influencing design parameter "gap filling efficiency" from a techno-economical point of view. This is accomplished by utilizing holistic fracture analysis with an innovative empirical evaluation approach. Since the fundamental principle of characterizing gap filling performance is not explicitly defined in the manufacturer's technical data sheets, FRACTURE ANALYTICS has developed an empirical in-house test standard, the so-called MCT method. It sets higher requirements than applied in the adhesive industry leading to superiority over standardized mechanical test setups, such as lap-shear, pull-off, tearing, and peel-off. The reason to this is they fully ignore interface damaging effects of adhesive joints and only apply stress-based, single-parameter failure criteria leading to results of limited significance. In this study, MCT is executed on different adhesive sealants for structural glazing to examine their gap-filling efficiency. The results reveal that both bonding efficiency and bonding costs vary greatly with a changing gap of the bonded joint. That is why the introduction of a novel evaluation parameter called gap filling efficiency allows empirically valid statements to be made about the adhesive bonding optimum incorporating bonding costs, bonding efficiency, and interfacial bonding safety. For the adhesive engineer, designer, and practitioner, this represents a powerful selection tool fostering the best design of an adhesive joint.

Keywords:
Gap Filling Efficiency, Adhesive Sealants, Structural Glazing, Holistic Fracture Analysis, MCT Method, Bonding Optimum.

Sika Technology AG
Tobias Illi



SIKAPOWER-800 – FAST CURING AND INJECTABLE EPOXY ADHESIVE

Abstract

Two component epoxy adhesives are widely used in the wind industry. For the production of wind turbine blades, bonding pastes (tough and structural epoxy adhesives) are used to durably bond the blade parts together. Besides that, epoxy adhesives are also in use for the repair in various applications along the blade and its manufacturing process

Customers expect that the adhesive solution selected to repair voids or dis-bonds of the main bond has the same final properties as the original blade bonding paste. However, the properties that make bonding pastes suitable for manufacturing large composite structures, such as long open time, high sag resistance and relatively long thermal curing profiles, are not suited for repair injection where low viscosity and full room temperature curing capability at low shrinkage are beneficial or preferred. It is therefore inevitable that an alternative to the blade bonding adhesive is required for injection bonding and ideally, it should have as similar properties as possible in the other areas. Sika has developed SikaPower®-800, a low-shrinkage epoxy repair injection adhesive that is chemically identical to current blade bonding adhesives. It offers very similar mechanical properties, a higher toughness to resist cracking and can also fully cure without the need for external heating

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ELANTAS Europe S.r.l.
Dr. Davide Malinverno

NEW DEVELOPMENTS OF EPOXY ADHESIVES

Abstract

In an entire production process, sometimes, the right selection of an adhesive could be an underestimated aspect due to the small amount used in the process. In truth, it hides a combination of sciences as chemistry, physic and engineering that must be combined to design and select the right product for the right application.

In modern technology, adhesives are replacing more and more classical bind process such as welding and joining. Building and construction industry had been first in using adhesives and sealants, followed by the composite industry. Today these types of materials are also a standard tool in automotive, nautical and many other industries, even in applications relevant for safety.
A multitude of applications and different processes must require a broad range of products.

In this lecture will be shown some insights about new development of Epoxy-amines adhesives dedicated to marine industry, winding blades, and automotive industry, where the combination of rheological properties and mechanical performances play a strategic role for the selection of the right product

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Schill+Seilacher "Struktol" GmbH
Sven Wiemer

BIOBASED TOUGHNESS

Abstract

Epoxies are inherently high strength but also brittle. In order to formulate a ductile, mechanically loadable epoxy-based system such as structural adhesives or fiber composite matrices, impact modifiers (tougheners) are required. In the case of structural adhesives, as used in modern body-in-white construction, where they represent the current standard of joining technology, crash-proof passenger compartments can be produced by joining components over the entire bonding area, which would not be achievable by spot welding alone.

The tougheners required for this are usually based on petrochemical precursors and substances. The most frequently encountered impact modifiers are epoxy resins (adducts) modified with CTBN (rubber) along with blocked polyurethanes. In addition, biobased epoxy resin adducts or those based on renewable raw materials have also been formulated for years. The most common are dimer fatty acids, as used by Struktol in the adduct Polycavit 3632, which can be described as quasi-sustainable resins before this definition became widely used.

Currently under development at Struktol is an epoxy resin adduct based on a bio-based polyester originally developed for classical UPE applications. However, first iterations show that tougheners based on this UPE have already shown promising results, which encourage us to further develop in this direction of a sustainable product.

Today we would like to give an interim summary as well as an outlook on the new type of impact modification, which is not exclusively based on the idea of sustainability, but rather on the further development and combination possibility(s) of chemistry.

University of Alicante / Adhesion and Adhesives Laboratory
Prof. José Miguel Martín-Martínez

PHYSICAL MIXING OF WATERBORNE POLYURETHANE AND NANOSILICA DISPERSION. IS IT A FEASIBLE STRATEGY FOR IMPROVING THE PROPERTIES OF WATERBORNE POLYURETHANE ADHESIVES?

Abstract

Waterborne polyurethane dispersions (PUDs) are multiphasic systems made of spherical nanoparticles dispersed in water. PUDs are synthesized by reacting a diisocyanate, a polyol, an

internal emulsifier and a chain extender, the internal emulsifier anchors covalently pendant ionic or non-ionic moieties in the linear polyurethane chain which are oriented outside of the particles in the presence of water. Although effective, the waterborne polyurethane adhesives have limited water resistance, relative low thermal resistance and insufficient mechanical properties. For improving these properties, several strategies have been proposed including the addition of cross-linkers and fillers, among other.

Fumed silica fillers have been commonly added for improving the rheological, mechanical and adhesion properties of the solvent born polyurethane adhesives. However, the addition of fumed silicas to PUDs is not effective due to the formation of silica agglomerates and the phase separation of the polyurethane micelles. Therefore, different procedures have been proposed for incorporating silica fillers in PUDs, including the sol-gel method, the in-situ polymerization of the silica precursor, and the physical mixing of the PUD and nanosilica dispersions, among other. Although the incorporation of silica precursors during the polyurethane synthesis is efficient for producing hybrid silica-waterborne polyurethane dispersions, their stabilities and adhesion properties are limited, the physical mixing of the PUD and nanosilica dispersions is simpler, this procedure has been selected in this study.

Nanosilica dispersion was added to waterborne polyurethane dispersion by using three different physical mixing procedures differing in the flow regime (tangential, laminar, radial) and the stirring rate (300-2400 rpm). The influence of the physical mixing procedure on the structural, thermal, rheological, mechanical, surface and adhesion properties of the polyurethanes (PUs) containing 1 wt.% nanosilica was evaluated. The nanosilica in the dispersion was functionalized with acrylic moieties and showed high surface tension and negative Z potential values. The PU+nanosilica blend made with higher shear rate and laminar flow regime showed high homogeneous dispersion of the nanosilica particles and greater extent of intercalation between the soft segments of the polyurethane, this led to higher thermal stability. Unexpectedly, the better dispersion of the nanosilica in the PU matrix decreased the wettability of the PU+nanosilica materials due to the migration of acrylic moieties from the nanosilica particles to the surface. As a consequence, a decrease of the final T-peel strength was found. However, the single lap-shear strength did not change by adding nanosilica because of the scarce improvement of the mechanical properties in the PU+nanosilica materials.

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siloxene AG
Dr. Matthias Koebel

CONTROLLING ADHESION AT THE MOLECULAR LEVEL – NEW MULTIFUNCTIONAL DENDRIMER SILANE ADDITIVES AND RESINS FOR FUNCTIONAL ADHESIVES

Abstract
Adhesive technology relies on curing of a resin to create a strong cohesion of the adhesive layer and good interfacial adhesion the the bonding subtrate(s). Typical raw materials comprised in commercial adhesives have been standardized and innovation in this sector is limited. Here we propose the use of a new class of multifunctional dendrimer silanes – so-called Q-T polysiloxane resins – to drive new solutions in the adhesives sector.

siloxene products offer tailorable chemical functionality, minimal eco impact and are solvent-free, non-flammable low-viscous raw materials. XenCure products come in a range of single or multi-functional dendrimer silanes, with selectable amino, glycidoxy, methacryloxy, vinyl chemistries. They can be thought of as a “silane 2.0” and are typically used as additives, offering superior adhesion and crosslinking properties compared to standard monomer silanes. XenRes products are hybrid dendrimers with grafted commodity resin chemistry, covering all standard resin types

such as bisphenol A epoxy, isocyanate, UV curable (meth)acrylate and silane terminated polymer (STP). These are used as co-resins, boosting adhesion on certain substrates and altering curing mechanism, speed and also mechanical properties.
At siloxene we are developing this innovative raw materials platform for a variety of technological applications with focus on structural adhesives, multi-cure chemistry and adhesion profile control. Examples will highlight some of the unique properties the concept has to offer

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nolax AG
Dr. Vincent Lutz

NON-ISOCYANATE POLYURETHANES (NIPUs): A PROMISING PATHWAY TOWARDS SUSTAINABLE AND ENVIRONMENTALLY FRIENDLY ADHESIVES

Abstract
Polyurethanes are widely used in a whole range of products in our daily life thanks to their large material portfolio, excellent properties, and versatility.
Due to REACH regulations and the use of hazardous isocyanates, nonisocyanate polyurethanes (NIPUs) have gained interest over the past decade. One of the most promising routes is the use of the polyaddition of different cyclic carbonates with polyamines to form polyhydroxyurethane (PHU) polymers.
Nevertheless, the availability of cyclic carbonates as raw material and their low reactivity at room temperature with polyamines remain quite challenging today.
Starting with a brief description of several routes investigated to synthetize PHU to overcome this limitation, new reactive systems are successfully cured at room temperature. Moreover, the resulting nonisocyanate polyurethane-based networks demonstrate a large variety of mechanical, thermo-mechanical and adhesion performances. This enables obviously a broad panel of candidates for a new class of sustainable and environmentally friendly adhesives in future.

Vinavil SpA
Luigi Mora

SUSTAINABLE DEVELOPMENT IN ADHESIVES: DESIGN OF NEW MONOMERS AND FORMULATIONS, MANAGEMENT OF WASTES

Abstract
The common accepted definition of sustainability is “meeting the needs of the present without compromising the ability of future generations to meet their own needs”.

In the last decades, Vinavil has improved its business to reach the quality and sustainability goals such as the removal of Substances of Very High Concern from our product formulas (ex: APEO, Boron, etc..) and the elimination/reduction of hazardous substances (like acetaldehyde, formaldehyde) as well as VOCs / SVOCs.

As a part of the EU Green Deal, chemical strategy for sustainability is a fundamental pillar dealing with research & innovation for chemicals and safe & sustainable by design criteria. Following this view, Vinavil, in collaboration with Florence University, has started a project for the design and polymerization of new monomers derived from biomasses.

Carbohydrates from waste sources have been derivatized using an unsaturated reactant, to be suitable to be used in radical polymerizations. The aim of this strategy is to introduce in some vinyl adhesives components obtained from renewable sources, in alignment with the increasingly frequent requests from some important industrial groups of adhesives containing biobased materials.

Vinavil is also going to launch in the DIY market a new line of adhesives sustainable and certified.
Further, various projects about polymeric waste sludges reuse are ongoing.

Jowat SE
Dr. Hartmut Henneken

RECYCLING ADHESIVES – A TECHNOLOGICAL OXYMORON?

Abstract
What opportunities are there for an adhesive manufacturer to align its own business more closely with a circular economy? Can adhesives be recycled and reused as adhesives after the end-of-life of their first application? What are the most viable ways to develop adhesives that are recycling-friendly? Does biodegradability make sense as a route to return products into the natural cycle? There are many fundamental questions of a strategic & technological nature. It is absolutely clear that the adhesives industry and their supply chain (as well as the whole industry, also on a global scale) needs to develop new processes / products that can avoid the use of "fresh" fossil carbon sources as much as possible (ideally not needing any at all). Technology development for this has been ongoing for many years. Predictions about the required future "carbon mix" (as a linguistic analogue to the energy mix) vary, but more or less only with respect to the ratio of the material origin of the carbon atoms, which we namely still need and will continue to need undiminished as unavoidable basic building blocks of life and most materials. Contrary to the field of energy use, it is therefore obviously not possible to decarbonize the material supply. The origin of the raw material/feedstock has to be changed in order to use sustainable technologies and resources. Basically, three pillars are identified to serve as future carbon sources: Direct CO2 use, bio-based feedstocks, and recycled "waste"/valuable materials as feedstocks. This presentation will attempt to answer some of the above questions. Examples from Jowat Research & Development will be shown to illustrate where the adhesives industry stands today when it comes to the idea of recycling and the circular economy in general.