Lit. T-17 (03/05) Rheology Control of Epoxy Formulations

General Description:

Nanomer® nanoclays are modified montmorillonite minerals capable of fully dispersing in thermoplastics and thermosets to form a new class of materials commonly known as nanocomposites. In thermosets, such as epoxy formulations, nanocomposites are characterized by enhanced strength and improved thermal properties, especially glass transition temperature (Tg). Epoxies are also benefited by improved chemical and scratch resistance. For more information see Tech Data Sheets T-10, T-11 and T-12.

Due to their extremely small dispersed particle size, Nanomer nanoclays interact with epoxy resin molecules prior to curing. The interaction creates a thixotropic system with shear thinning behavior similar to rheology control agents such as fumed silica. Although experience has shown that Nanomer nanoclays provide rheology control across a range of epoxy monomers and prepolymers, only EPON 828 (bisphenol A) and Nanomer I.28E have been studied systematically. This Tech Data publication presents the findings in condensed form. The full study is available upon request.

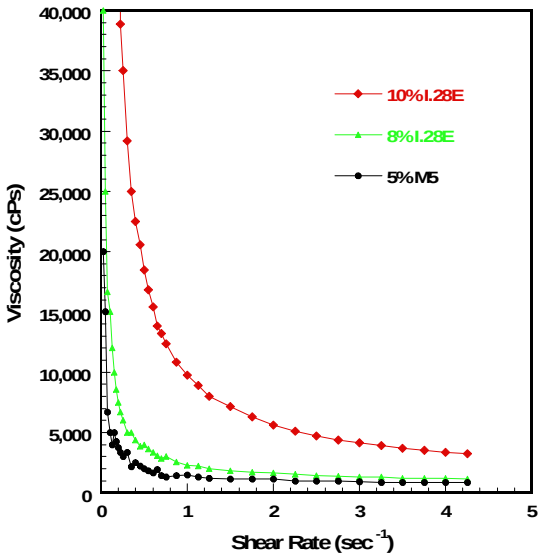
Fumed Silica Benchmark:

The performance of I.28E was benchmarked against CAB-O-SIL® grade M5, a non-surface treated fumed silica used extensively for epoxy formulations. M-5's addition levels generally range from 3-5% based on epoxy resin weight. An addition level of 5% wt/wt M5 was used for benchmarking. To achieve good nanocomposite reinforcement Nanomer I.28E nanoclay addition levels range from 8-10% based on epoxy resin weight. These levels were used for comparisons.

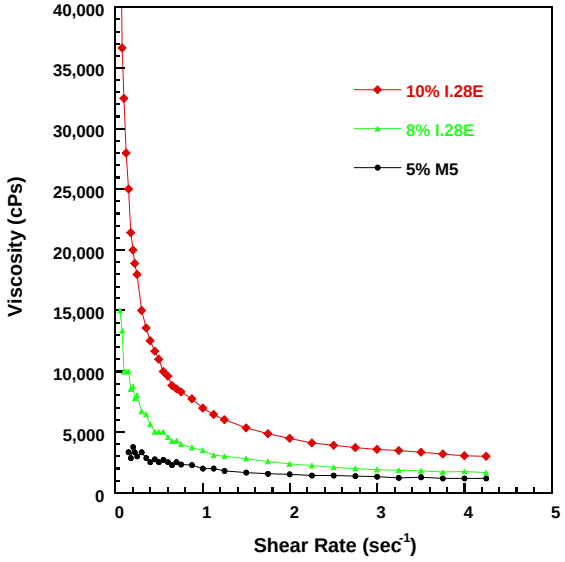
Shear Thinning:

Graphs 1 and 2 present shear thinning results for EPON 828 systems measured immediately upon mixing and aged 30 days. Shear thinning behavior is similar for both M5 and I.28E if measured soon after mixing. After aging, M5 looses most of its shear thinning ability while most of I.28E's thinning power remains.

Graph 1
Shear Thinning after Mixing at 60^{0}C



Graph 2
Shear Thinning after Aging at 60^{0}C



Nanocor®
Nanocor, Inc. 2870 Forbs Avenue, Hoffman Estates, IL 60192
847.851.1918, 800.426.5564, Fax: 847.851.1375, www.nanocor.com

Lit. T-17 (03/05) Rheology Control of Epoxy Formulations

Index[2]

Another measure is the Shear Thinning Index (STI), which is the ratio of the viscosity at 1 rpm shear to the viscosity at 10 rpm. Table A provides STI data. The STI for 8% I.28E is generally double M5.

TABLE A
Viscosity Values[1] (cPs) & Shear Thinning

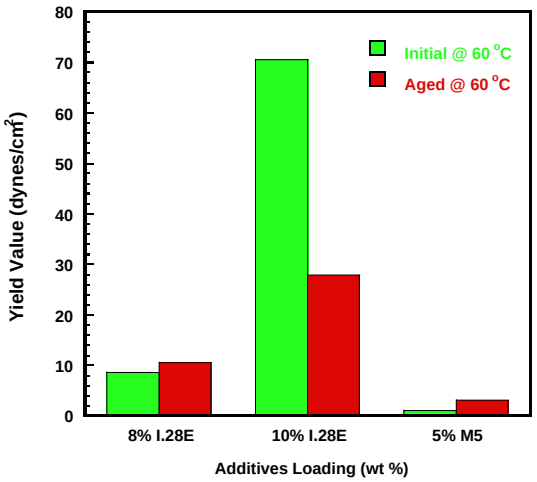
Additives	I.28E M5	8% 0%	10% 0%	0% 5%
Initial @ 60 °C	1 rpm	6,000	35,000	2,000
	10 rpm	1,400	4,700	1,000
	STI	4.29	7.45	2.00
Aged @ 60 °C	1 rpm	8,000	18,000	3,000
	10 rpm	2,100	3,900	1,400
	STI	3.81	4.62	2.14

1. **RV, Brookfield DV-III Rheometer, spindle SC4-29**
2. **STI = Viscosity at 1 rpm divided by viscosity at 10 rpm**

Yield Values:

Yield value provides a good indication of anti-settling and coating spreadability. Graph 3 shows that I.28E produces superior yield values.

GRAPH 3
Yield Value at 60°C



Nanocor®
Nanocor, Inc. 2870 Forbs Avenue, Hoffman Estates, IL 60192
847.851.1918, 800.426.5564, Fax: 847.851.1375, www.nanocor.com

Rheology Control of Epoxy Formulations

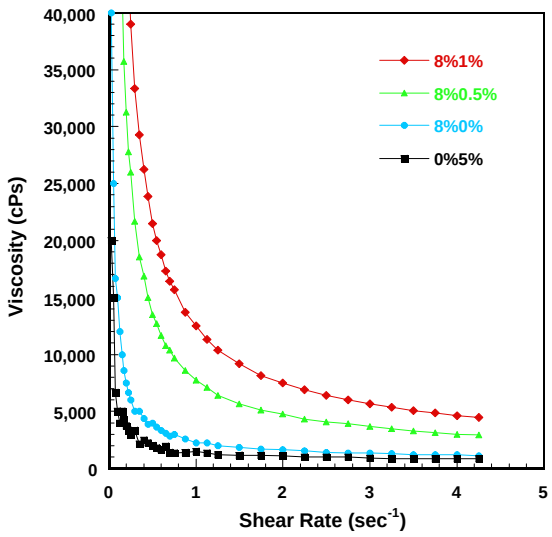
Sag Resistance:

Both I.28E and M5 have comparable sag resistance after aging.

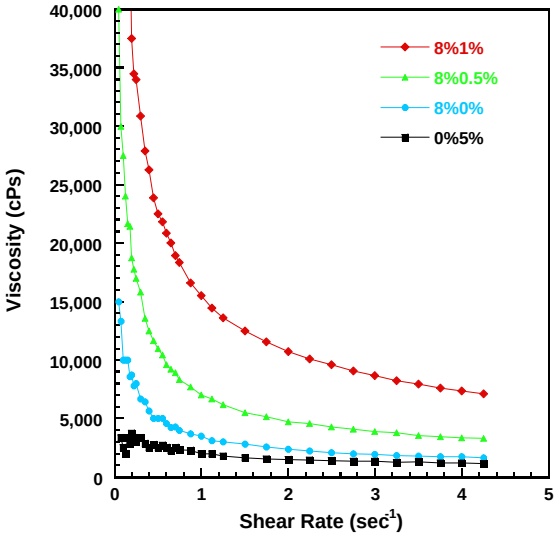
Synergism:

Because Nanomer nanoclays and fumed silicas create rheology by different mechanisms, they can be combined to create synergistic systems. Small amounts of M5 added to I.28E nanocomposite formulations promote further significant increases in system viscosity, shear thinning, STI and yield value. The graphs and charts below compare a combination system of 8% I.28E and just 0.5 - 1.0% M5.

GRAPH 4
Shear Thinning of Combinations Combinations After Mixing at 60^{0}C



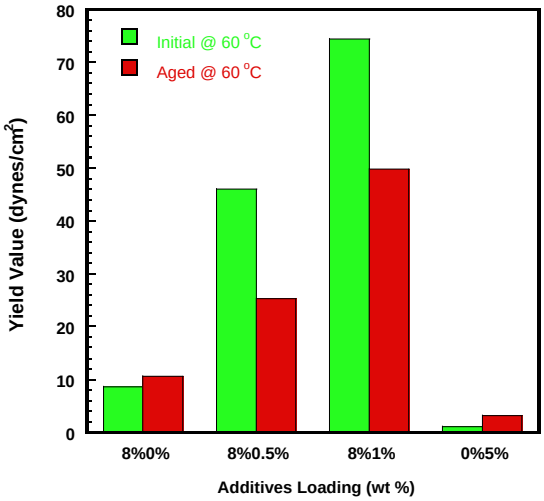
GRAPH 5
Shear Thinning of After Aging at 60^{0}C



Nanocor, Inc. 2870 Forbs Avenue, Hoffman Estates, IL 60192
847.851.1918, 800.426.5564, Fax: 847.851.1375, www.nanocor.com

T-17 (08/00) Rheology Control of Epoxy Formulations

GRAPH 6
Yield Value of Combinations



Viscosity Values[1] (cPs) and Shear Thinning Index[2] of Combinations

Additives	I.28E M5	8% 0%	8% 0.5%	8% 1%	0% 5%
Initial @ 60 °C	1 rpm	6,000	26,000	39,000	2,000
	10 rpm	1,400	4,100	6,400	1,000
	STI	4.29	6.34	6.09	2.00
Aged @ 60 °C	1 rpm	8,000	17,000	34,000	3,000
	10 rpm	2,100	4,300	9,600	1,400
	STI	3.81	3.95	3.54	2.14

1. **RV, Brookfield DV-III Rheometer, spindle SC4-29**
2. **STI = Viscosity at 1 rpm divided by viscosity at 10 rpm**

Summary:

Epoxy nanocomposites made with Nanomer I.28E nanoclays do not require additional rheology control additives. In addition to the reinforcing, thermal, barrier improvements characteristic of epoxy nanocomposites, the formulations can be simplified by removal of rheology control agents such as fumed silica.

As an alternative, combinations of Nanomer nanoclays and small amounts of fumed silica will create superior rheology control systems at lower cost.

CAB-O-SIL® is a registered trademark of Cabot Corporation

For more information on how Nanomer® nanoclays can work for you, contact Nanocor's Technical Service Group.

Nanocor, Inc. 2870 Forbs Avenue, Hoffman Estates, IL 60192
847.851.1918, 800.426.5564, Fax: 847.851.1375, www.nanocor.com