EVONIK
POWER TO CREATE

We give wings to wind power

AEROSIL® fumed silica, Dynasylan® silanes and Protectosil® silanes as essential additives in wind energy applications

Contents

Wind energy

The wind energy market, in particular, will still grow at an above average rate around the world for the next decade. It will be driven by pro-environmental regulations, as well as by a change in the ratio of on-shore to off-shore equipment installed. While off-shore wind turbines provide a higher yield on energy, the demands (salt water and winds, corrosion, etc.) on the materials (steel, resins, adhesives) used will increase. Here Evonik can provide special and tailor-made additives (e.g. AEROSIL®, Dynasylan® and Protectosil®) to make sure that the increased requirements will be met.

AEROSIL® R 202, AEROSIL® R 208 and AEROSIL® R 805 are very effective thixotropes for bonding pastes, laminating resins and gel coats for wind energy applications. Dynasylan® 1124, a secondary amino silane, and Dynasylan® 1146, an oligomeric amino silane, can be used successfully as adhesion promoters in bonding pastes for wind energy applications. Protectosil® BHN, Protectosil® CIT and Protectosil® DRY CIT are very efficient products to protect new and even already cracked concrete fundaments.

Evonik's silica and silanes products in wind energy applications

AEROSIL®, Dynasylan®

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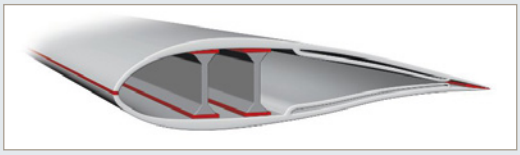


Dynasylan®

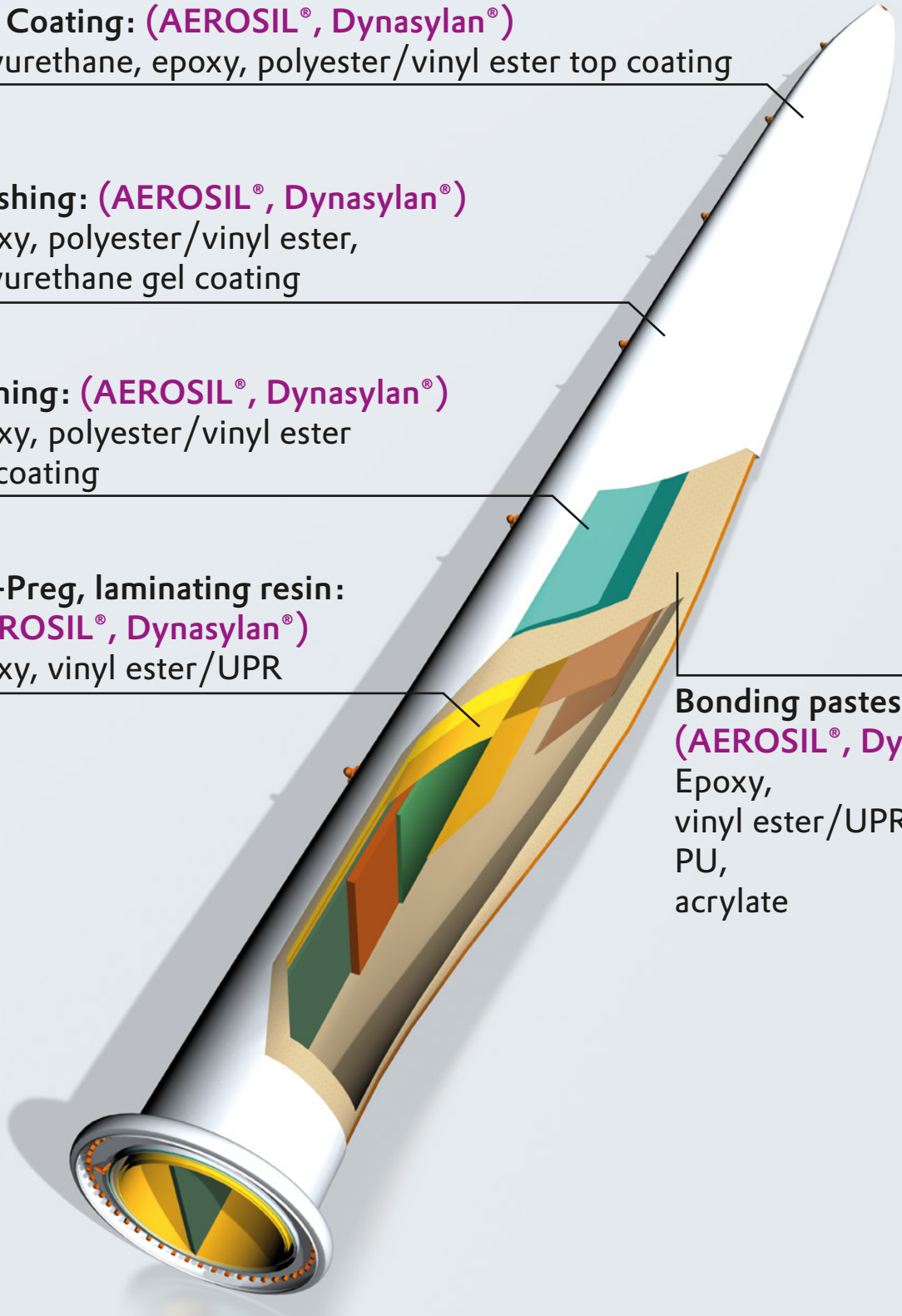
Protectosil®

Top Coating: (AEROSIL®, Dynasylan®)
Polyurethane, epoxy, polyester/vinyl ester top coating

Finishing: (AEROSIL®, Dynasylan®)
Epoxy, polyester/vinyl ester,
polyurethane gel coating

Priming: (AEROSIL®, Dynasylan®)
Epoxy, polyester/vinyl ester
gel coating

Pre-Preg, laminating resin:
(AEROSIL®, Dynasylan®)
Epoxy, vinyl ester/UPR



Bonding pastes:
(AEROSIL®, Dynasylan®)
Epoxy,
vinyl ester/UPR,
PU,
acrylate

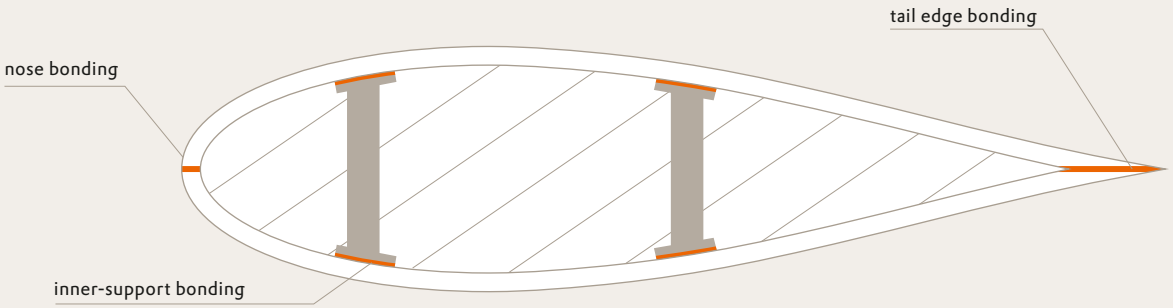
AEROSIL® and Dynasylan® for wind turbine bonding pastes

Large quantities of bonding pastes are used in the manufacturing of wind turbine rotor blades. The normal production procedure is to manufacture the upper and lower shell of the rotor blade shell in separate moulds and to glue them together by the bonding pastes. These bonding pastes must have good thixotropic und specific slump properties. That is why AEROSIL® fumed silicas are used as standard thixotropes in bonding pastes based on epoxy, polyurethane and vinyl ester resins. The hydrophobic fumed silicas AEROSIL® R 208 and AEROSIL® R 202 are high-performance thixotropes used in bonding pastes for the manufacturing of rotor blades.

Furthermore, bonding pastes must also have excellent fatigue properties. Structure-modified fumed silica grades like AEROSIL® R 7200, AEROSIL® R 8200 and AEROSIL® R 9200 can adjust bonding pastes with excellent reinforcing properties. Organo-functional silanes like Dynasylan® GLYMO, Dynasylan® AMMO, Dynasylan® 1124, and Dynasylan® 1146 act as an adhesion promoter in bonding pastes, and they can further improve the crosslinking density of suitable bonding pastes.

Products	Delivery Form	Characteristics	Applications
AEROSIL® R 208	White Powder	Hydrophobic fumed silica	The most efficient thixotrope for bonding pastes. Highly hydrophobic behaviour.
AEROSIL® R 202	White powder	Hydrophobic fumed silica	The thixotrope of choice for bonding pastes based on EP, PU, as well as VE resins for the bonding of rotor blades. Excellent storage stability.
AEROSIL® 200	White powder	Hydrophilic fumed silica	Thixotrope for bonding pastes based on unsaturated polyester and MMA resins, and for relatively non-polar amine hardeners for epoxy systems.
AEROSIL® R 7200 **AEROSIL® R 8200** **AEROSIL® R 9200**	White powder	Structure-modified hydrophobic fumed silica	Reinforcing agent with low thickening properties and excellent mechanical properties.
Dynasylan® AMMO	Liquid	Primary aminosilane	Conventional adhesion promoter – especially suitable for amine hardeners.
Dynasylan® 1124	Liquid	Secondary aminosilane	Adhesion promoter – especially suitable for amine hardeners for bonding pastes. High crosslinking potential.
Dynasylan® 1146	Liquid	Oligomeric aminosilane	Adhesion promoter – especially dedicated to 2K-PU and 2K-EP chemistries. Can also improve the crosslinking densities of bonding pastes and impart outstanding hydrophobicity. Innovative silane due to reduced VOC.
Dynasylan® GLYMO	Liquid	Epoxy silane	Adhesion promoter, can be formulated into the resin part.

Cross-section of a fiber-reinforced rotor blade



Offer for wind turbine bonding pastes

Please do not hesitate and contact us directly, if you would like to learn or discuss more about new, tailor made and innovative AEROSIL® and Dynasylan® products for windmill bonding pastes not described in this version of the brochure.

AEROSIL® R 208 –

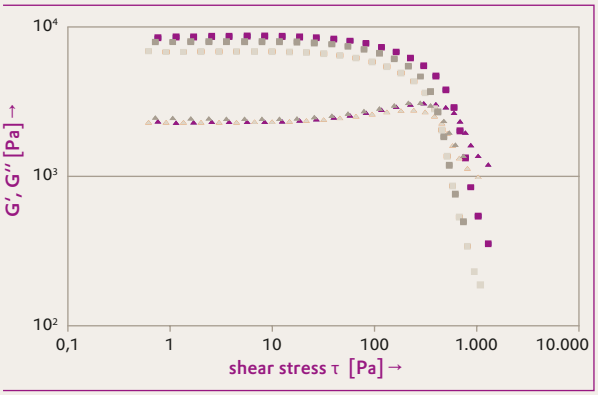
the fumed silica for 2K-epoxy, vinyl ester and 2K-polyurethane wind turbine bonding pastes

Highly hydrophobic AEROSIL® R 208 performs excellent in various bonding paste systems and offers additional value for growing market needs.

This is particular true for 2K-epoxy, 2K-polyurethane and vinyl ester systems. AEROSIL® R 208 provides an excellent thickening and thixotropic effect as well as flow limit as shown in the following examples for 2K-epoxy, vinyl ester systems and 2K-polyurethane formulations.

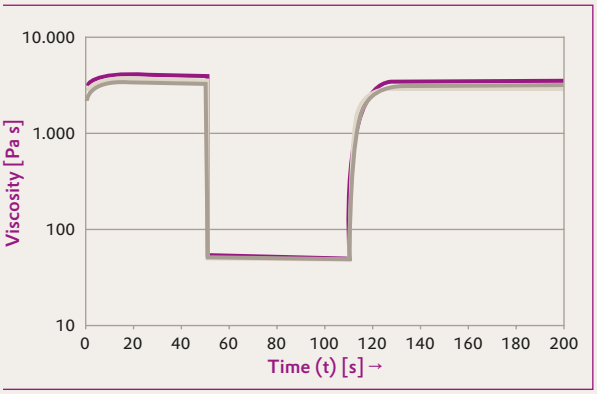
AEROSIL® R 208 in epoxy

flow point:
6% fumed silica in epoxy resin, 2 weeks @ RT



G'	G''	G' = storage modulus, G'' = loss modulus	
■	▲	AEROSIL® R 208	496 Pa
■	▲	Competitor A	379 Pa
■	▲	Competitor B	374 Pa

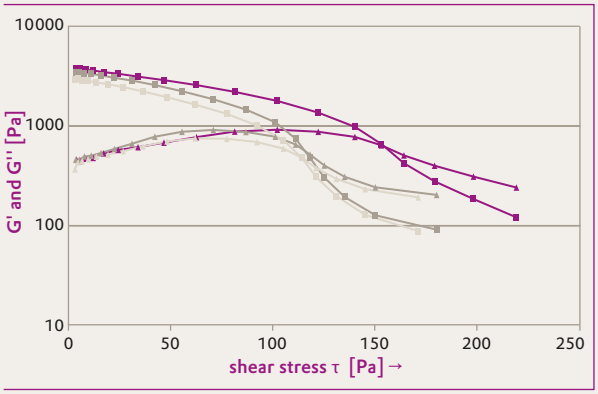
3-interval-time-test (structure recovery)
6% fumed silica in epoxy resin, 2 weeks @ RT



- AEROSIL® R 208
- Competitor A
- Competitor B

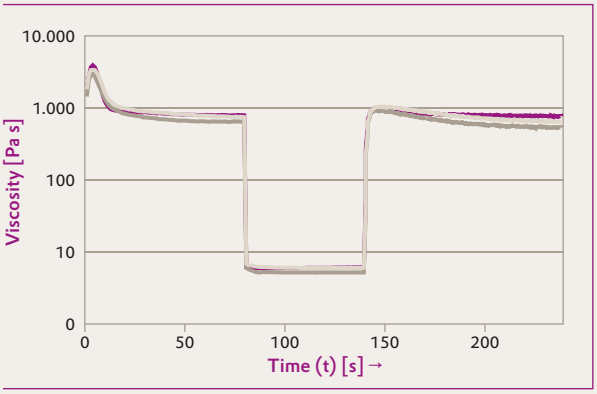
AEROSIL® R 208 in vinyl ester

flow point:
6% fumed silica in Atlac 430 (vinyl ester resin), after 4 weeks @ RT



G'	G''	G' = storage modulus, G'' = loss modulus	
■	▲	AEROSIL® R 208	154 Pa
■	▲	Competitor A	113 Pa
■	▲	Competitor B	115 Pa

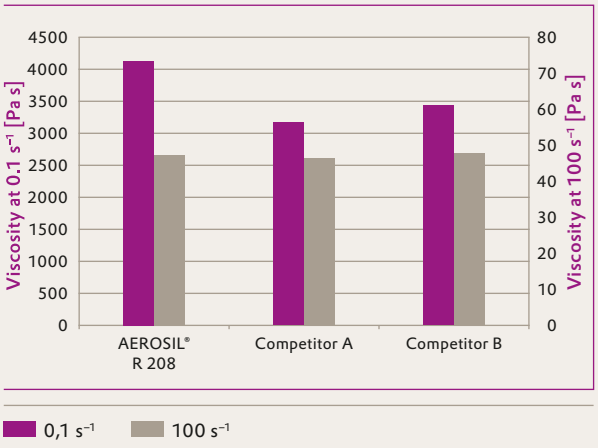
3-interval-time-test (structure recovery)
6% fumed silica in Atlac 430 (vinyl ester resin), after 4 weeks @ RT



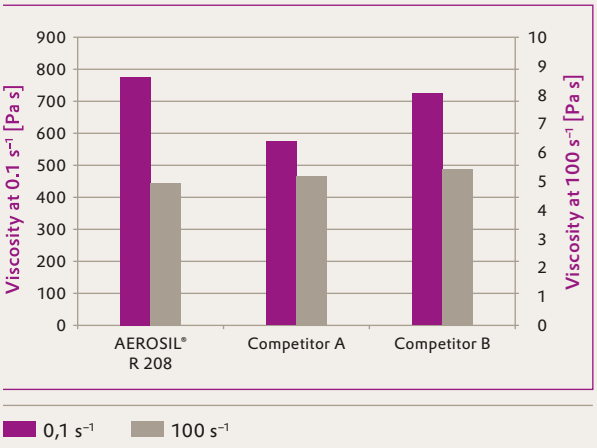
- AEROSIL® R 208
- Competitor A
- Competitor B

AEROSIL® R 208 in polyurethane

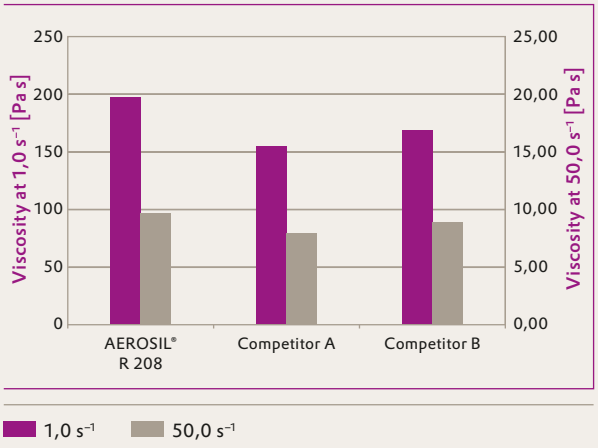
6% fumed silica in epoxy resin, 2 weeks @ RT



8% fumed silica in polyol, 4 weeks @ RT



6% fumed silica in Atlac 430 (vinyl ester resin), after 4 weeks @ RT



AEROSIL® for Gel Coats and Top Coats

Coatings on wind turbine blades for on-shore or off-shore wind turbines are exposed to extreme conditions. With increasing capacity (MW), wind turbine blades are getting longer. The high tip speed of the blades leads to the crucial need of very durable coating systems to withstand harsh environmentals over many years. Typical topcoats, completing the finish of the blade manufacturing, are based on polyurethanes, epoxy and unsaturated polyester resins. AEROSIL® 200 fumed silica is used as thickening agent and thixotrope for gel coats and top coats based on unsaturated polyester resins. For thickening polyurethanes, AEROSIL® R 812 S is recommended, in epoxy systems AEROSIL® R 805 improves rheology. Structure modified hydrophobic AEROSIL® R 9200 can improve the scratch resistance of coatings. AERODISP® 1030 is an easy to use dispersion based on AEROSIL® R 9200 (30 %) in methoxy-propyl acetate.

Products	Delivery Form	Characteristics	Applications
AEROSIL® 200	White powder	Hydrophilic fumed silica	Thixotrope for gel coats and top coats based on unsaturated polyester resin
AEROSIL® R 812 S	White powder	Hydrophobic fumed silica	Thixotrope for top coats based on polyurethanes
AEROSIL® R 805	White powder	Hydrophobic fumed silica	Thixotrope for top coats based on epoxy systems
AEROSIL® R 9200	White powder	Hydrophobic fumed silica	Structure modified hydrophobic silica for scratch resistant coatings
AERODISP® 1030	Dispersion in methoxy-propyl acetate	Hydrophobic fumed silica	Structure modified hydrophobic silica for scratch resistant coatings

Courtesy of LM wind power, lmwindpower.com

Dynasylan® for Glass Fiber

Glass fiber products, such as endless glass fibers, chopped strands, mats, rovings, yarns and milled glass fiber are used as reinforcing materials in thermoplastics and resins. Natural glass fiber shows poor adhesion to polymers, especially in the presence of moisture. For this reason, the glass surface is made organophilic by a sizing or finishing treatment. Our Dynasylan® products are essential components in sizing or finishing, which positively effect the following properties:

- transmission of glass fiber strength, to the polymer
- improvement of adhesion
- minimization of moisture sensitivity
- mechanical protection of glass fibers

Selecting the right organofunctional group of Dynasylan® silane is decisive for the bond to the polymer.

Products	Delivery Form	Characteristics	Applications
Dynasylan® AMEO	Liquid	Aminosilane	*, ** PA, PU, EP, Phenolic, Melamine
Dynasylan® GLYMO	Liquid	Epoxysilane	*, ** EP, PU, Phenolic, Melamine
Dynasylan® MEMO	Liquid	Methacrylsilane	*, ** UP, Acrylic,
Dynasylan® 2201 EQ	Liquid	Ureidosilane	PA, Phenolic
Dynasylan® 1189	Liquid	Sec. Aminosilane	PP, PA
Dynasylan® SIVO 214	Liquid	Proprietary aminosilane composition	PP, PA, Phenolic
Dynasylan® 1175	Liquid	Cationic aminosilane	PA, EP, Phenolic
Dynasylan® HYDROSIL 1151	Liquid	VOC free water borne silane system	PA, PU, EP, Phenolic

* Important component in glass fiber sizes
** adhesion promoter for (selection): PA = polyamide, PU = polyurethane, EP = epoxy resin, UP = unsaturated polyester, PP = polypropylene

Protectosil® to protect wind turbine fundaments

Due to the special design of wind turbines – a high tower usually built in an area of strong winds – the concrete fundaments of such constructions have to bear very high loads. Concrete will eventually crack under such conditions[1)] and cracking will lead to further deterioration due to e. g. corrosion of reinforcement, alkali-silica-reaction or freeze/thaw damage, thus posing a threat to the structural integrity and safety of the whole construction.

Protectosil® BHN, Protectosil® CIT and Protectosil® DRY CIT are very efficient products to protect new and even already cracked concrete. Protectosil® BHN, being a water repellent impregnation, as well as Protectosil® CIT and DRY CIT, stopping and protecting from corrosion, have been shown to successfully protect concrete for decades wherever they are applied. Calculations have shown that the cost for the repair of concrete structures can be cut by up to 98 % when using Protectosil® products.[2)] Of course, Protectosil® products are tested and controlled according to the latest building standards available, such as EN 1504-2.

1) F. Langer „Bauzustandsbetrachtungen an Betonfundamenten von Windenergieanlagen", Beton 05/2009, S. 186–192.
2) Ch. Haag „Der ökologische Break Even" in R. Baumann, F. Wittmann (Hrsg.), Technologie, Ökonomie und Ökologie, Herausforderungen an die moderne Bauchemie, Aedificatio Verlag Freiburg, 2002.

Products	Delivery Form	Characteristics	Applications
Protectosil® CIT	Colorless liquid	modified alkylsilane	ready-to-use impregnation to prevent and to stop chloride induced corrosion in steel reinforced concrete, to be applied on cured concrete surfaces
Protectosil® DRY CIT	White powder	polymer blend based on alkylsiloxane	corrosion protection system to be mixed into cementitious mixes, to prevent chloride induced corrosion of new concrete structures
Protectosil® BHN	Colorless liquid	monomeric alkylsilane	water repellent impregnation according to EN 1504-2 to prevent water uptake and uptake of water soluble aggressive pollutants, to be applied on cured concrete surfaces
Protectosil® 850	White powder	polymer blend based on alkylsiloxane	water repellent to be mixed into cementitious mixes, to prevent water uptake and uptake of water soluble aggressive pollutants, tested according to EN 934-2

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