

Abstract

Oxford Advanced Surfaces (OAS) has developed the Onto™ EP1000 series – a range of functional surface treatments that can be used to promote adhesion of two-part polyurethane and epoxy coatings to difficult-to-bond substrates such as engineering polymers, high performance (speciality) plastics and thermoplastic composites. The treatment can be applied to a substrate from solution using a range of coating methods to form a functional layer of material that is strongly bonded to the substrate surface. The new surface functionality is chemically compatible for bonding to polyurethane and epoxy coatings and the treatment has been shown to prevent delamination even under severe weathering conditions.

| Onto™ EP1000 for Adhesion Promotion | | |
|-------------------------------------|-------------|---------------------|
| Coatings | Substrates | Coating methods |
| Cationic epoxy ✓ | PP ✓ | Dip ✓ |
| Anionic epoxy ✓ | UHMWPE ✓ | Spray ✓ |
| Two part PU ✓ | PET ✓ | Gravure ✓ |
| Silicones ✓ | PEN ✓ | Flexo ✓ |
| Siloxane-based epoxy ✓ | PEEK ✓ | K bar (meter rod) ✓ |
| Solvent-based TPU ✓ | PI ✓ | Metred slot ✓ |
| | PEI ✓ | Ink jet ✓ |
| | Aluminium ✓ | Spin ✓ |

Adhesion promotion of polyurethane and epoxy coatings

Onto™ EP1000 provides adhesion promotion for two-part polyurethanes (2K PU) as well as for cationic and anionic epoxy systems because its functionality is suitable for covalent bonding with epoxide and isocyanate components. Bonding via a secondary mechanism also provides adhesion promotion to siloxane-based epoxies, silicones and solvent-based thermoplastic polyurethanes. It is fully compatible with solvent borne or waterborne PU/epoxy formulations because the layer is strongly bound to the substrate.

Difficult-to-bond materials

In many high performance products, engineering and speciality plastics are increasingly being used as replacements for metals because they provide significantly more favourable properties, including light weight, flexibility and chemical resistance. However, their excellent solvent and heat resistance also makes them extremely difficult to bond to because they are either highly crystalline or have no useful surface chemical functionality.

Onto™ EP1000: Adhesion Promotion of Polyurethane and Epoxy Coatings

For many high-end products, delamination can be catastrophic so that adhesion promotion of these materials becomes paramount.

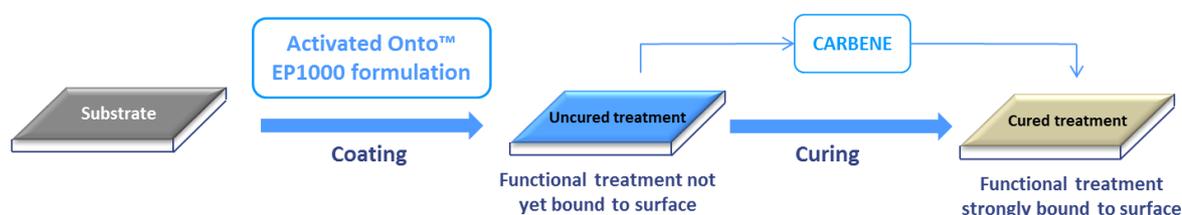
In many industries, corona or plasma treatment of the substrate is used to activate the surface before bonding, but such treatments are not always suitable. In some cases, the treatment is sufficiently harsh that surface damage occurs, and this can be particularly problematic for materials such as fibres in which the surface area is large in proportion to the bulk material. Significantly, the Onto™ EP1000 treatment modifies only the surface of the substrate without affecting the bulk properties of the material, but still give excellent adhesion promotion.

Primers are often used to improve bonding to engineering and speciality plastics. Many of these treatments use either harmful solvents like xylene or chlorinated polymers, but owing to the regulations surrounding such materials, much effort aims to reduce or even completely remove these chemicals from manufacturing. Importantly, Onto™ EP1000 treatments do not require the use of harsh solvents such as xylene.

Processing the treatment

All Onto™ materials are precursors to highly reactive carbenes. In the unactivated form they are stable to heat and light, and therefore Onto™ EP1000 can be shipped and stored in this stable form. The treatment is compatible with a variety of solvents and formulations to suit specific applications can easily be designed. An environmentally friendly alcohol/water mixture is ideal, and harmful solvents can be avoided in many applications.

Once chemically activated, the treatment can be applied from solution to a substrate using standard wet-coat techniques such as dip, spray, flexo, K bar (meter rod), metred slot, gravure, spin and ink jet. The versatility in processing enables the use of Onto™ EP1000 treatments on a variety of material forms including sheets, films, powders, fibres and fabrics.



A curing stage is required to generate the highly reactive carbene species, which then reacts and forms a bond to the substrate surface. This functional layer is now permanently bound to the surface, and any following treatment (lamination, coating, printing, etc) can be completed offline. This is in stark contrast to corona or plasma treatment and even some wet primer treatments, where longevity can be an issue and it is often necessary to bond the substrate within hours or days of treatment.

Demonstration of Onto™ EP1000

OAS has demonstrated adhesion promotion of Miracure (Mirage Inks), a cationic 2K epoxy-based ink, on ultra-high molecular weight polyethylene (UHMWPE) using Onto™ EP1000 which is formulated as an alcohol/water mixture. UHMWPE has no useful surface chemistry and is therefore considered a difficult material to bond.

Processing the Onto™ treatment

The UHMWPE samples were degreased with acetone. Onto™ EP1000 was applied to the substrate from an alcohol/water solvent mixture using a K bar autocoater to produce a coating that is around 200nm in thickness. The curing stage was carried out using a laboratory convection oven at 115°C. The processing

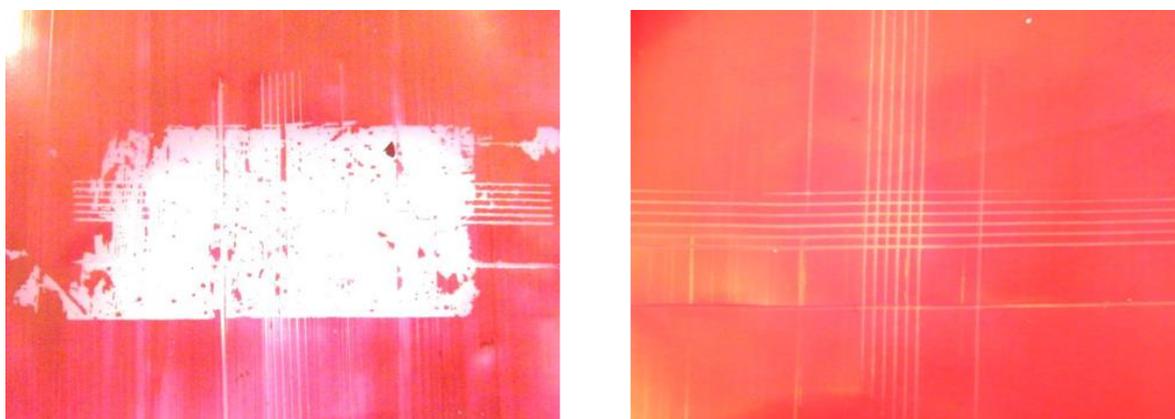
temperature can be varied to suit application and manufacturing capabilities, but for lower curing temperatures longer cure times may be required. The cure time is dependent on several factors including oven efficiency, substrate and Onto™ layer thickness.

Adhesion promotion to the 2K epoxy ink

The Onto™ treated UHMWPE samples were coated with Miracure Red ink using a K bar autocoater to apply a dried layer of approximately 2µm thick. The ink was cured at 115°C for 15 minutes.

Control samples containing no Onto™ treatment were also made for comparison - the Miracure was applied using the same conditions as the treated samples.

An industry-standard cross hatch tape test was used to assess the samples; this aggressive test gives an excellent indication of the adhesion of coatings. The test was carried out according to ASTM D3359-08 using Scotch tape 610. In all cases, the Onto™ treated samples passed the test at level 5B, while the control samples all failed. Visually, the difference is obvious, and is completely reproducible.



Cross hatch tape testing of Miracure Ink on UHMWPE: a) Control sample; b) Sample treated with Onto™ EP1000

Onto™ EP1000 promotes adhesion even in harsh conditions

Onto™ EP1000 has been used to improve the adhesion of other PU and epoxy coatings to high performance plastics and composites. A selection of examples is shown in the table below. Exposure to harsh weathering conditions, chosen to exceed likely exposure over service lifetime, showed that the control samples all delaminated, whereas the Onto™ treated samples all passed the test criteria.

| Substrate | Coating | Exposure conditions and test | Adhesion test | |
|--|---------------------|---|-----------------|-----------------------|
| | | | Control samples | Onto™-treated samples |
| Thermoplastic polyolefin | 2K PU Solvent borne | Water immersion and cross hatch testing | Fail | Pass |
| High temperature thermoplastic composite | 2K epoxy Waterborne | Industry standard test for weathering | Fail | Pass |
| High temperature thermoplastic composite | 2K PU Solvent borne | Industry standard test for weathering | Fail | Pass |

Onto™ EP1000 prevents coating delamination even under severe exposure conditions



Summary

We have used Onto™ EP1000 to demonstrate adhesion promotion of 2K PU and epoxy coatings to various difficult-to-bond plastics, including polyolefins and high temperature thermoplastic composites. It is also applicable for other high performance substrates such as PI, PEEK and PEI, PET, PEN polymers and composites. This treatment offers adhesion promotion solutions to multiple industrial bonding challenges for PU- and epoxy-based inks, functional coatings and paints.

OAS is currently taking enquiries for Evaluation Packs of Onto™ EP1000. The pack contains all the required components for a laboratory based assessment of the product using the K bar (meter rod) coating technique. Please [contact us](#) if you would like an Evaluation Pack so that we can assess whether Onto™ EP1000 is suitable for your adhesion challenge.

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