

NANOSTRENGTH[®] E21

EPOXY APPLICATION

TECHNICAL DATA SHEET

Description:

Nanostrength[®] E21 is a PS-*bloc*-PB-*bloc*-PMMA copolymer. Nanostrength[®] E21 is particularly well suited when toughening is required while maintaining the thermal properties of thermoset systems. Nanostrength[®] E21 has been specifically designed to provide excellent properties in low polar and low Tg thermoset systems like Epoxy-polyetheramines or Epoxy DETA.

Typical dosages range from 2 to 15% for toughening. Nanostrength[®] is used at higher loadings (15-50%) to increase the viscosity of the formulation to allow for innovative automated solvent free processing of thermoset systems.

Key features:

Nanostrength[®] E21 has the following key characteristics

Property	Method	Unit	Typical value ⁽¹⁾
Aspect	Visual		White powder
Rubber content			Medium
Polarity			Low
EEW	ISO 3001	g/Eq	0
Viscosity at 10% in DGEBA LY556 at 80°C	Rheometer	mPa.s	1060
Thermal stability	TGA under N ₂	°C	> 300°C

⁽¹⁾ Data not intended for specification purposes

Benefits and applications:

Nanostrength[®] is a new family of self-assembling block copolymers. They are constituted of three blocks of linear chains covalently bonded to one another. The family currently consists in two categories: The SBM and the MAM series. SBM are constituted of polystyrene, 1,4-polybutadiene and syndiotactic poly(methyl methacrylate) whereas MAM are pure acrylic symmetric block copolymers constituted of a center block of poly(butyl acrylate) and two side blocks of poly(Methyl methacrylate). Due to repulsive interactions between adjacent polymer blocks, Nanostrength[®] self-organizes on the nanometer scale. When blended with a polymer compatible with one of their blocks, Nanostrength[®] disperses easily and imposes a structuration to the host matrix. This organization imparts unique combinations of properties, such as impact strength, high rigidity and transparency.

Thanks to its polybutadiene central block, the Nanostrength[®] E21 provides excellent crack resistance at very low temperature.

In low Tg systems like DGEBA-Jeffamine systems, Nanostrength[®] E21 increases the final Tg of the cured thermoset thanks to the high Tg of the PMMA block that stay miscible in the system until the end of the polymerization.

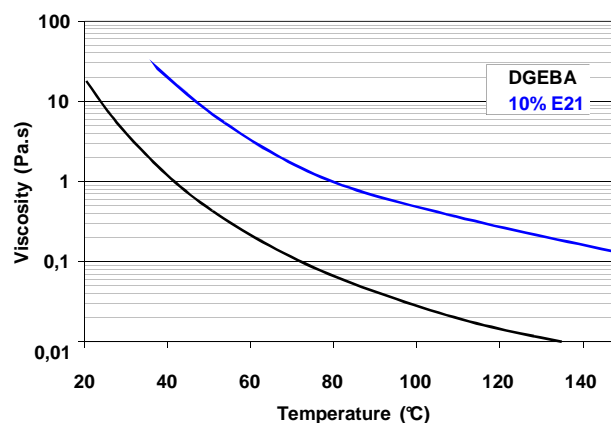
Thanks to its Polystyrene block, the Nanostrength[®] E21 has a low dielectric constant.

Typical properties:

Viscosity

Example of the temperature dependence of the viscosity* of an Epoxy/E21 90/10 mixture.

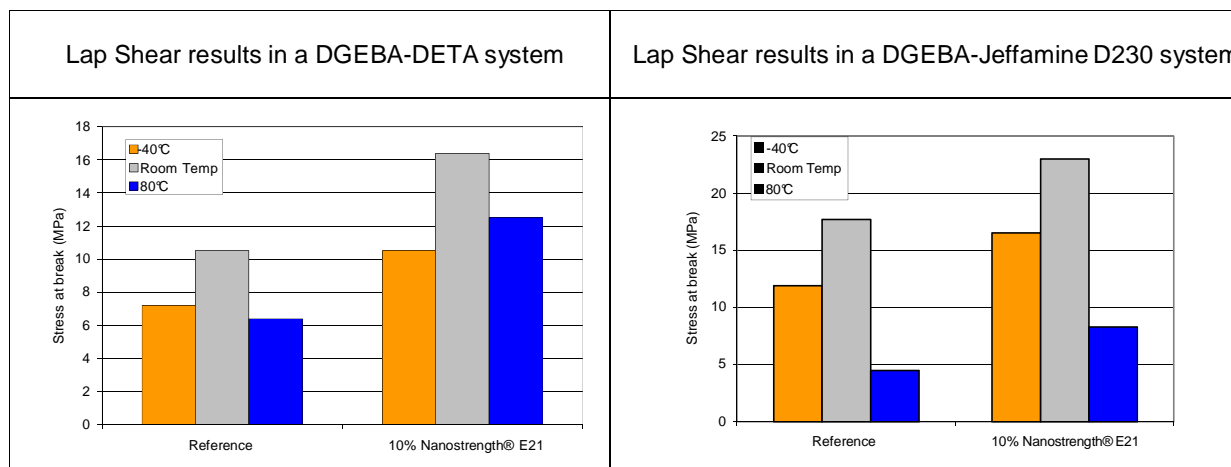
* The curve is intended solely for indicating potential performance that can be achieved with Nanostrength® E21 but it doesn't replace the reader's own evaluations and experimentation



Mechanical properties

Systems	K_{IC} (MPa.m ^{0.5})	G_{IC} (J.m ²)	T_g (°C)
DGEBA-Jeffamine	0.76	183	92
+ 10% E21	2.9	3940	97
DGEBA-Dicy	0.9	283	175
+10% E21	1.5	803	175
DGEBA-MDEA	0.74	258	170
+10% E21	0.93	-	176

Adhesives typical results



Dilution and processing:

For thermoset applications, Nanostrength[®] are offered in powder or microgranules forms. These can be dissolved in many epoxy precursors by heating/stirring process (typically between 130 and 170°C).

A typical dissolution procedure (e.g: LY556 (*Huntsman*) and 10% of Nanostrength[®]) is as follow:

- Thicken the epoxy at room temperature by gently stirring the Nanostrength[®] powder. This technique should avoid the agglomeration of the powder that can occur when it is added in the hot epoxy.
- Heat the mixture at the appropriated temperature (often in the 90 - 160°C range: see table 1) and continue slow stirring until complete dissolution. This step can be done under vacuum.
- When the Nanostrength[®] is dissolved, the temperature can be decrease (if necessary), and the hardener added.

In some system such as bis aniline (e.g: MDEA, MMPI...), it is advantageous to dissolve the Nanostrength[®] powder in the curing agent and then to add the epoxy precursor in the blend (before it recrystallizes).

Solubility:

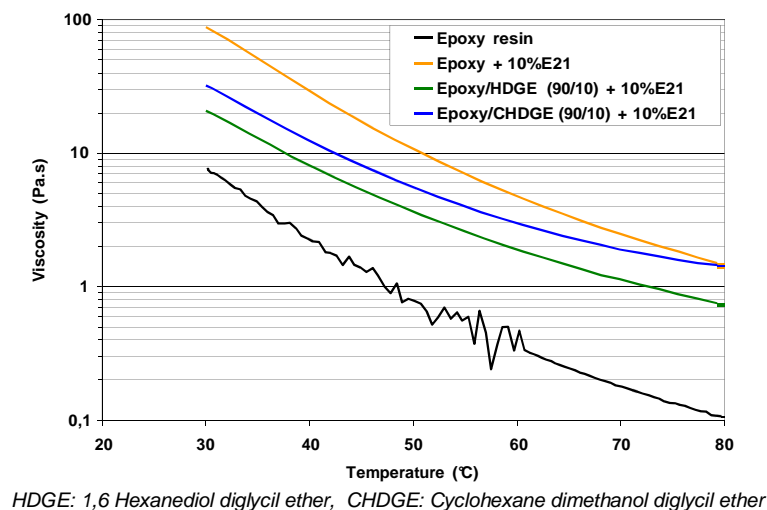
The best solubility occurs in liquid bisphenol A epoxy (DGEBA). When the molecular weight of the DGEBA is increased (type 1 to 9), the solubility of the Nanostrength[®] slightly decreases. The consequence is that the time to solubilize the Nanostrength[®] in a liquid/solid epoxy system can be slightly higher than in a pure low viscosity liquid epoxy.

Solvent based applications

Nanostrength[®] E21 is soluble in many common organic solvents (toluene, methyl ethyl ketone (MEEK), dimethylformamide (DMF), tetrahydrofuran (THF).

Reactive diluents

Reactive diluents are also excellent solvents for the Nanostrength[®] powder. Nanostrength[®] can be dissolved first in the reactive diluents or in the mixture of epoxy/reactive diluents. They allow a great decrease of the viscosity of the epoxy/Nanostrength[®] solution.



The addition of reactive diluents allows even better results. New compromise of toughness versus T_g are achievable.

Jeffamine based system

Epoxy/Reactive diluent		E21	Properties			
Type	Ratio	Loading	Viscosity at 40°C (mPa.s)	K _{IC} (MPa.m ^{0.5})	G _{IC} (J.m ²)	T _g (°C)
Epoxy	100/0	0	1 200	0.76	183	92
Epoxy	100/0	10%	30 000	2.76	3400	93
Epoxy/HDGE	95/5	10%	-	2.63	3900	91
Epoxy/HDGE	90/10	10%	7 900	2.9	4500	88

Bubbles formation/Degazing step:

To avoid bubbles formation, work at low shear rate rather than high shear rates. Because Nanostrength[®] are dissolved and not dispersed, a high shear is also not recommended.

A degazing step can be necessary in some case to remove some bubbles. For a better efficiency, the degazing step should be done at the highest possible temperature. The addition of anti-foaming agent can be recommended in some cases.

Packaging and Storage:

Nanostrength[®] E21 is available in powder (NP) and microgranules (MG) form, and provided in 20kg bags. Nanostrength[®] E21 should be stored in a dry place, protected from light. It should be stored below 70°C to avoid any alteration of the product.

If the bags have been opened for a long time, a drying of the Nanostrength[®] might be necessary. Typical conditions are one night at 60°C under vacuum.

Safety and Handling:

Please refer to the Safety Data Sheet

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