APPLICATION BULLETIN

UL94 V-O rated formulation based on Poly BD® Resin

Poly BD® resin-based polyurethane products usually do not qualify for V-0 rating in UL-94 flammability test with or without plasticizers. To obtain UL94 V-0 rating, it was deemed necessary to incorporate flame retardants in the formulation. Here we describe the formulations and flame retardants tested. Two formulas with halogenated and non-halogenated flame retardant, respectively, are introduced based on the investigation.

Requirements for our study:

Handling:
Viscosity <5000 cps @20°C

Mechanical properties:
Elongation @ break >150%
Tensile strength >2 MPa / >300 psi
Hardness >50 Shore A

Storage stability part A:
No settling of the fillers

Dielectrical properties:
Dielectrical rigidity >15 KV/mm
Surface Resistivity >10E14 Ω
Volume Resistivity >10E14 Ω.cm

Fire resistance:
UL 94 V-O, 2mm (80 mil) thickness

Toxicity:
Low hazard products

Starting formulation:

Product	Supplier	pbw
Poly BD® R45 HTLO	Resin Solutions	100
2-Ethyl-1,3-Hexanediol	Kyowa Hakko	16
DOP	Sartomer Co.	40
Irganox 1520	Ciba	0.25
DPDPI	Ceca	0.5
No Air Liquid	Barlocher	0.5
Isonate 143L	Dow Chemical Co	46

Mechanical Properties

Elongation @ Break	233%
Tensile Strength	3.3 MPa (480 psi)
100% modulus	1.7 MPa (250 psi)
Tear Strength	9.5 N/mm (54 pli)
Hardness	58 Shore A
Viscosity Part A, @ 86F	1,400 cps

Fire Retardants Studied

Product	Supplier (Europe)	I (OH) meq/g	Type of product	note
Hostaflam RP652	Hoechst	1.4	Red phosphorous (50% in castor oil)	NH
DE-60 FS	Chemtura		Pentabromodiphenyl oxide + aromatic phosphate	Brominated
Fire Brake ZB	Borax		Zinc borate	NH
Kaolin Sokalite	SOKA		Kaolin	NH
Kaolin Sialite	SOKA		Kaolin	NH
Kaolin Blankalite	SOKA		Kaolin	NH
FR Cross 484F	Budenheim		Ammonium polyphosphate	NH
FR Cross 484FSC	Budenheim		Coated ammonium polyphosphate	NH
Fyroflex RDP	Supresta		Resorcinol bis(diphenyl phosphate)	NH
Fyrol FR2	Supresta		Tri(2-chloroisopropyl)phosphate	Chlorinated
Fyrol PBR	Supresta		Pentabromodiphenyl oxide	Brominated
Fyro 6	Supresta	8.2	Diethyl N, N Bis (2 hydroxy ethyl) amino ethyl phosphonate	NH
Fyrol PCF	Supresta		Tri(2-chloroisopropyl) phosphate	NH
Phosphflex 31P	Supresta		Isopropyl triaryl phosphate	NH
TCPP	Planet Chemicals		Tri(1-chloro-2-propyl) phosphate	Chloinated
PHT 4-Diol	Chemtura	3.9	Tetrabromophthalate diol	Brominated
BRE5110	Chemtura	2.7	Tris (2-chloropropyl) phosphate (30) + tetrabromophthalate diol (70)	Brominated
Pyronyl 45	Oxychem		Tetrabromophthalate	Brominated
Decabromo diphenyl oxide	Total Specialty Chemicals, Inc.		Decabromodiphenyl oxide	Brominated
	Alfa Aesar		Antimony trioxide	NH
Martinal ON310	Albemarle		$Al(OH)_3$ particle size: 9 to 13 µm	NH
Martinal OL104	Albemarle		$Al(OH)_3$ particle size: 1.3 to 2.6 µm	NH
Magnifin H10	Albemarle		$Mg(OH)_2$ particle size 9 50 13 µm	NH

Note: NH means Non-Halogenated

Formulation CE690 A/B
UL94: V-O, Halogenated

Composition

PART A		**pbw**
Poly BD® R45 HTLO (0.83 meq/g)	Resin Solutions	100
2-ethyl-1.3-hexane diol (13.7 meq/g)	Kyowa Hakko	16
DE-60 FS	Chemtura	110
Irganox 1520 (antioxidant)	Ciba	0.25
DPDPI (antioxidant)	Ceca	0.5
No Air Liquid (defoamer)	Barlocher	0.5
		MA = 227.25
NCO/OH = 1.05		
PART B		**pbw**
Isonate 143L (29% NCO)	Dow Chemical Co.	45.8
		Total = 273.05

Mechanical Properties (speed: 50 mm/min.)

Hardness	56	Shore A
Tensile Strength	552 (3.6)	Psi (MPa)
Elongation @ break	260	%
100% modulus	217.5 (1.5)	Psi (MPa)
Tear	48.5 (8.5)	Pli (N/mm)

Other Properties
Mixing ratio: Part A 100 // Part B 20.15
Viscosity (Brookfield RV5) @30°C (86°F): 2,100 cps

Fire Resistance
UL 94 (2 mm – 80 mils thickness): V-O

Electrical Properties

Thickness	**Frequency**	**Capacity (F)**	**ε**	**Tg Delta**	**Transversal resistivity**	**Dielectric strength**	**Surface resistivity**
0.13 (50 mils)	100Hz	1.03E-11	4.8	0.046	1.2E+15 Ohm.cm	7.9 KV/mm	1.4E+16 Ohm
	1KHz	9.59E-11	4.5	0.047			
	10KHz	8.86E-11	4.1	0.052			
	100 KHz	8.22E-11	3.8	0.056			
	1 MHz	9.53E-11	3.5	0.056			

Formulation
CE 694 A/B
Non,-halogenated, UL94: V-O (2mm – 80 mils thickness)

Composition

PART A		**pbw**
Poly BD® R45 HTLO (0.83 meq/g)	Resin Solutions	100
2-ethyl-1,3-hexane diol (13.7 meq/g)	Kyowa Hakko	16
Hostaflam RP652 (1.43 meq/g)	Hoechst	60
Santicizer 141	Ferro	60
Martinal OL104	Albemarle	60
Martinal ON310	Albemarle	60
Anti Terra 204 (anti settling)	BYK	3.5
Irganox 1520 (antioxidant)	Ciba	0.25
DPDPI (antioxidant)	Ceca	0.5
No Air Liquid (defoamer)	Barlocher	2
PART B	**NCO/OH = 1.05**	**pbw**
Isonate 143L (29% NCO)	Dow	45.8

Mechanical Properties (speed: 50 mm/min.)

Hardness	58	Shore A
Tensile Strength	333 (2.3)	Psi (MPa)
Elongation @ break	100	%
100% modulus	333 (1.5)	Psi (MPa)
Tear	45 (8.5)	Pli (N/mm)

Other Properties
Mixing ratio: Part A 86 // Part B 14
Viscosity (Brookfield RV5) @ 30°C (86°F): 3,900 cps

Fire Resistance
UL 94 (2 mm – 80 mils thickness): V-O

Electrical Properties

Thickness	**Frequency**	**Capacity (F)**	**ε**	**Tg Delta**	**Transversal resistivity**	**Dielectric strength**	**Surface resistivity**
0.13 (50 mils)	100Hz	1.59E-11	8.0	0.075	6.6E+13 Ohm.cm	10.6 KV/mm	4.3E+14 Ohm
	1KHz	1.43E-11	7.2	0.072			
	10KHz	1.28E-11	6.4	0.078			
	100 KHz	1.12E-11	5.6	0.095			
	1 MHz	1.01E-11	5.1	0.072			

About Resin Solutions

Resin Solutions is the premier global supplier of specialty chemical additives, hydrocarbon specialty chemical, and liquid and powder tackifying resins used as ingredients in adhesives, rubbers, polymers, coatings and other materials. Resin Solutions has pioneered the development of these advanced technologies, introducing products that enhance the performance of products in energy, printing, packaging, construction, tire manufacture, electronics, and other demanding applications.

For more information, please visit **www.resinsolutions.com.**

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