



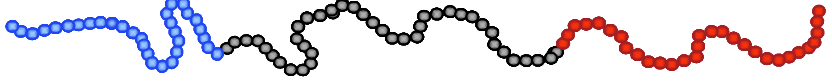
NANOSTRENGTH®

EPOXY APPLICATION

TECHNICAL DATA SHEET OF THE COMMERCIAL RANGE

Description:

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. 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). Because of repulsive interactions between the three blocks, Nanostrength® self-organize at the nanometer scale. Blended with a polymer compatible with one of their blocks, Nanostrength® disperse easily and impose a structuration to the host matrix. This organization imparts unique combinations of properties, such as impact strength, high rigidity and transparency.

| |
|--|
| Regular MAM Nanostrength |
|  |
| Poly[(Methyl)methacrylate] -b- poly(Butyl Acrylate) -b- poly[(Methyl)methacrylate] |
| Functionnal MAM Nanostrength |
|  |
| Poly[(Methyl)methacrylate-co-polar comonomer] -b- poly(Butyl Acrylate) -b- poly[(Methyl)methacrylate-co-polar comonomer] |
| Regular SBM Nanostrength |
|  |
| Poly(Styrene) -b- poly(Butadiene) -b- poly[(Methyl)methacrylate] |

Commercial Nanostrength® Grade :

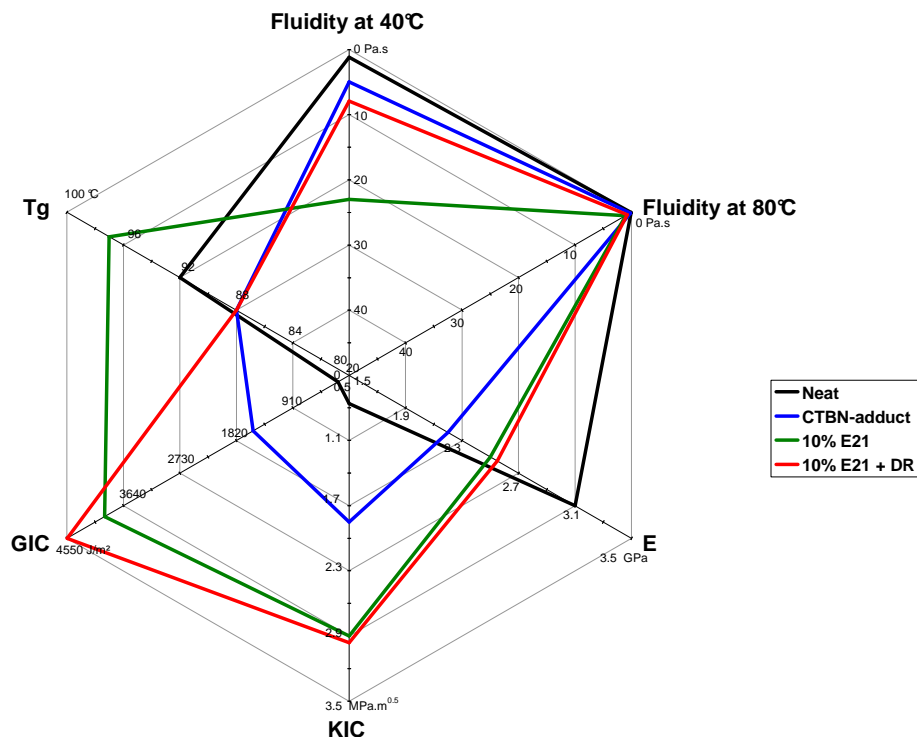
| Grade | Type | Molecular weight | Polarity | Soft phase content |
|---------|-----------------|------------------|----------|--------------------|
| E21/E20 | SBM | Low-Medium | Low | Medium |
| E41 | SBM | Low | Low | Low |
| M51 | MAM | Low | Standard | Medium |
| M52 | MAM | Medium | Standard | Medium |
| M53 | MAM | High | Standard | Medium |
| M22 | MAM | High | Standard | Low-Medium |
| M52N | Functionnal MAM | Medium | + | Medium |
| M22N | Functionnal MAM | Medium-High | ++ | Low-Medium |

Typical performance of Nanostrength® in epoxies

To illustrate the global performance of Nanostrength® in an epoxy system, one can analyze the effect of adding 10% of Nanostrength E21 in a DGEBA-Jeffamine T403 system.

Exceptional value of crack resistance propagation can be obtained while keeping or even increasing the final Tg of the cured system.

To overcome the viscosity penalty at 40°C, the use of reactive diluent (RD) is highly recommended. In addition to the reduction of the viscosity, it can be observed a great synergy on the crack resistance propagation.



The viscosity can sometimes be greatly increased in the case of hot melt process or extrusion process to allow a thermoplastic behavior of the liquid epoxy. This behavior is due to the unique nanostructuring of the Nanostrength® in the thermoset precursor.

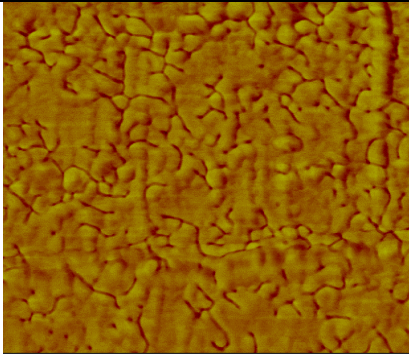

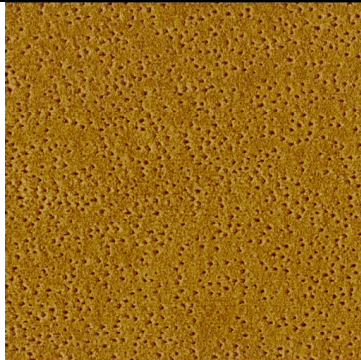
Formulation guide line

In order to fit with a high diversity of hardeners, a broad commercial range of Nanostrength® has been built. The following table help in choosing the right Nanostrength® for a defined system.

| Resin | Hardener | Recommended grades | |
|---------------|-------------------------|--------------------|-----------|
| | | Regular grades | N Grades |
| DGEBA | Aliphatic amine | E21 | |
| DGEBA | Jeffamine | E21-M53-M52 | |
| DGEBA | Dicy | | M52N |
| DGEBA | MDEA | E21-E41 | |
| DGEBA | DDS | | M52N-M22N |
| DGEBA | Anhydride | | M52N |
| TGDDM | MDEA | M52 | |
| Epoxy Novolac | Phenol Novolac | M51-E41 | |
| DGEBA | Thermal cationic curing | | M52N |

Nanostrength® additives can be mixed together or with other toughening agents to reach innovative combination of morphologies.

Morphologies

| DGEBA-Dicy +10% M52N | DGEBA-Jeffamine +10% M53 | DGEBA-DDS +10 % M52N |
|---|--|---|
|  |  |  |
| 0 2.00 µm | 0 10.0 µm | 0 2.00 µm |
| Translucent | Opaque | Transparent |

Processing guide line

For thermoset applications, Nanostrength® are offered in powder forms. The powders can be dissolved in many epoxy precursors by heating/stirring process (typically between 80 and 150°C).

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)

Reactive diluents are also excellent solvent for the Nanostrength® powder. Nanostrength® can be dissolved first in the reactive diluents or in the mixture of epoxy/reactive diluents.

Packaging and Storage:

Nanostrength® are provided in powder form in 20kg bags.

Nanostrength® powders should be stored in a dry place, protected from light. It should be stored below 70°C to avoid any alteration of the product.

Shelf life: As long as the storage conditions are reasonable the material will be fine for months or even years. In the case of hydrophilic grades (M22N and M52N), after a long storage time, one should check the water uptake and run a drying step if needed (several hours at 60°C under vacuum)

Contacts:

- www.nanostrength.com
- info.nanostrength@arkema.com

The information contained in this document is based on trials carried out by our Research Centers and data selected from the literature, but shall in no event be held to constitute or imply any warranty, undertaking, expressed or implied commitment from our part. Our formal specifications define the limit of our commitment. No liability whatsoever can be accepted by Arkema with regard to the handling, processing, or use of the product or products concerned - which must in all cases be employed in accordance with all relevant laws and/or regulations in force in the country or countries concerned.

The statements, technical information, and recommendations contained herein are believed to be accurate as of the date hereof. Since the conditions and methods of use of the product and of the information referred to herein are beyond our control, ARKEMA expressly disclaims any and all liability as to any results obtained or arising from any use of the product or reliance on such information; NO WARRANTY OF FITNESS FOR ANY PARTICULAR PURPOSE, WARRANTY OF MERCHANTABILITY OR ANY OTHER WARRANTY, EXPRESSED OR IMPLIED, IS MADE CONCERNING THE GOODS DESCRIBED OR THE INFORMATION PROVIDED HEREIN. The information provided herein relates only to the specific product designated and may not be applicable when such product is used in combination with other materials, or in any process. The user should thoroughly test any application before commercialization. Nothing contained herein constitutes a license to practice under any patent and it should not be construed as an inducement to infringe any patent and the user is advised to take appropriate steps to be sure that any proposed use of the product will not result in patent infringement. See MSDS for Health & Safety Considerations.