TOSOH

The Chemistry of Innovation

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TOSO-CSM®

Chlorosulphonated Polyethylene

extos®

Alkylated Chlorosulphonated Polyethylene

TOSOH CORPORATION

Production method of TOSO-CSM® and extos®

Chlorosulphonated Polyethylene (CSM) is a Special Synthetic Rubber manufactured through chlorination and chlorosulphonation of polyethylene
Extos is new type of CSM with improved Dynamics and Low Temperature Properties

Structural Features

Chlorine

- Destruction of the crystalline segments
- Oil Resistance
- Solubility
- Higher glass-transition temperature

Sulphonyl Chloride Groups

- Cross-Linking Point

Single Bond on the main chain

Production process

TOSO-CSM®

(Polyethylene)

$(CH_2\text{-}CH_2)\,n$

Chlorination (+Cl) | Chlorosulphonation ($+SO_2Cl$)

(TOSO-CSM®)

$(CH_2\text{-}CH_2)\,l\ (CH_2\text{-}CH)\,m\ (CH_2\text{-}CH)\,n$ (Cl; SO_2Cl)

extos®

(Alkylated polyethylene)

$(CH_2\text{-}CH_2)\,m\ (CH_2\text{-}CH)\,n$ (R)

Chlorination (+Cl) | Chlorosulphonation ($+SO_2Cl$)

(extos®)

$(CH_2\text{-}CH_2)\,k\ (CH_2\text{-}CH)\,l\ (CH_2\text{-}CH)\,m\ (CH_2\text{-}CH)\,n$ (R; Cl; SO_2Cl)


Certificate of Approval

TOSO-CSM® and extos® are manufactured under certified ISO-9001 conditions at Tosoh's Nanyo Complex.

Comparison of TOSO-CSM® with other synthetic rubbers

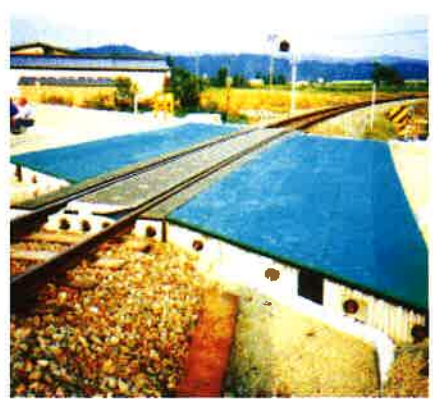
	TOSO-SM®	CR	EPDM	NBR	SBR	IIR	NR
Tensile strength (pure gum)	◎	◎	△	△	△	◎	◎
Tear strength	○	○	△	○	△	○	◎
Abrasion resistance	◎	◎	○	◎	◎	○	◎
Compression set	○	◎	○	◎	○	△	◎
Anti-gas permeability	○	○	△	○	△	◎	△
Weather resistance	◎	○	◎	△	△	○	△
Ozone resistance	◎	○	◎	X	X	○	X
Heat resistance	◎	○	◎	△	△	○	△
Flame resistance	○	○	X	X	X	X	X
Discolour resistance	◎	X	◎	○	○	○	○
Strong acid resistance	◎	○	◎	○	△	○	△
Alkali resistance	◎	◎	◎	○	○	◎	○
Gasoline resistance	○	○	X	◎	X	X	X
Oil resistance	○	○	X	◎	X	X	X

◎ – Excellent, O - Good, Δ – Possible, X – Impossible

Automobile rubber parts

Escalator handrails

protective
barriers on
public transportation systems
(Urban liner/Kintetsu Corporation)



Rubber panels for railroad crossings

Features and specifications

	Grades	Chlorine content (%)	Sulfur content (%)	Mooney viscosity ML(1+4) 100℃	Features
TOSO-CSM®					
	TS-530	35	1.0	56	General-purpose grade that achieves balance in physical properties and processability
	TS-430	35	1.0	46	Similar to the TS-530 with low Mooney viscosity
	TS-830	36	1.0	90	Similar to the TS-530 with high Mooney viscosity
	TS-930	36	1.0	105	Similar to the TS-530 with high Mooney viscosity
	TS-320	23	1.0	37	Thermoplastic that can be used without curing
	TS-340	43	1.1	350※	Good solubility, low solution viscosity, oil resistance
	CN-1500	30	1.4	1400※	Good solubility, low solution viscosity
extos®					
	ET-8010	26	0.7	40	Good dynamic and low temperature properties Vulcanizing adhesion with EPDM is possible
	ET-8510	30	0.9	40	Oil resistance

※ 25% tolunen solution viscosity {(mPa·s/Brookfield(BL) type viscometer, 23℃)}

TOSO-CSM®

TS-530 Most well-balanced grade, superior in physical properties anti-degration, and processability
TS-430 Low viscosity form of the TS-530, with good processability
TS-830 Visocity is between TS-530 and TS-930
TS-930 Highest visocity of the TS-series. Suitable for expansion using large amounts of filler or oil in order to reduce costs
TS-320 Lower chlorine content than general grades, with high hardness and good resistance to cold
TS-340 Superior solubility as an organic solvent
CN-1500 Superior solubility as an organic solvent

extos®

ET-8010 Good resistance to cold, offering better dynamic fatigue resistance
ET-8510 Similar to ET-8010 in all respects, with good resistance to oil

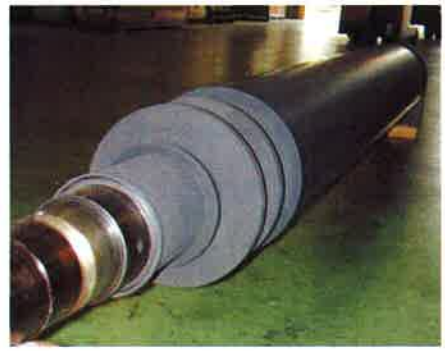
TOSO-CSM® Applications

	Fields	Applications
TOSO-CSM®	Automotive parts	Fuel hoses, power steering hoses, hydraulic hoses, brake hoses
	Electric parts, electric wire	High-tension cables, low-tension cables, communication cables, submarine cables, ship's wires, heat-resistant wire coverings, radioactive-resistant cables
	General industrial articles	High-pressure hoses, LPG hoses, chemical-resistant hoses, rolls, linings
	Engineering and building articles	Escalator handrails, building gaskets pond lining sheets, roofing sheets weather-resistant paints
	Others	Rubber boats, rainwears, chemical-resistant gloves adhesives, paints, coatings

extos® Applications

	Fields	Applications
extos®	Automotive parts	Synchronous timing belts, poly-V-belts, coverings for the weatherstrips
	Train parts	Coupling coverings
	Engineering and building articles	Building gaskets

Rubber boats



Rubber rolls for iron manufacturing

TOSO-CSM® Properties

Grades			TS-430	TS-530	TS-830	TS-930	TS-320	TS-340	CN-1500
Formulation	TOSO-CSM®		100phr						
	MgO (High activity)		4						
	Pentaerythritol		3						
	Accelerator DPTT		2						
Compound Properties	Mooney viscosity ML (1+4) 100 ℃		58	66	111	114	49	37	41
	Mooney Scorch ML (1) 125 ℃								
	Vm		28	34	64	66	25	12	20
	t_5	min	23.1	21.0	20.0	20.0	20.2	31.9	31.4
Vulcanizate Properties	100% Tensile stress(M_{100})	MPa	1.1	1.1	1.2	1.2	3.0	3.3	1.3
	300% Tensile stress(M_{300})	MPa	2.3	2.4	3.0	2.9	4.4	12.5	3.6
	Tensile strength(T_B)	MPa	20.6	20.3	21.0	21.3	30.6	18.1	7.4
	Elongation at break(E_B)	%	550	540	530	520	520	410	420
	Hardness(Hs)	JIS-A	56	55	57	57	80	82	55
	Resilience	%	40	42	38	37	61	4	49
	Compression set (25% compression, aging for 70hrs. at 70℃)	%	79	73	72	69	72	83	83
	Oil resistance (ASTM#3oil, aging for 70hrs. at 125℃) Change rate in volume	%	81	80	73	71	230	35	200
	Heat resistance (Aging for 70hrs. at 100℃) Residual rate for T_B	%	134	126	131	128	48	122	103
	Residual rate for E_B	%	80	80	75	77	67	71	64
	Change in Hs	point	+2	+3	+3	+3	+1	+10	+3
Curing conditions	Sheet 160 ℃	min	20	20	20	20	25	35	35
	Compression set 160 ℃	min	25	25	25	25	30	40	40

※ Figures are provided only as a reference and do not serve as exact specifications

extos® Properties

Grades			ET-8010	ET-8510
Formulation	extos®		100phr	
	MgO (High activity)		4	
	Pentaerythritol		3	
	Accelerator DPTT		2	
Compound Properties	Mooney viscosity ML (1+4) 100 ℃		52	50
	Mooney Scorch ML (1) 125 ℃			
	Vm		26	25
	t_5	min	14.1	21.6
Vulcanizate Properties	100% Tensile stress(M_{100})	MPa	1.3	1.3
	300% Tensile stress(M_{300})	MPa	2.4	2.7
	Tensile strength(T_B)	MPa	22.5	17.8
	Elongation at break(E_B)	%	570	540
	Hardness(Hs)	JIS-A	56	56
	Resilience	%	70	60
	Compression set (25% compression, aging for 70hrs. at 70℃)	%	70	70
	Oil resistance (ASTM#3oil, aging for 70hrs. at 125℃) Change rate in volume	%	260	184
	Heat resistance (Aging for 70hrs. at 100℃) Residual rate for T_B	%	56	67
	Residual rate for E_B	%	65	68
	Change in Hs	point	+2	+3
Curing conditions	Sheet 160 ℃	min	20	25
	Compression set 160 ℃	min	25	30

※ Figures are provided only as a reference and do not serve as exact specifications

Ingredients	The example of Agents	Notes
Acid acceptors	Magnesium Oxide - Starmag Synthetic Hydrotalcite Hisorb 4A	Acid acceptors have to be added to CSM compound to catch & absorb acid when CSM is vulcanized Reinforcing agents
Reinforcing agents	Carbon Black	The effects of Carbon Black on vulcanized product are similar to other vulcanized rubber. They increase modulus and hardness and improve abrasion resistance. SRF, FEF, FT and MT are used frequently. With a decrease in the Particle Size, the Viscosity of the compounds, modulus and hardness of the vulcanized product are increased, working stability, elongation and rebound elasticity are decreased and Tensile Strength is increased slightly.
	Silica	Elongation and Tear Strength are increased but tensile strength and Abrasion Resistance are decreased when compared with carbon black..
Fillers	Calcium carbonate Clay Talc	Used as diluents for cutting down on expenses
Oils **Plasticizers** **Softeners**	Phthalic acid derivatives Fatty acid derivatives Mineral oils Aromatic oils Vegetable oils Rapeseed oil	The use of oils results in characteristics of low temperature and flexibility of the vulcanized product. A larger amount of oil is required for obtaining the vulcanized products having the same hardness as other vulcanized rubber products. Naphthenic oil may be bled by adding an amount higher than 20 phr. When a large amount is to be used, aromatic oil or chlorinated paraffin is effective.
Processing aid	Vaseline, microcrystalline wax, Low molecular weight polyethylene, (AC-617) Stearic acid	Added to improve the processability of compounds
Antioxidants **Antiozonants**		Added to improve Ozone Resistance. NBC is used generally. When NBC is used in an amount higher than 3 phr, the working stability is reduced.
Tackifier **Blowing agents** **Flame retardants**	 Antimony Trioxide Chlorinated Paraffin Aluminium Hydroxide	Added to give tackiness to compound. Aromatic oil or low molecular weight Coumarone Indene resin. Used to make foaming products

Ingredients	The example of Agents	Notes
Vulcanization Agents	Thiuram vulcanization system • Dipentamethylenethiuram tetrasulfide, DPTT (TRA) • Tetramethylthiuramdisulfide, TMTD (TT) • Tetraethylthiuramdisulfide, TETD (TET) + • Pentaerythritol	Merit • Stability of compound during mixing process • Tensile strength • Elongation at break Demerit • Stability of compound under storage • Compression set • Heat resistance • Discolour resistance
	Bismaleimide vulcanization system • N, N'-m-phenylendimaleimide (Vulnoc PM) + • Nickel dibutyldithiocarbonate (NBC) • 6-Ethoxy-2, 2, 4-trimethyl-1, 2-dihydroquinoline	Merit • Heat resistance • Compression set Demerit • Stability of compound under storage • Stability of compound during rubber mixing process • Tensile strength • Elongation at break
	Peroxide vulcanization System • 1,3-bis (tert-butylperoxy isopropyl) benzene + • Trially isocyanurate (TAIL)	Merit • Stability of compound under mixing process • Heat resistance • Compression set • Discolour resistance Demerit • Tensile strength • Elongation at break • Handelling of peroxide • Smell of peroxide

Mixing

CSM compounds are mixed in internal mixers and on roll mills. Internal mixers are preferred for speed and batch sizes. For small batches mill mixing is satisfactory.

Internal Mixing
A: Upside-down Mixing (recommended)
1st stage (internal mixer)

1) Charging of all ingredients except accelerators
2) Charging of CSM
3) Cleaning
4) Mixing
5) Dumping
6) Sheeting off
7) Cooling and storage

2nd stage (mixing roll)

8) Banding of compound
9) Charging of accelerator
10) Mixing to adequate distribution
11) Release at mil
12) Cooling and storage

Mill Mixing

1) Mastication of CSM
2) Charging of reinforcements (1/2) and acid acceptors
3) Charing of processing aids (1/2)
4) Charging of reinforcements (1/2) and processing aids (1/2)
5) Charging of fillers and plasticizers
6) Charging of accelerators
7) Mixing to adequate distribution
8) Release at mill
9) Cooling and storage

Notes on Mixing and storage

Mixing

(1) Internal mixing
(1)The milling can be carried through normal procedure, however the up-side-down procedure is most effective.
(2) Charging : 70 ~75% as a proportion standard
(3) Scorching can be prevented by
a) Controlling the temperature of dumped compound to a value of less than 100°to 110°C
b) Adding the vulcanizing agent and accelerator using the rolls
c) Cooling the compound. However when the compound is cooled by dipping it in cold water, the water that adheres should be completely removed and the sheets dried.

(2) Milling through rolls
(1) Suppression of heat generation by passing cooling water through the rolls
(2) The milling is facilitated by passing the thin sheet 3 to 5 passes through the rolls
(3) Cool sheets quickly by reducing the thickness of sheet

Storage of compounds

- Mixed compounds should not be stored in conditions of high humidity.
- Mixed compounds containing accelerators should be used immediately.
- If the mixed compounds need to be stored, accelerators should be added just before use.

Comparison of TOSO-CSM® with other synthetic rubbers

Hose			
Formulation	TOSO-CSM® TS-530		100 phr
	Starmag 150		20
	Special Wax		2
	ACPE 617A		3
	Struktol WB-222		2
	FEF Carbon Black		55
	Hydrous Silica		8
	TOTM		20
	DCP-40		7.5
	TAIC M-60		6.7
Compound Properties	Mooney Scorch ML (1) 125°C		
	Vm		67
	t5	Min	24.7
Vulcanizate Properties	100% Tensile stress (M100)	MPa	9.8
	Tensile strength (Ts)	MPa	20.8
	Elongation at break (E_B)	%	200
	Hardness (Hs)	JIS-A	78
	Compression set (25% compression aging for 70hrs at 150°C)	%	39
	Heat resistance (aging for 70hrs at 150°C) Residual rate for T_B	%	9.2
	Residual rate for E_B	%	7.6
	Change in Hs	point	+5
Curing Condition	Sheet 160°C	min	40
	Compression set 160°C	min	45

Electrical wire and cable			
Formulation	TOSO-CSM® TS-530		100 phr
	Starmag 150		5
	Special Wax		2
	White Vaseline		2
	HAF Carbon Black		15
	Dixie clay		50
	Mistron vapour		40
	Naphthenic process oil		15
	Chlorinated paraffin (Cl:45%)		15
	Antioxidant NBC		1
	Pentaerythritol		3
	Accelerator DPTT		2
	Accelerator DM		0.5
Compound Properties	Mooney Scorch ML (1) 125°C		
	Vm		23
	t5	Min	18.6
	100% Tensile stress (M100)	MPa	4.6
Vulcanizate Properties	Tensile strength (Ts)	MPa	13.6
	Elongation at break (E_B)	%	500
	Hardness (Hs)	JIS-A	73
	Compression set (25% compression aging for 70hrs at 150°C)	%	74
	Heat resistance (aging for 70hrs at 150°C) Residual rate for T_B	%	89
	Residual rate for E_B	%	58
	Change in Hs	point	+15
Curing Condition	Sheet 160°C	min	15
	Compression set 160°C	min	20

Roofing sheet			
Formulation	TOSO-CSM® TS-320		100 phr
	Starmag 150		4
	ACPE 617A		2
	Polyethylene glycol #4000		1
	Calcined clay		30
	Light Calcium carbonate		50
	Titanium dioxide (Rutile type)		25
	DOP		7
	Antioxidant BHT		2
Compound Properties	Mooney Scorch ML (1) 125°C		
	Vm		50
	t5	Min	>100
	100% Tensile stress (M100)	MPa	4.3
	Tensile strength (Ts)	MPa	9.4
	Elongation at break (E_B)	%	780
	Hardness (Hs)	JIS-A	86
Sheeting Process Condition	Heating Press : Preheating 100°C X 1 min Pressure 100°C X 5 min X 10 MPa Cooling 23°C X 1 min X 5 MPa Tensile test : Tensile rate 50min / min		

Belt			
Formulation	extos ET-8010		100 phr
	Hydrotalcite KW-2100		12
	Special Wax		2
	Struktol 40MS-F		5
	FEF Carbon Black		50
	Hydrous silica		2
	DOS		16
	Antioxidant NBC		0.7
	Pentaerythritol		2
	Accelerator DPTT		0.5
	Vulcanizing agent PM		3
Compound Properties	Mooney Scorch ML (1) 125°C		
	Vm		43
	t5	Min	20.9
Vulcanizate Properties	100% Tensile stress (M100)	MPa	5.6
	Tensile strength (Ts)	MPa	18.8
	Elongation at break (E_B)	%	330
	Hardness (Hs)	JIS-A	72
	Compression set (25% compression aging for 70hrs at 100°C)	%	30
	Heat resistance (aging for 70days at 140°C) Residual rate for T_B	%	101
	Residual rate for E_B	%	55
	Change in Hs	point	+13
Curing Condition	Sheet 160°C	min	30
	Compression set 160°C	min	35

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