Environmental Impact of Using Suprmix® Versus Liquid

The cycle time advantages of utilizing Suprmix® powder liquid dispersions with two-roll mill mixing is well known in the rubber mixing industry. This technical report is an analysis of the cost savings associated with Banbury mixing. Liquids such as plasticizers, process aids, tackifiers, co-agents and other additives are thought to disperse into rubber compounds faster and more efficiently when they are added in a powder form. The effects of utilizing Suprmix® forms of liquid plasticizers were compared to the effects of adding the same active ingredient in a liquid form. Significant improvements were noted in both mix cycle times and energy consumption.

Suprmix® dispersions are liquids that are typically dispersed on amorphous silica or calcium silicate powder carriers. The powders are low-dust, free-flowing mixtures that contain between 50 and 80 percent active ingredient. Most typically, the Suprmix® dispersions contain 72 percent liquid. The liquids may be solid at room temperature but are melted for dispersing on the carrier powder. Some typical active ingredients are ester plasticizers, coumarone indene resin, epoxy resins, waxes, petrolatum, liquid polymers, anti-oxidants, peptizers, co-agents, process oils and adhesion promoters. Some of the above materials are extremely viscous liquid solids at room temperature. The Suprmix® dispersions are used to improve handling, improve batch-to-batch consistency, reduce employee exposure, limit spill potential, improve batch incorporation, reduce equipment clean out and reduce packaging and residual chemical disposal. Suprmix® dispersions used in low-melt pre-weighs further improve handling, efficiency and quality.

From a previous laboratory study,[1] a compound utilizing 30 parts of liquid dioctylphthalate (DOP) was compared to the same recipe utilizing the Suprmix® version. The compound made utilizing the liquid plasticizer required a cycle time of 10 minutes, while the cycle time for the compound utilizing the Suprmix® was reduced to seven minutes in a Haake Rheomix 600 mixer.

TABLE 1

	DOP	**Suprmix® DOP**
Plasticizer level, PHR	30	30
<u>Rheomix 600, 77 rpm, 93 C</u>		
Maximum Torque, m·g	2080	2400
Compound Temperature, °C	108	111
Maximum Energy, KJ	64	46
Dispersion Time, mins.	10.0	7.0

Table 1 data indicates an approximate 30 percent improvement in cycle time by utilizing the Suprmix® powder versus the liquid. In addition, the maximum energy was reduced by approximately 28 percent. These are significant gains in a laboratory setting. Would similar results be realized in an actual production environment?

Production runs were scheduled, but due to the proprietary nature of the compounder and the end use of the compounds, we were restricted from analyzing the physical properties of compounds. However, similar formulations were produced to analyze the difference in performance characteristics between compounds that included the Suprmix® versus compounds produced with the neat liquid. The physical properties and formulations are listed below. We believe the below to be a typical example of performance characteristics.

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Suprmix® Performance Data		
The following compound performance data provides a comparison of Suprmix® versus the neat liquid version of Plasthall® dibutoxyethoxyethyladipate (DBEEA). The data shows that the Suprmix® version of the ingredient results in very little change in the overall rubber compound performance.		
Recipe Variable	**Suprmix® Plasthall® DBEEA**	**Neat Liquid Plasthall® DBEEA**
Processing Properties		
Viscosity and Curing Properties Mooney Viscosity at 121°C (250°F)		
Minimum Viscosity	67.2	82.4
t5, min	1.3	0.83
t35, min	2.5	1.4
Oscillating Disc Rheometer at 170°C (338°F)		
t'c (90), min	2	2.3
Original Physical Properties		
Stress at 300% Elongation, Mpa	10.2	9.8
Tensile Ultimate, Map	15.6	15.5
Psi	2265	2250
Elongation at Break, %	575	515
Hardness Duro A, pts.	65	61
Specific Gravity	1.233	1.215
Brittle Point, as molded, °C	-35	-35
Air Oven Aging, 70 h at 125°C (257°F)		
Elongation Change, %	-31	-37
Weight Change, %	-2.5	-3
ASTM 1 Oil, 70 h at 125°C		
Elongation Change, %	-43	-39
Weight Change, %	-9.3	-9.4
IRM 903 Oil, 70 h at 125°C		
Elongation Change, %	-60	-62
Volume Change, %	-3	-4
Distilled Water, 70 h at 100°C		
Elongation Change, %	-21	-38
Volume Change, %	4	4

The recipe for compound testing follows.
All testing was done in accordance with standard ASTM procedures.

	PHR	PHR
Krynac 34E50	100	100
Kadox® 920	5	5
Agerite Resin D	1	1
Stearic Acid	1	1
N660	65	65
Plasthall® 226 DBEEA	0	20
Suprmix® Plasthall® 226 DBEEA	27.8	0
Sulfur	0.4	0.4
Altax	2	2
Methylzimate	1.5	1.5
	203.7	195.9

With performance characteristics confirmed, the next step was the mix cycle time and energy consumption comparison between Suprmix® and compounds utilizing the neat liquid plasticizer. Four test formulations were prepared in an intermeshing internal mixer. Three (3) batches of each formulation were mixed. Formula 1, which contained the liquid dioctylterephthalate (DOTP) plasticizer, was compared to an identical formula 2, which contained the Suprmix® version of the same ester plasticizer. The rotor speed of the mixer remained constant for the six batches. The mix was completed based upon obtaining a target temperature. Once the target temperature was met, the mixing was concluded. Mix cycle times were recorded. Motor load data was recorded once per second during the mix cycle. Summary data is shown in Table 3.

TABLE 2

DOTP Formulations, parts	1	2
NBR	100	100
Carbon Black	75	75
Hard Clay	80	80
Silica	11.6	0
DOTP	30	
Suprmix® DOTP		41.6
	296.6	296.6

Comparison of formula 1 and formula 2 (Table 3) indicated an average mix cycle time reduction of 3.9 percent and power reduction of 4.2 percent.

TABLE 3

Formula	Mix Time, s	kWh
1 – liquid	291.3	35.3
2 – Suprmix®	280.0	33.8
Δ	11.3	1.5
Δ %	3.9%	4.2%

Formulas 3 and 4 were mixed and compared as well. The formulation information is shown in Table 4. Mix parameters were held constant and the mix concluded at a set target temperature. Cycle time and power data is shown in Table 5. There was a 27 percent improvement in mix cycle time and a 16.2 percent reduction in energy consumption.

TABLE 4

DBEEA compound, parts	3	4
NBR/PVC (70/30)	142.8	142.8
Carbon Black	35	35
Silica	21.8	0
Hard Clay	85	85
DBEEA	56	
Suprmix® DBEEA		77.8
	340.6	340.6

TABLE 5

Formula		Mix Time, s	KWh
3 – liquid		323.7	17.2
4 – powder		236.3	14.4
	Δ	87.3	2.8
	Δ %	27.0%	16.2%

It is evident that Suprmix® versions of liquid rubber additives show significant improvement in mix cycle times and in total power consumption. The U.S. Department of Energy estimates that coal power plants generate approximately 2.1 lbs. of carbon dioxide (CO_2) per kilowatt hour (kWh). Estimating a reduction of 2.15 kWh per batch based on the mix data from above, a rubber mixing facility that produces 40,000 batches per year would save 86,000 kWh, which would translate to a reduction of approximately 180,600 lbs. of carbon dioxide. For U.S manufacturers paying $0.14/kwh and assuming the example above, the savings would be $12,000 per year. For an EU manufacturer, the savings would be approximately $32,000 per year. In March of 2007, the European Council approved proposals that include the reduction of greenhouse gas emissions by 20 percent by 2020 and reducing carbon emissions from primary sources by 50 percent by 2050 versus 1990 levels. Organizations that reduce their carbon footprint will have a competitive advantage in the future. Incorporating liquids by utilizing Suprmix® powders is a simple way to reduce energy costs, improve mix cycle times and reduce an organization's carbon footprint.

References

1. O'Rourke, Stephen, "Improved Processing and Batch Time Reduction through Powder Liquid Dispersions", Hallstar (2008).