THIOKOL® LP

LP-32

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Toray Fine Chemicals Co., Ltd.

Description of LP-32

LP-32 polymer is one of a family of liquid polysulfide polymers manufactured by Toray Fine Chemicals Co., Ltd. It is widely used as the base for sealants applied to aircraft, buildings, marine vessels, automobiles, canals, highways, and insulating glass units. Other applications for LP-32 polymer include casting compounds, electrical potting compounds, fuel tank coatings, and chemical resistant coatings.

LP-32 polymer can be cured in place at room temperature to solid rubber without shrinkage. Cured compositions based on LP-32 polymer display excellent stress-strain properties as well as outstanding solvent and chemical resistance. These compositions also exhibit a broad service temperature range of-54C (-65F) to121C (250F) coupled with the ability to resist aging due to oxidation, ozone, exposure and weathering.

Chemically, LP-32 is a polymer of bis-(ethylene oxy) methane containing disulfide linkages. The polymer segments are terminated with reactive mercaptan (-SH) groups; pendant mercaptan groups are built into the chain to control modulus and elongation.

The average structure of LP-32 liquid polysulfide polymer is:

$$HS(C_2H_4{-}O{-}CH_2{-}O{-}C_2H_4SS)_{23}{-}C_2H_4{-}O{-}CH_2{-}O{-}C_2H_4SH$$

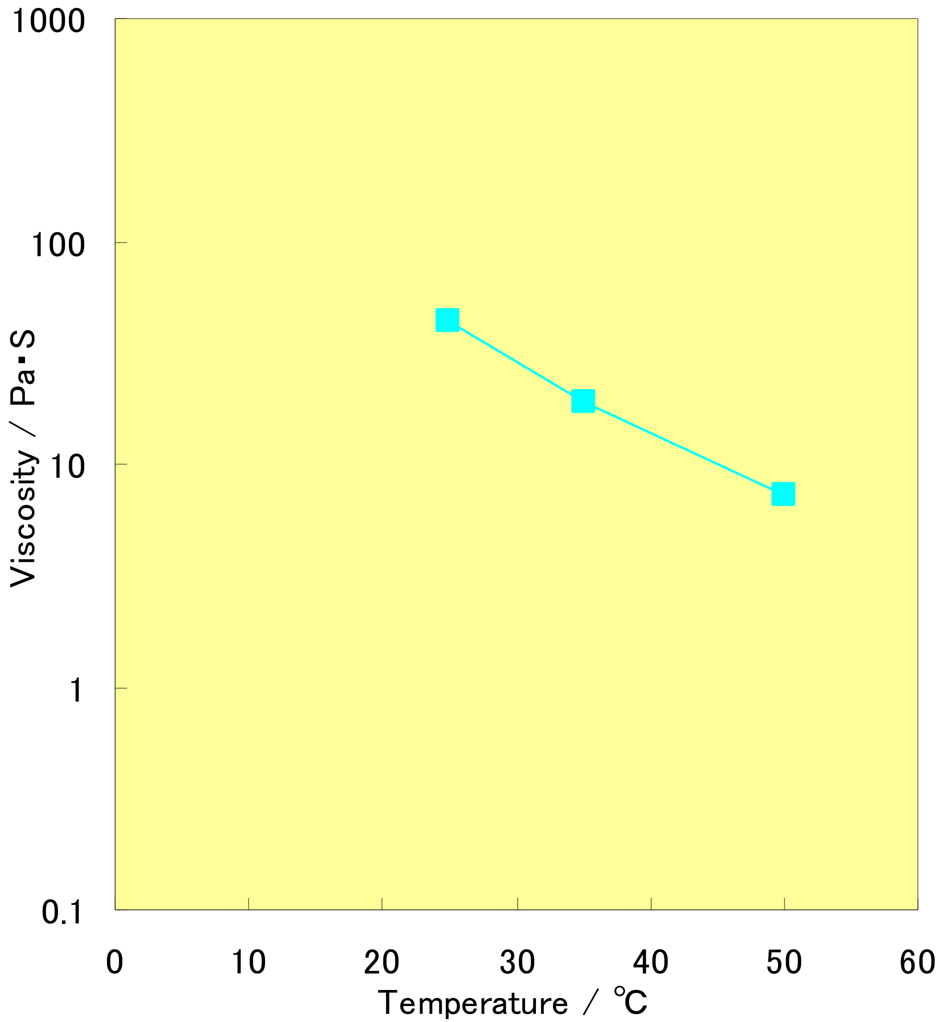
LP-32 polymer has a certain proportion of branched chains in its structure which are not shown. It produces very little crosslinking in the cured polymer. Typical LP-32 polymer properties are listed in Table 1.

Properties of LP-32 (Table 1)

Properties	LP-32
Physical Form	Viscous Liquid
Color / Gardner	Amber, 12max
Viscosity at 25C(77F)/ Pa･s	41-48
Average molecular weight	4000
Moisture content / %	0.15-0.25
Mercaptan content / %	1.5-2.0
Refractive index n_D^{25}	1.5662
Cross-linking agent / %	0.5
Specific gravity at 25C(77F)	1.29
Fire point / C(F)	Cleveland Open Cup 252(485)

Viscosity of LP-32

Change in Viscosity of LP-32 Polymer with Temperature



Compatibility of Solvents (Table 2)

Solvents, such as cyclohexanone, dioxane, and toluene are compatible in all proportions with LP-32 liquid polysulfide polymer. Solvents partially miscible with LP-32 polymer include methyl ethyl ketone, butyl acetate, and perchloroethylene. Methanol and mineral spirits are incompatible with LP-32 polymer.

The compatibility values were determined by stirring measured increments of solvent into weighed quantities of liquid polymer at room temperature until separation or cloudiness occurred.

The compatibility results are shown in Table2. This should not be confused with the solvent resistance of cured compositions based on LP-32.

Solvents	Parts by Weight of Solvent Compatible with 100 Parts of LP-32 at 25C (77F)
Ketones	
Acetone	70
Methyl Ethyl Ketone	200
Cyclohexanone	All proportions
Alcohols	
Methanol	0
Ethylene Glycol	0
Aldehydes	
Benzaldehyde	All
Furfural	All
Ether	
Dioxane	All
Aromatic Hydrocarbons	
Benzene	All
Toluene	All
Xylene	250
Ester	
Buthyl Acetate	130
Aliphatic Hydrocarbons	
VMP Naphtha	0
MineralSpirits	0
Nitro Paraffin	
2-Nitropropane	600
Chlorinated Hydrocarbons	
1,1,1-Trichloroethane	All
Perchloroethylene	80

Curing of LP-32

Curing of LP-32 polymer is accomplished by converting the mercaptan (-SH) terminals to disulfide (-S-S) bonds. This results in a high molecular weight polymer with elastomeric properties.

The curing agents most commonly used are oxygen-donating materials such as certain grades of manganese dioxide, calcium peroxide,zinc peroxide, cumene hydroperoxide, ammonium dichromate and p-quinone dioxime (GMF). The mechanism of cure is as follows:

$$2\text{-RSH} + (\text{O}) \rightarrow \text{R-S-S-R} + H_2O$$

The rate of curing may be accelerated or retarded by using small amounts of specific additives. Generally, the overall pH of the system is the controlling factor; acidic materials retarding the cure and alkaline materials accelerating the cure. Chemicals that react or interfere with the reactive SH of the LP polymer also affect the cure rate and final properties of the composition.

In compounding, the effect of the major additives (such as fillers and plasticizers) on the cure rate are evaluated. The, adjustments are made with accelerators and retarders. Some of the more commonly used accelerators and retarders are discussed in Table 3.

Curing System for Compositions Base on LP-32 Polymer (Table 3)

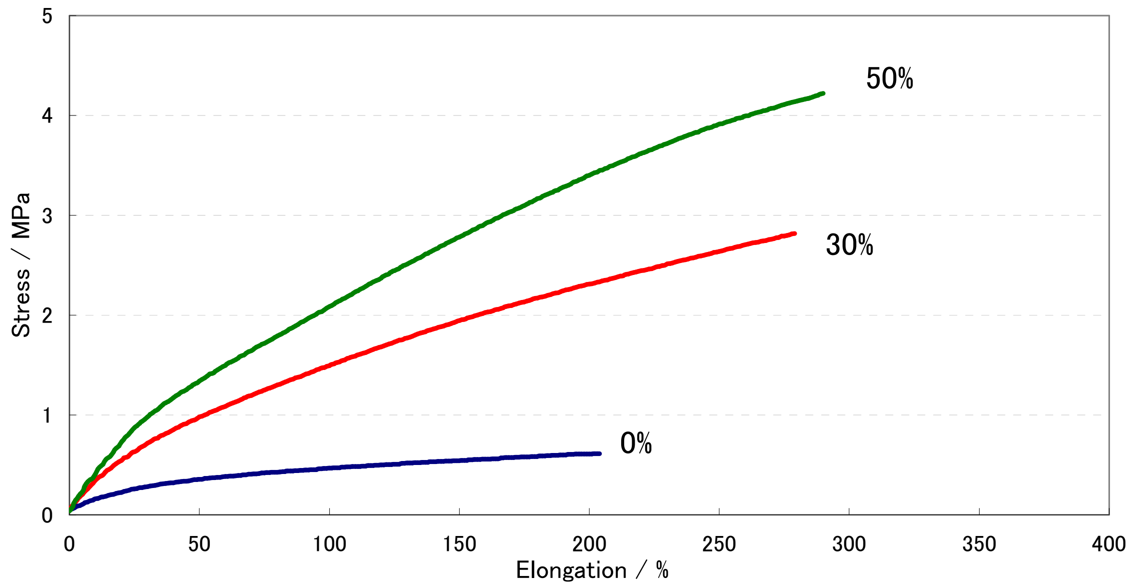
Curing Agents	Accelerators	Retarders	Comments
Manganese Dioxide (active grade)	Amines, inorganic bases, H_2O, meta-dinitrobenzene	Stearic acid, isostearic acid	MnO_2 (active grade) provides polysulfide compositions with heat resistance. Amount recommended per 100 parts of polysulfide polymer: 7.5 parts
Calcium Peroxide	H_2O, amines, bases	Molecular sieves	CaO_2 requires moisture for activation and can provide a white cured system. Amount recommended per 100 parts of polysulfide polymer: 10 parts
Zinc Peroxide	Amines	Molecular sieves, sulfur	ZnO_2 can provide white polysulfide compositions. Amount recommended per 100 parts of polysulfide polymer: 10 parts
Ammonium Dichromate	H_2O, polar solvents such as dimethylformamide, sulfur	Stearic acid	Ammonium Dichromate provides polysulfide compositions with high service temperatures for specialty applications. Amount recommended per 100 parts of polysulfide polymer: 2-7 parts
Cumene Hydroperoxide	Copper ions (cupric resinate) ,amines	H_2O, cupric resinate in excess of 0.07% by weight of LP polymer	Cumene hydroperoxide, in liquid form, is useful for pourable compositions with compression set resistance. Metallic oxides (ZnO or MgO) neutralize acid by-products. Amount recommended per 100 parts of polysulfide polymer: 8 parts
P-Quinone Dioxime (GMF)	Diphenylguanidine, sulfur, metallic oxides	None normally required	GMF reacts very slowly at room temperature and thus requires heat and diphenylguanidine for activation. Amount recommended per 100 parts of polysulfide polymer: 2-5 parts

Fillers (Carbon)

LP-32 liquid polysulfide polymers can be compounded with a variety of fillers to increase its strength and reduce finished products compounding costs. Also to be considered in the choice of fillers are the effects on processing, storage, and curing characteristics.

Filler Level (SRF Carbon) (pbw)	Tensile (MPa)	50% Modulus (MPa)	100% Modulus (MPa)	200% Modulus (MPa)	Elongation (%)	Hardness (Shore A)
0	0.61	0.35	0.47	0.61	203	19
30	2.82	0.98	1.50	2.31	279	48
50	4.22	1.34	2.09	3.40	290	57

Formulation (pbw)	
Part A	
LP-32	100
Stearic Acid	0.5
Sulfur	0.1
SRF Carbon	As noted
Part B	
MnO_2	7.5
D-180	7.5

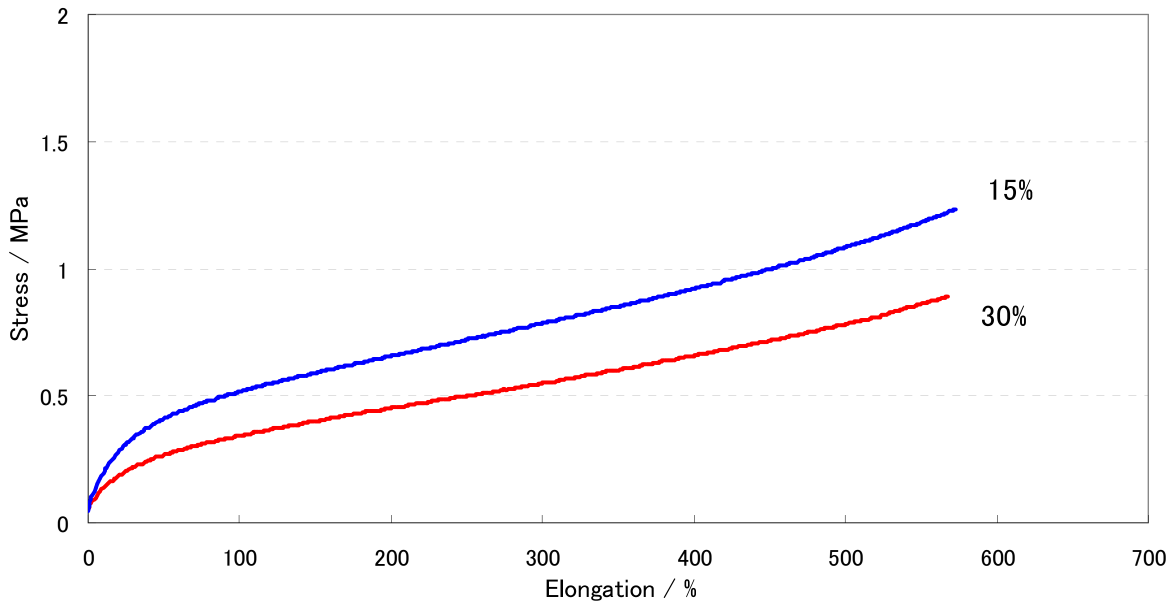


Plasticizers

Plasticizers are used in the formultion cf compositions containing LP-32 liquid polysulfide polymers for a variety reasons, not the least of which is cost reduction. Certain physical properties, such as lower hardness or self-leveling qualities, are provided largely by the use of a plasticizer.

Plasticizer Level (pbw)	Tensile (MPa)	100% Modulus (MPa)	200% Modulus (MPa)	300% Modulus (MPa)	400% Modulus (MPa)	500% Modulus (MPa)	Elongation (%)	Hardness (Shore A)
15	1.23	0.52	0.65	0.78	0.92	1.08	573	33
30	0.89	0.34	0.45	0.55	0.66	0.78	568	24

Formulation (pbw)	
Part A	
LP-32	100
Precipitated $CaCO_3$	50
BBP	As noted
Part B	
MnO_2	7.5
D-180	7.5



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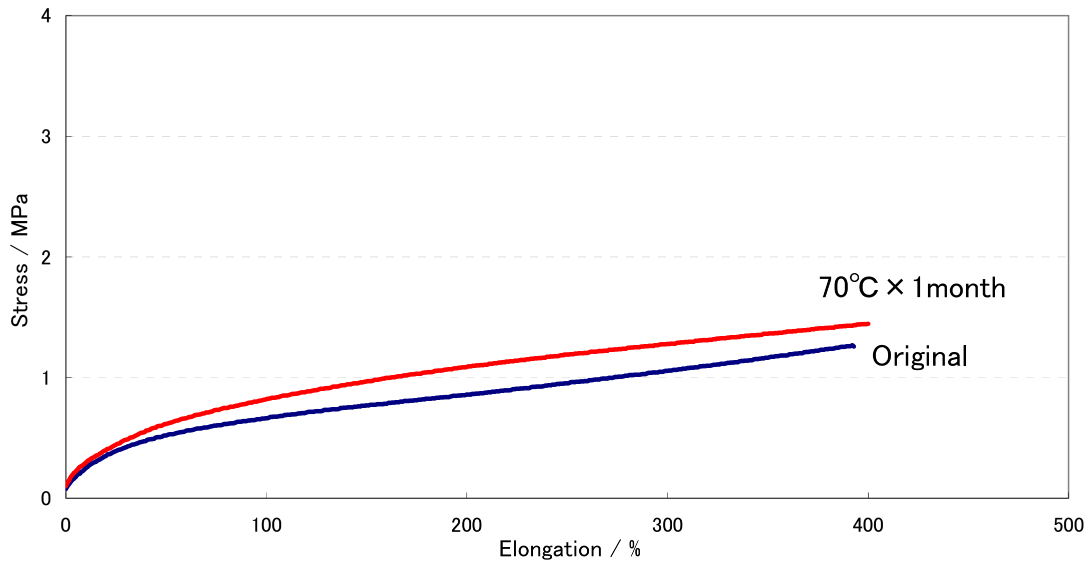
Aging and Weathering Resistance

Cured liquid polysulfide polymer-based compositions display excellent resistance to heat exposure, ozone, oxidation, sunlight and weathering. Lon-term "Weatheromter" tests have indicated that cured compositions have excellent resistance to outdoor exposure. The table below shows the heat-aged properties of cured LP-32-based compositions. In particular, note that only moderate changes took place after heat aging for one month at 70℃(158F).

Sample	Tensile (MPa)	100% Modulus (MPa)	200% Modulus (MPa)	300% Modulus (MPa)	Elongation (%)	Hardness (Shore A)
Original	1.26	0.66	0.86	1.06	393	38
Heat Aged 1 month at 70℃	1.45	0.82	1.09	1.28	400	42

Formulation (pbw)	
Part A	
LP-32	100
Precipitated $CaCO_3$	30
Stearic Acid	0.5
Sulfur	0.1
Part B	
MnO_2	7.5
D-180	7.5



Responsibility

We accept no responsibility for results obtained by the application of this information or the safety or suitability of our products, either alone or in combination with other products.Users are advised to make their own tests to determine the safety and suitability of each such product or product combination for their awn purposes.

Caution:

Do not use in medical applications involving permanent implantation in the human body.

Refer to our Material Safety Data Sheet before use.