Low Profile Additive

For Unsaturated Polyester Resin

MODIPER® S series

NOF CORPORATION

1 Introduction

For Sheet Molding Compound (SMC)/Bulk Molding Compound (BMC) molding process, Low Profile Additives (LPAs) are key materials to obtain Fiber Reinforced Plastics (FRP) products having excellent properties such as surface quality, dimensional stability, pigmentability and mechanical strength without cracking during cure.

Several conventional thermoplastics such as Poly vinyl acetate(PVAc), Polymethyl methacrylate(PMMA), Polystyrene (PS) and styrene/butadiene/styrene copolymer(SBS) have been used as LPAs. However, these LPAs have advantages and disadvantages and none of them satisfy all properties. Especially it is well known that good shrinkage control and good pigmentability conflict with each other.

Features of SMC/BMC molding parts using several LPAs are summarized in Table1.

Table1. Features of SMC/BMC molding parts using several LPAs

LPAs Abbreviation	Dimensional Stability	Surface Quality	Mechanical Property	Pigmentability		Hot water Resistance
				Hazing	Mottling	
MODIPER® S	Good	Good	Good	Good	Good	Good
PVAc	Excellent	Excellent	Poor	Poor	Poor	Poor
PMMA	Good	Poor	Good	Good	Good	Good
PS	Poor	Poor	Good	Good	Poor	Good
SBS	Good	Poor	Good	Excellent	Poor	Good

Table1 shows that PVAc gives molding parts having excellent dimension stability, but lacks pigmentability, mechanical property, mechanical property and hot water resistance. On the other hand, molding parts containing PS and SBS have good pigmentability

Since MODIPER® S series are block copolymer basically consists of PS and PVAc segment using special organic peroxides (see Figure 1), SMC/BMC molding parts using MODIPER® S series have an excellent balance of all properties.

Figure 1 Schematic diagram of MODIPER® S

2 Grade of MODIPER® S series

■General Information

General information of MODIPER® S series classified into grades are listed in Table2.

Table2. Grade of MODIPER® S series and typical properties

MODIPER®	Composition [1)]	Viscosity [2)] (Pa・s) at 25℃	CAS-No.	Features
SV10B	PVAc-b-PS(10/90)	1.8	79509-24-3	Standard Grade
SV10A	PVAc-b-aPS(10/90)	3.8	84888-24-4	Containing acid groups Low mottling
SV30B	PVAc-b-PS(30/70)	2.3	79509-24-3	Standard Grade
S501	mPVAc-b-PS(50/50)	4.5	110037-75-7	Standard Grade

1) aPS: acid denaturized polystyrene, mPVAc: modified poly vinyl acetate

2) Dispersion in 70%styrene(30% solid content)

■ Recommended molding process and application using MODIPER® S series

Recommended molding process and application using MODIPER® S series classified into grades are listed in Table 3.

Table3. Recommended molding process and application using MODIPER® S series

MODIPER®	Hot press molding				Room temperature molding	
	Molding process	Application			Molding process	Application
	SMC/BMC	Automobile parts	Electrical parts	Household appliances	Casting	Resin concrete
SV10B	○		○	○		
SV10A	○		○	○		
SV30B	○		○	○		
S501	○	○	○	○	○	○

3 Typical properties of SMC/BMC molding parts using MODIPER® S series

■ Class A SMC application

Formulation

Table4. Class A SMC formulation

Components	Formulas (wt% in total SMC formulation)
Unsaturated polyester (Maleic anhydride / Propylene glycol)	16
LPA (30wt% in styrene)	13
tert-Butyl peroxybenzoate(TBPB)	0.4
p-Benzoquinone (PBQ)	0.1
Zinc Stearate	1.2
Magnesium Oxide	0.4
Calcium Carbonate	59
Fiberglass (1/4-inch, chopped)	10

Curing conditions

All ingredients were mixed together to form SMC and thickened for 24 hours at 40 ˚C before molding. Then they were molded at 152 ˚C (lower mold) / 146 ˚C (upper mold) for 3 minutes under a pressure of 10 MPa. A mold having 100 mm diameter and 5 mm depth was used to measure dimensional changes on curing, and another 150 mm × 100 mm × 4 mm mold, with a class A surface finish, was used to assess surface quality and prepare specimens for mechanical testing.

Typical properties of Class A SMC molding parts using MODIPER® S series

Table5. Typical properties of Class A SMC molding parts using MODIPER® S series

LPA	Cure analysis [1]		Shrinkage control (%) [2]	Mechanical properties [3]		Surface quality	
	GT	CT		Flexural strength	Flexural modulus	Average roughness [4]	Gloss [5]
	(CP3,sec)	(CP4,sec)		(MPa)	(GPa)	(μm)	(%)
SV10B	41	107	0.00	74	10.1	0.11	86
SV10A	44	103	-0.33	68	10.2	0.12	85
SV30B	42	105	-0.11	86	9.9	0.08	90
S501	43	108	-0.03	71	9.5	0.14	81
PS	42	102	0.05	84	10.7	0.48	69
SBS	46	102	-0.05	81	9.0	0.35	47
PVAc	47	117	-0.09	64	7.9	0.06	95

1) Measured by Micromet Cure Analyzer (ICAM 2000)

2) According to Japan Industrial Standard Method (JIS K6901): - sign indicates expansion

3) According to Japan Industrial Standard Method (JIS K7705)

4) According to Japan Industrial Standard Method (JIS B0610)

5) According to Japan Industrial Standard Method (JIS K7105)

■ Deep colored SMC/BMC application

Formulation

Table6. Deep colored SMC/BMC formulation

Components	Formulas(wt% in total SMC formulation)
Unsaturated polyester (Maleic anhydride / Propylene glycol)	25
LPA (30wt% in styrene)	11
tert-Butyl peroxybenzoate(TBPB)	0.4
Carbon Black Dispersion(50wt% in styrene)	1.8
p-Benzoquinone (PBQ)	0.02
Zinc Stearate	1.8
Magnesium Oxide	0.4
Calcium Carbonate	50
Fiberglass (1/4-inch, chopped)	10

Curing conditions

All ingredients were mixed together to form SMC/BMC and thickened for 24 hours at 40 ˚C before molding. Then they were molded at 145 ˚C (lower mold) / 130 ˚C (upper mold) for 4 minutes under a pressure of 10 MPa.

A mold having 100 mm diameter and 5 mm depth was used to measure dimensional changes on curing, and another 150 mm × 100 mm × 4 mm mold, with a class A surface finish, was used to assess surface quality and prepare specimens for mechanical testing.

Typical properties of deep colored SMC/BMC molding parts using MODIPER® S series

Table7.Typical properties of deep colored SMC/BMC molding parts using MODIPER® S series

LPA	Shrinkage control (%) [1]	Pigmentability		Surface quality
		L-values [2]	σ⊿E [3]	Gloss(%) [4]
None	0.50	12	0.6	47
SV10B	0.25	24	1.4	63
SV10A	0.24	22	0.7	75
SV30B	0.24	28	0.8	66
S501	0.22	30	0.9	73
PS	0.29	18	1.8	59
SBS	0.26	15	1.5	61
PVAc	0.09	39	1.7	86

1) According to Japan Industrial Standard Method (JIS K6901): - sign indicates expansion

2) Mean of ten L-values are measured by color difference meter implied hazing

3) Standard deviation of ten color difference value are measured by color difference meter implied mottling

4) According to Japan Industrial Standard Method (JIS K7105)

■ Combination MODIPER® S series and PS

Formulation

Table8. Deep colored SMC/BMC formulation

Components	Formulas(wt% in total SMC formulation)
Unsaturated polyester (Maleic anhydride / Propylene glycol)	25
LPA (30wt% in styrene)	11
tert-Butyl peroxybenzoate(TBPB)	0.4
Carbon Black Dispersion(50wt% in styrene)	1.8
p-Benzoquinone (PBQ)	0.02
Zinc Stearate	1.8
Magnesium Oxide	0.4
Calcium Carbonate	50
Fiberglass (1/4-inch, chopped)	10

Curing conditions

All ingredients were mixed together to form SMC/BMC and thickened for 24 hours at 40 ˚C before molding. Then they were molded at 145 ˚C (lower mold) / 130 ˚C (upper mold) for 4 minutes under a pressure of 10 MPa.

A mold having 100 mm diameter and 5 mm depth was used to measure dimensional changes on curing, and another 150 mm × 100 mm × 4 mm mold, with a class A surface finish, was used to assess surface quality and prepare specimens for mechanical testing.

Typical properties of deep colored SMC/BMC molding parts

Table9. Typical properties of deep colored SMC/BMC molding parts

LPA		Shrinkage control (%) [1)]	Pigmentability		Surface quality
			L-values [2)]	σ⊿E [3)]	Gloss(%) [4)]
None		0.50	12	0.6	47
SV10B		0.25	24	1.4	63
SV10A		0.24	22	0.7	75
S501/PS	100/0	0.22	30	0.9	73
	20/80	0.24	22	1.8	73
	10/90	0.27	20	0.8	68
	0/100	0.29	18	1.3	59

1) According to Japan Industrial Standard Method (JIS K6901): - sign indicates expansion

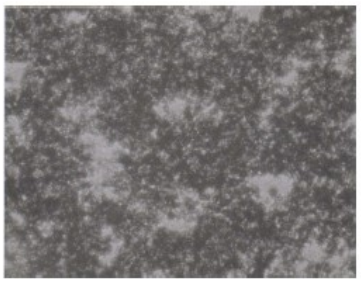
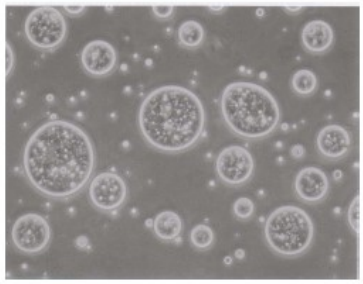
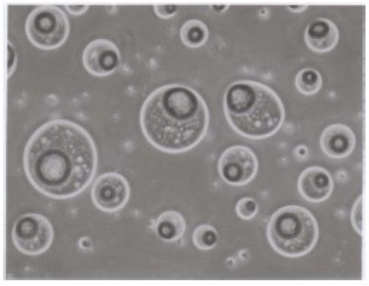
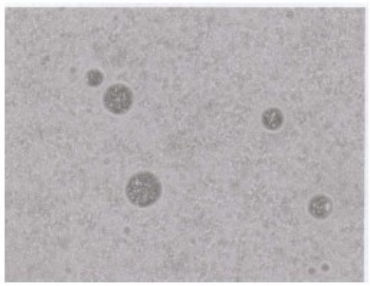
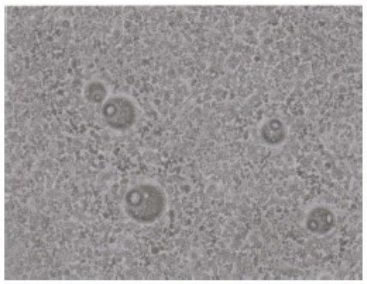
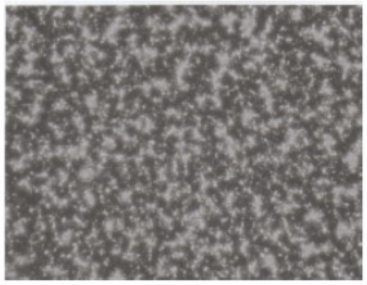
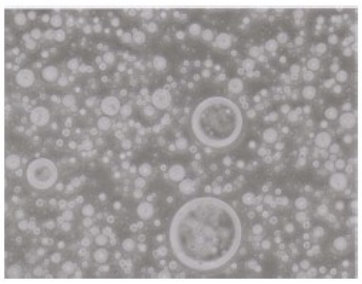
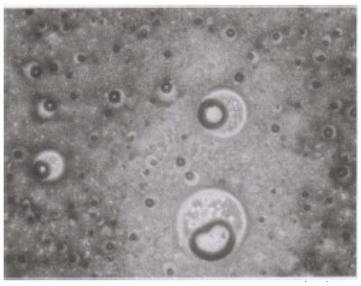
2) Mean of ten L-values are measured by color difference meter implied hazing

3) Standard deviation of ten color difference value are measured by color difference meterImplied mottling

4) According to Japan Industrial Standard Method (JIS K7105)

4 Appendix

Optical microscope of uncured and cured unsaturated polyester Resin with several LPAs.

LPA	Uncured	Cured
PVAc		
PS		
MODIPER® SV10B		
MODIPER® S501		
Mixture of PS/PVAc (50/50)		

50µm

5 Package

- 20kg in paper bag

6 Contact

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