Toray Fine Chemicals Co., Ltd.

http://torayfinechemicals.com

THIOKOL® LP

(Liquid Polysulfide Polymer)

$$HS-(C_2H_4-O-CH_2-O-C_2H_4-S-S)_n-C_2H_4-O-CH_2-O-C_2H_4-SH$$

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Liquid Polymer

Sealants based on polysulfide liquid polymer (LP) have found worldwide acceptance, in industries such as construction, aircraft, insulating glass, automotive, and marine.

Construction

With the advent of the curtain wall and high-rise structures came need for a sealant which would adhere tenaciously to almost any surface, maintain a weatherproof seal against leakage and have excellent movement capabilities.

Aircraft

Since the 1940s, sealants based on polysulfide polymers have been used on virtually every commercial and military aircraft. Because of their excellent resistance to fuels, these compounds have been specified for sealing integral fuel-tanks and numerous other areas on aircraft of all sizes.

Insulation Glass

Only a few compounds can meet the rigid requirements placed on insulation glass sealants. Polysulfide base sealants, because of their excellent adhesion and high resistance to UV, are used in the manufacture of insulating glass units and in glazing applications, specifically windows, patio doors, and windows for environmental chambers.

Additional Applications

There are many other traditional polysulfide-based applications. Including: Cold molding, potting, formed-in-place gaskets, trailer waterproofing, flexible molds, auto glass and body sealing, filleting and mold sealing, membrane coating, gas main sealing, concrete bonding, plastic tooling, wire and cable sealing, anti-corrosion coating, leather impregnation, chemical resistant coatings, printing rollers, propellant binders, vibration damping and dental molding compounds.

Liquid Polymer Applications

Application	LP-3	LP-33	LP-23	LP-980	LP-2	LP-32	LP-12	LP-31	LP-55	LP-56
Aircraft sealant			●	●	●	●	●	●	●	●
Automotive sealants				●	●	●				
Building sealants				●	●	●	●	●	●	
Flow type sealants			●	●	●	●	●		●	●
Heavy construction sealants				●	●	●		●		
Insulating glass sealants			●	●	●	●				
Marine sealants				●	●	●		●		
Dental molding compounds					●					
Epoxy modifiers	●	●								
Fluid membranes				●	●	●				
Concrete coatings	●	●								●
Intumescent coatings	●	●								
Electrical potting	●	●		●	●	●				
Leather impregnation	●				●					
Propellant binders	●	●								

Chemical Properties

Properties	LP-3	LP-33	LP-23	LP-980	LP-2	LP-32	LP-12	LP-31	LP-55	LP-56
Color / Gardner	13max	12max	14max	12max	14max	12max	12max	12max	12max	12max
Viscosity at 25C(77F)/Pa・s	1.2	1.8	12	12	45	45	45	130	45	18
Moisture content / %	0.1max	0.1max	0.15-0.25	0.15-0.25	0.15-0.25	0.15-0.25	0.15-0.25	0.15-0.25	0.15-0.25	0.15-0.25
Mercaptan content / %	5.9-7.7	5.0-6.5	2.5-3.5	2.5-3.5	1.5-2.0	1.5-2.0	1.5-2.0	0.8-1.5	1.5-2.0	2.0-2.5
Average molecular weight	1000	1000	2500	2500	4000	4000	4000	7500	4000	3000
Refractive index n/D	1.5574	–	1.5652	1.566	1.5672	1.5662	–	1.5676	–	–
Flash point(PMCC) / C(F)	>177 (350)	>177 (350)	>177 (350)	>177 (350)	>177 (350)	>177 (350)	>177 (350)	>177 (350)	>177 (350)	>177 (350)
Cross-linking agent / %	2.0	0.5	2.0	0.5	2.0	0.5	0.2	0.5	0.0	0.0
Specific gravity at 25C(77F)	1.27	1.27	1.28	1.29	1.29	1.29	1.29	1.31	1.29	1.28

Chemical Structure and Curing Mechanism (LPs)

Chemical Structure

Polysulfides are polymers of bis-(ethylene oxy) methane containing disulfide linkages. The reactive terminal groups used for curing are mercaptans (-SH). The general structure is:

$$HS(C_2H_4-O-CH_2-O-C_2H_4SS)_xC_2H_4-O-CH_2-O-C_2H_4SH$$

Curing Mechanism for LP Polysulfide Polymers

Curing of liquid polysulfide polymers to high molecular weight elastomers is normally accomplished by oxidizing the polymer's thiol (-SH) terminals to disulfide (-S-S-) bonds.

$$2\ R-SH\ +\ (O)\ \longrightarrow\ -R-S-S-R-\ +\ H_2O$$

The curing agents most commonly used are oxygen donating materials such as manganese dioxide, calcium peroxide, cumene hydroperoxide, and p-quinone dioxime. Lower valence metallic oxides, other organic hydroperoxides, metallic paint driers, and aldehydes can also function as curatives.

Selection of Curing Agents (LP-2,12,31,32)

The final selection of a curing agent is based on its overall perfomance with respect to a number of requirements, including: cost, stability, controllable cure rate, heat stability of cured composition, elastomeric properties, toxicity, etc.

With LP-2, LP-12, LP-31, LP-32

(Note that LP-31, because of its higher molecular weight, requires generally less curative than is recommended in the following paragraphs.)

MnO_2(active grade)

Provides polysulfide polymer based compositions with improved heat resistance.

Amount required per 100 parts of polysufide polymer: 7.5-10.0 parts.

CaO_2

Requires moisture for activation. It can be used to provide a white one-part moisture curing system.

Amount required per 100 parts of polysufide polymer: 10.0-12.0 parts.

ZnO_2

Reacts slowly with LP polymers. It can be used to provide white compositions with moderate heat stability.

Amount required per 100 parts of polysufide polymer: 10.0 parts.

Cumene Hydroperoxide

It is in convenient liquid form which is useful for obtaining pourable compositions that have compression set resistance. Amount required per 100 parts of polysufide polymer: 8.0 parts.

Selection of Curing Agents (LP-3,33)

With LP-3, LP-33

MnO_2(active grade)

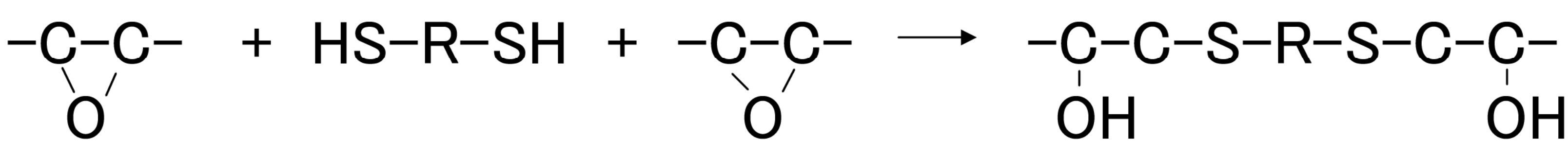
Permits room temperature cures sith the addition of 1.5 to 4 parts of m-dinitrobenzene as an accelerator. Amount of MnO_2 required per 100 parts of polysufide polymer: 2-6 parts.

Para-Quinonedioxime(GMF)

Requires heat activation and the addition of 0.5-3 parts of diphenyl-guanidine(DPG). Amount of GMF required per 100 parts of polysufide polymer: 5-7 parts.

Others

LP-3 and LP-33 can slso co-cure with various polymers to yield elastomeric and/or plastic properties based on the ratio of ingredients used. In particular, epoxy resins in conjunction with aliphatic or aromatic amines are commonly co-cured with the polysulfides, The following cure mechanism is suggested:



Compounding

Compounding and Processing

Liquid polymers are compounded with a variety of plasticizers, reinforcing agents, thixotropes, and extending fillers which influence the composition's dynamic properties, viscosity, and cost. Processing of most liquid polymer compositions requires the use of high shear mixing equipment. Most widely used are sigma blade and planetary type mixers, high speed dispersers and three-roll paint mills.

Adhesion Properties

Excellent adhesions to most substrates, coupled with good flexibility, is obtained with properly compounded polysulfide polymer based compositions. Typical values obtained are peel adhesions of approximately 3.6 to 10.8 kg/cm (20 to 60 lb/in) to aluminium, glass, and steel surfaces. Shear values to aluminium range from approximately 7 to 14 kg/cm^2 (100 to 200 lb/in^2) for cross-sections 0.3cm (1/8 inch) thick.

Electrical Properties

Electrical Properties

Cured liquid polysulfide polymers have good electrical properties which can be improved through compounding. Typical electrical and special properties at 25C (77F) and 50% relative humidity of cured compositions are shown in Table.

Electrical Properties	
Volume resistivity (ohm-cm)	$1x10^{11} – 7x10^{12}$
Surface resistivity (ohm)	$1x10^{12} – 2x10^{14}$
Dielectric constant @ 1Kc	5.5 – 8
Dissipation factor @ 1Kc	0.001 – 0.010

Resistance

Oil, Solvent, and Chemical Resistance

Cured liquid polysulfide based compositions display excellent resistance to a wide number of oils and solvents including aliphatic and aromatic hydrocarbons, seters, ketones, dilute acids and alkalies. Table shows typical volume swell values on specimens immersed in solvent for 30 days at 27C (80F).

Solvent and Oil	Volume Swell(%)
ASTM Reference Fuel A	−1 to −7
ASTM Reference Fuel B	1 to 12
ASTM Oil No.1	−7 to 5
JP−5	−5 to 12

Aging and Weather Resistance

Cured Liquid polysulide polymer based compositions display excellent resistance to aging, ozone, oxidation, sunlight, and weathering. Long term "Weather−ometer" tests, as well as actual usage, indicate that these materials have excellent resistance to daily exposure in varying climates.

Toxicological Properties

Toxicological Properties of LP Polysulfide Polymers

Liquid polysulfide polymers are relatively non-toxic. The actual oral toxicity of LP-3 has been measured in rats as 3.5 g/kg body weight (equivalent to table salt), and other LP polymers were measured as being even less toxic orally. Eye irratation test conducted on rabbits showed no corneal or iridial effects, but slight conjunctival involvement was found for LP-32 and LP-33. Sin irritation studied on human volunteers indicate that upon repeated 24-hour applications to the same area of skin, some individuals developed perceptible erythema evaluated as due to skin fatigue and not to sensitization. With these indivisuals, an application to another skin area, or to the same area after a rest of period, showed no reaction. It is therefore advised that prolonged or repeated contact with the skin be avoided, and protective gloves be worn as a precaution.

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.