FUJIFILM
Value from Innovation

Wako

Azo Polymerization Initiators Comprehensive Catalog

FUJIFILM Wako Pure Chemical Corporation

INDEX

Introduction

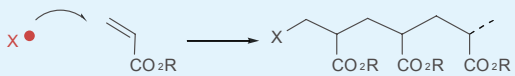
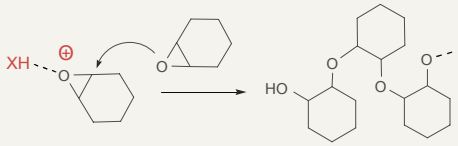
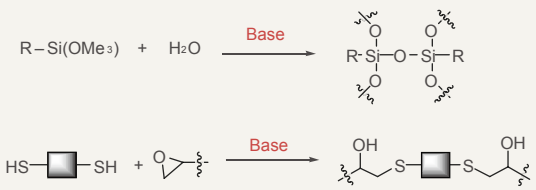
We develop a large variety of products taking advantage of our original organic synthesis technology, production technology, and refining technology accumulated in our long experience in the manufacturing of reagents.
Azo polymerization initiators are used as reaction initiators in the synthesis of polymers. They are used mainly as radical polymerization initiators in a wide range of industries, such as acryl resins for paints, water absorbent resins, polymer coagulants, adhesives, and paper finishing agents.
We have approximately 20 types of azo polymerization initiators of organic-solvent soluble type and water-soluble type.

What is Radical Polymerization?

Radical polymerization is initiated by the formation of free radicals. Free radicals are formed by thermac energy, light, or radioactivity. Radical polymerization is mainly used for the polymerization of vinyl monomers. In addition to radical polymerization, cationic polymerization and anionic polymerization are common polymerization methods. In the case of radical polymerization, initiators are generally used. The typical initiators are azo polymerization initiators and peroxides.

Characteristics of Radical Polymerization Initiators

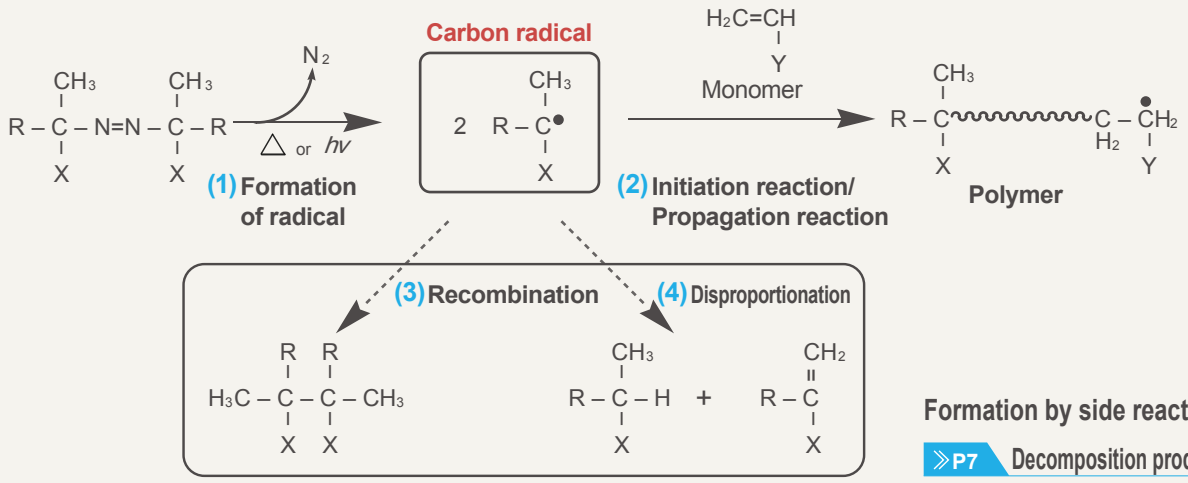
- Radical polymerization initiator shows an effect even in a small amount.
- It is not polar-sensitive, and a large number of solvent is available, a wide range of monomers can be polymerized.
- Polymerization at a low to high temperature ranges is possible.
- Reaction with simple facility and equipment is possible.

Active Species	Typical Reaction	Addition Amount	Type of Solvent
Radical		Small amount ○	Usable in many solvents ○
Cationic		△	×
Anionic		×	△

What are Azo Polymerization Initiator?

An azo polymerization initiator is a compound having an azo group (R-N=N-R'), which decomposes with heat and/or light, and forms carbon radical. The formed carbon radical is excellent in reactivity, and progresses polymerization and halogenation reactions of different types of vinyl monomers.

Radical Formation Mechanism of Azo Polymerization Initiators (Thermal Decomposition)



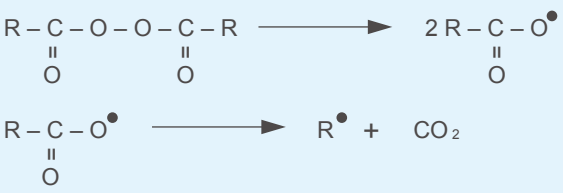
(1) Formation of radical: Azo polymerization initiators decompose with heat or light, and form nitrogen gas and carbon radicals.
*The decomposition rate (in solution) follows first-order reaction rate kinetics and aries due to structure differences.

(2) Initiation reaction/Propagation reaction: Azo polymerization initiator addition-polymerizes with vinyl monomers and forms a polymer.
*Since a section of the azo polymerization initiator is introduced at the end of polymer, the effect of end group is expected. The efficiency of common azo polymerization initiators is approximately 0.5-0.7, and the remaining results in (3) recombination or (4) disproportionation

(3) Recombination: The carbon radicals which did not engage in polymerization recombine.

(4) Disproportionation: The carbon radicals which did not engage in polymerization abstracts hydrogen of other carbon radicals.

Reference Radical Formation Mechanism of Peroxides



Where R is an alkyl.

$R\text{-}CO_2\cdot$ decomposes (decarboxylation) immediately, and $R\cdot$ starts polymerization.

Where R is an aryl,

$R\text{-}CO_2\cdot$ is hard to decompose (decarboxylation), so decarboxylation and addition reaction to monomers are competitive reactions. Therefore, $R\cdot$ or $R\text{-}CO_2$ are the radical active species.

Characteristics of Azo Polymerization Initiators and Comparison with Peroxides

Peroxides are used as an initiator for radical polymerization, in addition to azo polymerization initiators.

Characteristics of Azo Polymerization Initiators

- Azo polymerization initiators can be used safely as they do not decompose by induction and there is no risk of explosion.
- They decompose at a constant rate regardless of the solvent used, so they can be used with different solvents.
- Unlike the case of peroxides, the resulting carbon radical does not cause a hydrogen abstraction reaction, but forms linear polymers.

Comparison with Peroxides

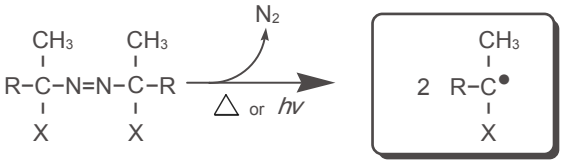
	Item	Azo Polymerization Initiator	Peroxide
Decomposability	Reversibility of decomposition	Irreversible reaction	Reversible reaction
	Efficiency of initiator	0.5 to 0.7	0.9 to 1
	Decomposition rate	First-order reaction rate equation shall apply.	Depends on additives and solvents.
	Solvent effect*1	Small	Large
	Induced decomposition	Not reactive	Reactive (Pay attention to contact with metal.)
	Redox*2 decomposition	Not reactive	Reactive (Forms redox system with a reducing substance)
Reactivity of Formed Radicals	Formed radical	RC •	RO •
	Hydrogen abstractability	Small	Large
	Graft/crosslinking polymer	Hard to occur	Easy to form.
	Formed polymer	Forms linear polymers.	Forms branched polymers.
Others	Gas generation	Reactive	Not reactive
	Oxdizability	Not reactive	Reactive

*1 Solvent effect: This means that the system is affected by polarization of hydrogen bonding, etc. depending on the types of solvent.

*2 Redox: Redox reaction is a chemical reaction that electrons are given and received between atoms, ions, or compounds in the process of formation of products from reactants.

Examples of radical reactions using Azo Polymerization Initiators

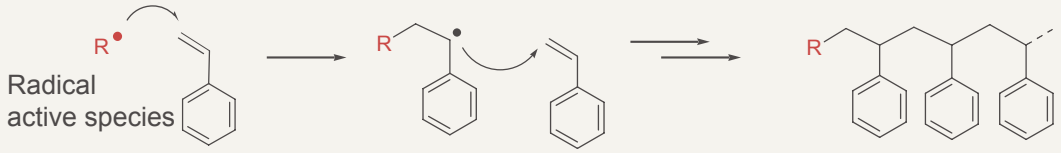
Azo polymerization initiators are used as catalyst and foaming agent in organic synthesis, in addition to in polymer synthesis.



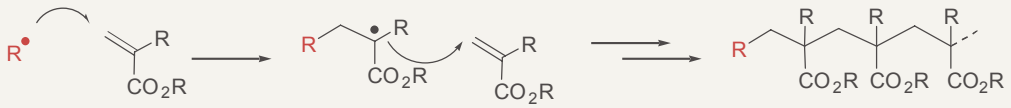
Carbon radical

Polymer Synthesis

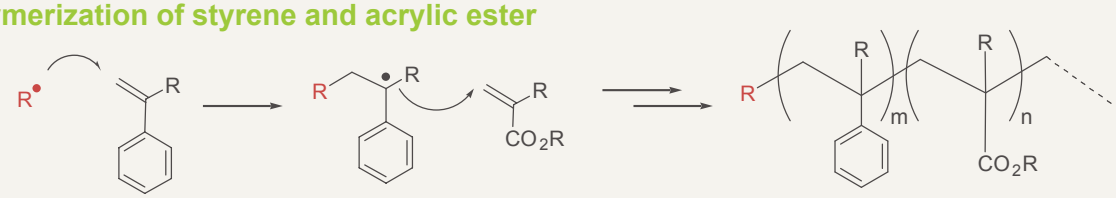
Radical polymerization of styrene



Radical polymerization of acrylic ester



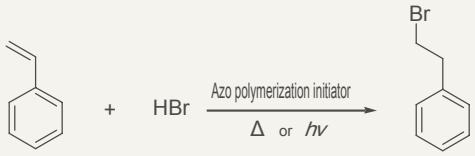
Copolymerization of styrene and acrylic ester



Catalyst for Organic Synthesis

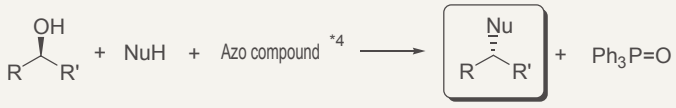
Addition reaction to olefins

Azo polymerization initiator can be used for addition reactions of HBr, H_2S, etc. to olefins. Especially, when using styrenes, bromine or mercapto groups may be selectively introduced to the β position.



Mitsunobu reaction[*3]

Azo compounds[*4] can be used as reagents for Mitsunobu reaction.



Foaming Agent

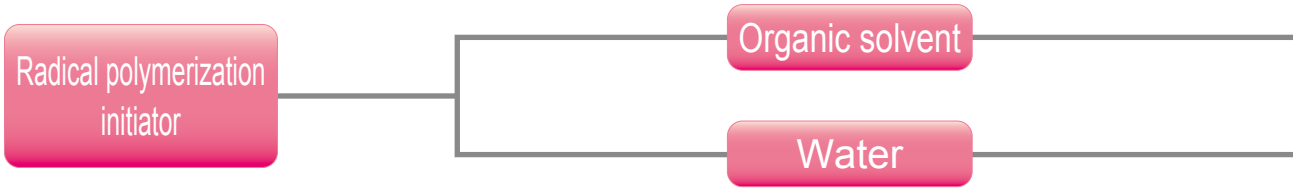
Azo polymerization initiators are used as foaming agents for vinyl chloride or other plastics, taking advantage of the property of generating nitrogen gas.

*3 Mitsunobu reaction: Sn2 (reaction) that activates hydroxyl group of alcohol with azo carboxylic acid ester and triphenylphosphine.
*4 Azo compounds: Bis (2-methoxyethl) azodicarboxylate, etc.

Selection Guide

Selection of Polymerization Process

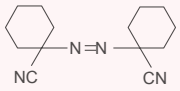
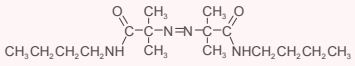
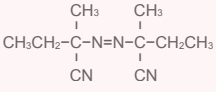
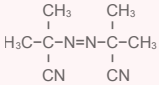
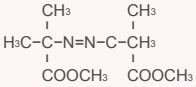
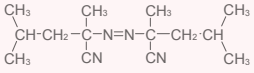
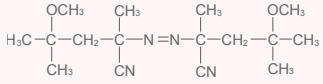
Step 1 Is polymerization process a radical reaction? Step 2 Is the solvent an organic solvent or water?



10-hour Half-life Temperature by Structure

We have azo polymerization initiators fit for a large extent of 10-hour half life temperature (*). You can select an initiator fit for your purpose.
(*10-hour half-life temperature: A temperature at which the concentration (amount) of azo group becomes a half in 10 hours in the solvent.)

Organic solvent soluble type (oil-solubility)

10-hour Half-life Temperature	Azo nitrile	Azo Ester	Azo Amide
110 °C	» P13 V-40 (88 °C) 		» P17 VAm-110 (110 °C) 
80 °C	» P12 V-59 (67 °C) 		
70 °C	» P12 AIBN (65 °C) *Metal-content-control-grade products are also available. 	» P15 V-601 (66 °C) *Metal-content-control-grade products are also available. 	
60 °C			
50 °C	» P11 V-65 (51 °C) *Metal-content-control-grade products are also available. 		
30 °C	» P11 V-70 (30 °C) 		

Step 3 Polymerization Method

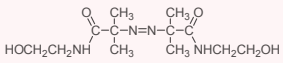
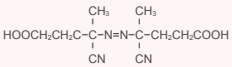
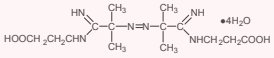
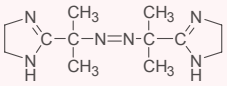
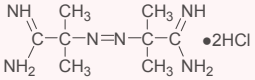
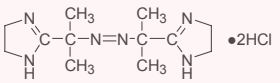
- **Suspension polymerization** — A polymerization method to heat the oil-soluble monomers in a dispersed condition in water (The initiator solves in monomers.)
- **Solution polymerization** — A polymerization method under which the initiator, monomers and formed polymers are all dissolved status.
- **Bulk polymerization** — A polymerization method under which liquid monomers are polymerized by itself or with adding the initiator.
- **Emulsion polymerization** — A polymerization method under which oil-soluble monomer is dispersed in water with emulsifying agent. (The initiator dissolves in water.)

Step 4 Polymerization Temperature

88 ºC	V-40
66 ºC	V-601
51 ºC	V-65
	etc

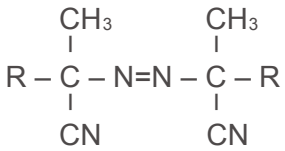
86 ºC	VA-086
56 ºC	V-50
44 ºC	VA-044
	etc

Water-soluble type (water solubility)

10-hour Half-life Temperature	Azo nitrile	Azo Amide	Azo Amidine	Azo Imidazoline
80 ºC		P17 VA-086 (86 ºC) 		
70 ºC	P13 V-501 (69 ºC) 			
60 ºC			P21 VA-057 (57 ºC) 	P19 VA-061 (61 ºC) 
50 ºC			P21 V-50 (56 ºC) 	
30 ºC				P19 VA-044 (44 ºC) 

Decomposition Product of Azo Polymerization Initiators

1. Formed Amount of each Decomposition Product of Azo Nitrile



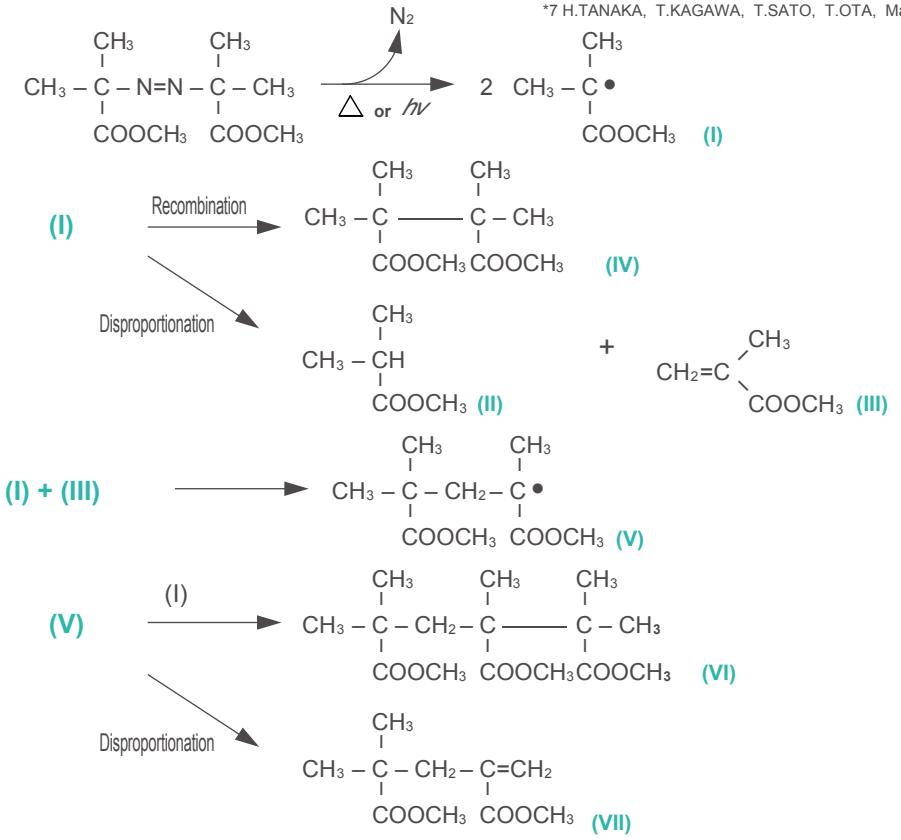
Ratio of decomposition product in the case of thermal decomposition with GC (%)

Compound Name	R	Disproportionation		Recombination	Polymer Unknown
					
AIBN	CH_3 *5	4	4	92	Trace
V-59	C_2H_5 *6	6	Trace	86	8
V-65	$(CH_3)_2CHCH_2$ *5	7	7	85	Trace
V-70	$CH_3OC(CH_3)_2CH_2$ *5	8	8	78	8
V-40	c-C_6H_{10} *5	9	9	82	1

*5 In-house Data *6 Polymer journal 9275 (1977)

2. Decomposition Product of V-601 (Special Case)*7

*7 H.TANAKA, T.KAGAWA, T.SATO, T.OTA, Macromolecules, 19(3), 934(1986)



Ratio of decomposition product in the toluene solution (%)

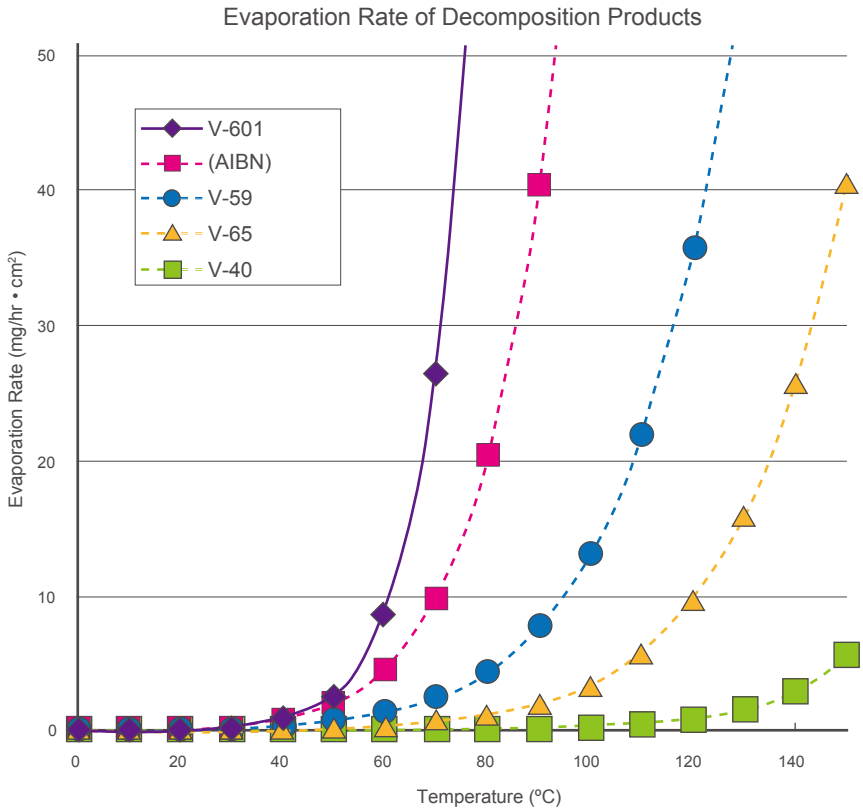
Decomposition Product	Thermal Decomposition (80 °C)	Photodecomposition (25 °C) (100 W HP Hg lamp)
IV	42.1	42.7
II	36.4	38.5
VI	13.8	13.8

3. Volatility of Decomposition Products

The decomposition product of V-601 is characterized by a higher volatility than that of AIBN. Also, the decomposition product of V-601 is azeotropic with water, therefore, thus can be easily removed from the post-reaction system.

- Boiling point of decomposition product of V-601: 85-90 ºC (5 mmHg)
- Azeotropic point of decomposition product of V-601 with water: 90 ºC

On the other hand, the decomposition product of V-40 is hardly volatile, therefore, applications such as paint are expected.



Solubility

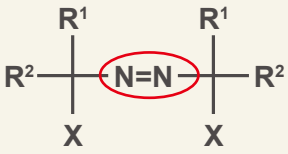
Oil-soluble Azo Polymerization Initiators (g/100 g solvent, ambient temperature)

	V-70	V-65	AIBN	V-601	V-59	V-40	VAm-110
Water	0.1	<0.1	<0.1	0.3	<0.1	0.1	<0.1
Methanol	1	28	7.5	>50	>50	4.4	>50
Acetone	3.3	>50	29	>50	>50	30	>50
Chloroform	20	>50	25	>50	>50	>50	>50
Ethyl Acetate	2.0	>50	14	>50	>50	15	>50
Toluene	3.0	>50	7.0	>50	>50	27	>50

Water-soluble Azo Polymerization Initiators (g/100 g solvent, ambient temperature)

	VA-044	V-50	VA-057	VA-086
Water	34.7	23.2	14.0	4.5
Methanol	1.7	2.1	28.8	7.4
Acetone	Not soluble	Not soluble	Not soluble	Not soluble
Ethyl Acetate	Not soluble	Not soluble	Not soluble	Not soluble
Toluene	Not soluble	Not soluble	Not soluble	Not soluble
N,N-Dimetylformamide	Not soluble	Not soluble	Not soluble	4.4

Reference Photocharacterization



Absorbs around 360 nm.

These products are decomposed by exiting of Azo (N=N) group by light irradiation. They are able to be used also as photo radical initiators.

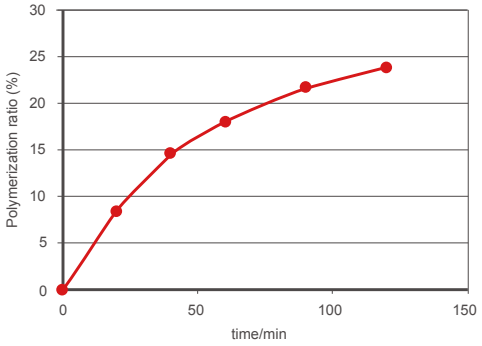
Photo Polymerization by Oil-Soluble Azo Polymerization Initiators

Photodecomposition Reaction Rate Constant

Solvent: Toluene
Light source: 100 W high-pressure mercury lamp

Azo Compound	MW	λmax (nm)	Molar Absorbance Coefficient ε (L/mol·cm)	$k_d \times 10^4$ (sec^{-1})
V-59	192.26	348	16	3.76
AIBN	164.21	347	13	3.97
V-40	244.34	350	17	4.13
V-601	230.26	368	14	4.43
V-65	248.37	350	22	4.86
VAm-110	312.45	376	30	8.01

Example of Photo Polymerization (Bulk Polymerization)



Monomer	Methyl methacrylate
Initiator	0.01 mol/l (ratio to monomer)
Light Source	100 W high-pressure mercury lamp

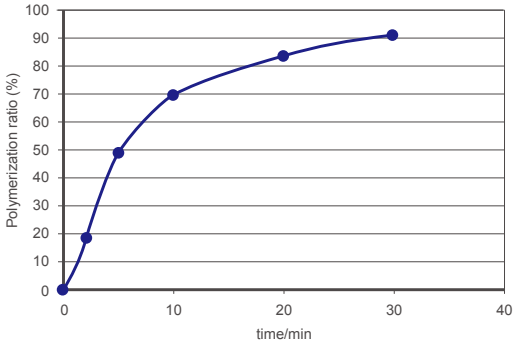
Photo Polymerization of Water-Soluble Azo Polymerization Initiators

Photodecomposition Reaction Rate Constant

Solvent: Water
Light source: 100 W high-pressure mercury lamp

Azo Compound	MW	λmax (nm)	Molar Absorbance Coefficient ε (L/mol·cm)	$k_d \times 10^4$ (sec^{-1})
V-50	271.19	367	22	5.37
VA-057	414.46	371	26	7.23
VA-044	323.33	363	23	7.53
VA-086	288.35	375	30	7.72

Example of Photo Polymerization (Solution Polymerization)



Monomer	Acrylamide 10 w/wt%
Initiator	0.01 mol/l (ratio to monomer)
Light Source	100 W high-pressure mercury lamp

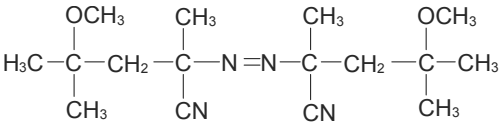
*Since photodecomposition reaction rate constant depends on the strength of light source, the above photodecomposition reaction rate constant is not an absolute value. However, since these are data measures with a same light source, these data can be used for relative comparison.

Detailed Explanations

1. Azo Nitrile

V-70

2,2'-Azobis(4-methoxy-2,4-dimethylvaleronitrile)



Low-temperature type

Oil-soluble type

Characteristics

V-70 is an oil-soluble azo polymerization initiator of which 10-hour half-life temperature is 30 ºC. V-70 can be used as a polymerization initiator for different types of vinyl monomers and a catalyst for organic radical reactions at a low temperature.

Properties

Item	
Molecular formula	$C_{16}H_{28}N_4O_2$
Molecular weight	308.43
CAS No.	15545-97-8
Form	nearly white, crystalline powder *Contains water.
Melting point	50-96(dec.) °C
10-hour half life temperature	30 ºC (Toluene)
Solubilities	water : practically insoluble. dichloromethane : freely soluble. acetonitrile, N,N-Dimethylformamide : soluble. methanol, acetone, toluene : slightly soluble.

Applicable Laws and Regulations

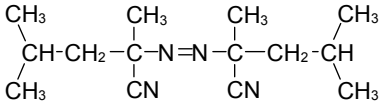
Item	
TSCA	Listed
EINECS	Listed

Packaging and Storage Requirements

Item	
Packaging	100 g
	25 kg
Storage requirement	Please keep at -10 ºC or less.

V-65

2,2'-Azobis(2,4-dimethylvaleronitrile)



Low-temperature type

Oil-soluble type

Characteristics:

When compared with AIBN, the 10-hour half-life temperature of this oil-soluble azo polymerization initiator is 10 ºC or lower than AIBN.
This product can be used for a wide range of applications, from versatile polymers to cosmetics-related use.

Properties

Item	
Molecular formula	$C_{14}H_{24}N_4$
Molecular weight	248.37
CAS No.	4419-11-8
Form	white, crystalline powder
Melting point	45-70(dec) °C
10-hour half life temperature	51 ºC (Toluene)
Solubilities	water : insoluble. benzene, acetone, ether, N,N-Dimethylformamide, toluene, methanol : soluble.

Applicable Laws and Regulations

Item	
TSCA	Listed
EINECS	Listed

Packaging and Storage Requirements

Item	
Packaging	500 g
	25 kg
Storage requirement	Please keep at 10 ºC or less.

V-65HP (Metal-content-control-grade products)

Semiconductors

LCD

Packaging and Storage Requirements

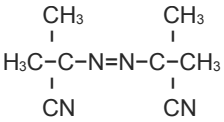
Item	
Packaging	500 g
	10 kg
Storage requirement	Please keep at 10 ºC or less.

Metal Content

Metal	Specification value
Na	500 ppb or less
Li,Mg,Al	300 ppb or less
K,Ca,Cr	
Mn,Fe,Ni	
Cu,Zn,Zr	
Pb,Sn	

AIBN

2,2'-Azobis(isobutyronitrile)



Oil-soluble type

Characteristics:

AIBN is the most common oil-soluble azo polymerization initiator, and is used for polymerization of versatile polymers.

Properties

Item	
Molecular formula	$C_8H_{12}N_4$
Molecular weight	164.21
CAS No.	78-67-1
Form	white, crystalline powder
Melting point	100-103(dec.) °C
10-hour half life temperature	65 °C (Toluene)
Solubilities	water : very slightly soluble. acetone : free soluble. methanol, toluene : soluble. Ethanol : sparingly soluble.

Applicable Laws and Regulations

Item	
TSCA	Listed
EINECS	Listed

Packaging and Storage Requirements

Packaging	20 kg
Storage requirement	Please keep at 20 °C or less.

AIBN-HP (Metal-content-control-grade products)

Semiconductors LCD

Packaging and Storage Requirements

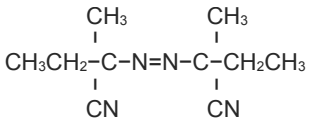
Item	
Packaging	500 g
	10 kg
Storage requirement	Please keep at 20 °C or less.

Metal Content

Metal	Specification value
Li,Na,Mg	500 ppb or less
Al,K,Ca	
Cr,Mn,Fe	
Ni,Cu,Zn	
Zr,Pb,Sn	

V-59

2,2'-Azobis (2-methylbutyronitrile)



Oil-soluble type

Characteristics:

V-59 is an oil-soluble azo polymerization initiator which shows almost a similar 10-hour half-life temperature to that of AIBN and has excellent solubility to many different solutions.

Properties

Item	
Molecular formula	$C_{10}H_{16}N_4$
Molecular weight	192.26
CAS No.	13472-08-7
Form	white, powder
Melting point	48 - 52 °C
10-hour half life temperature	67 °C (Toluene)
Solubilities	water : very slightly soluble. dimethyl sulfoxide : free soluble. toluene, methanol : Very soluble.

Applicable Laws and Regulations

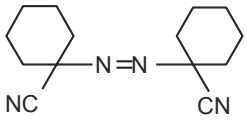
Item	
TSCA	Listed
EINECS	Listed

Packaging and Storage Requirements

Item	
Packaging	500 g
	10 kg
	25 kg
Storage requirement	Please keep at 10 °C or less.

V-40

1,1'-Azobis(cyclohexane-1-carbonitrile)



Characteristics:

Since the 10-hour half-life temperature is as high as 88 ºC, V-40 can be used to decrease residual monomer concentration when used with other initiators, such as V-65. This is an oil-soluble azo polymerization initiator which has a high solubility in various organic solvents. The decomposition product of V-40 has a unique characteristic of low volatility, therefore it could be useful for cow-voc paint applications.

High-Temperature Type | Oil-soluble type

Properties

Item	
Molecular formula	$C_{14}H_{20}N_4$
Molecular weight	244.34
CAS No.	2094-98-6
Form	white, crystals
Melting point	110-120 ºC
10-hour half life temperature	88 ºC (Toluene)
Solubilities	Water : practically insoluble. acetone, chloroform, benzene : freely soluble. Ethanol : soluble. petroleum ether : practically insoluble

Applicable Laws and Regulations

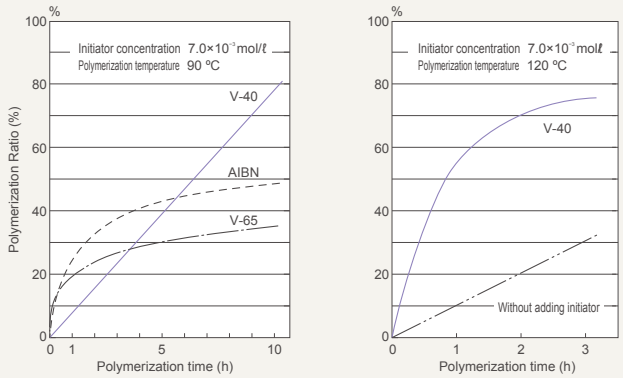
Item	
TSCA	Listed
EINECS	Listed

Packaging and Storage Requirements

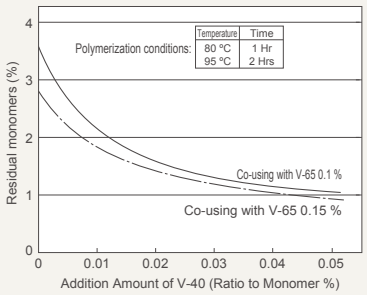
Item	
Packaging	500 g
	20 kg
Storage requirement	Please keep at 20 ºC or less.

Example of Polymerization

Block Polymerization of Styrene

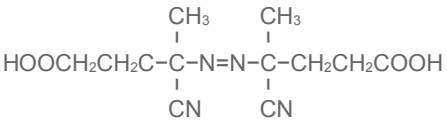


Suspension Polymerization of MMA by co-using with V-40 and V-65.
(Relationship between the addition amount of initiator and residual monomers)



V-501

4,4'–Azobis(4–cyanovaleric acid)



Characteristics:

V-501 is a nitrile-based water-soluble azo polymerization initiator, having a carboxyl group at the end. By introducing carboxyl group at polymer, post-polymerization mddification can be achieved.

Water-soluble type | Non-halogen F Cl Br I

Properties

Item	
Molecular formula	$C_{12}H_{16}N_4O_4$
Molecular weight	280.28
CAS No.	2638-94-0
Form	white, powder *Containing water
Melting point	120-123(dec.) °C
10-hour half life temperature	69 ºC (In water, as sodium salt)
Solubilities	water : practically insoluble. Ethanol, ether, formamide : freely soluble methanol : soluble. toluene : insoluble.

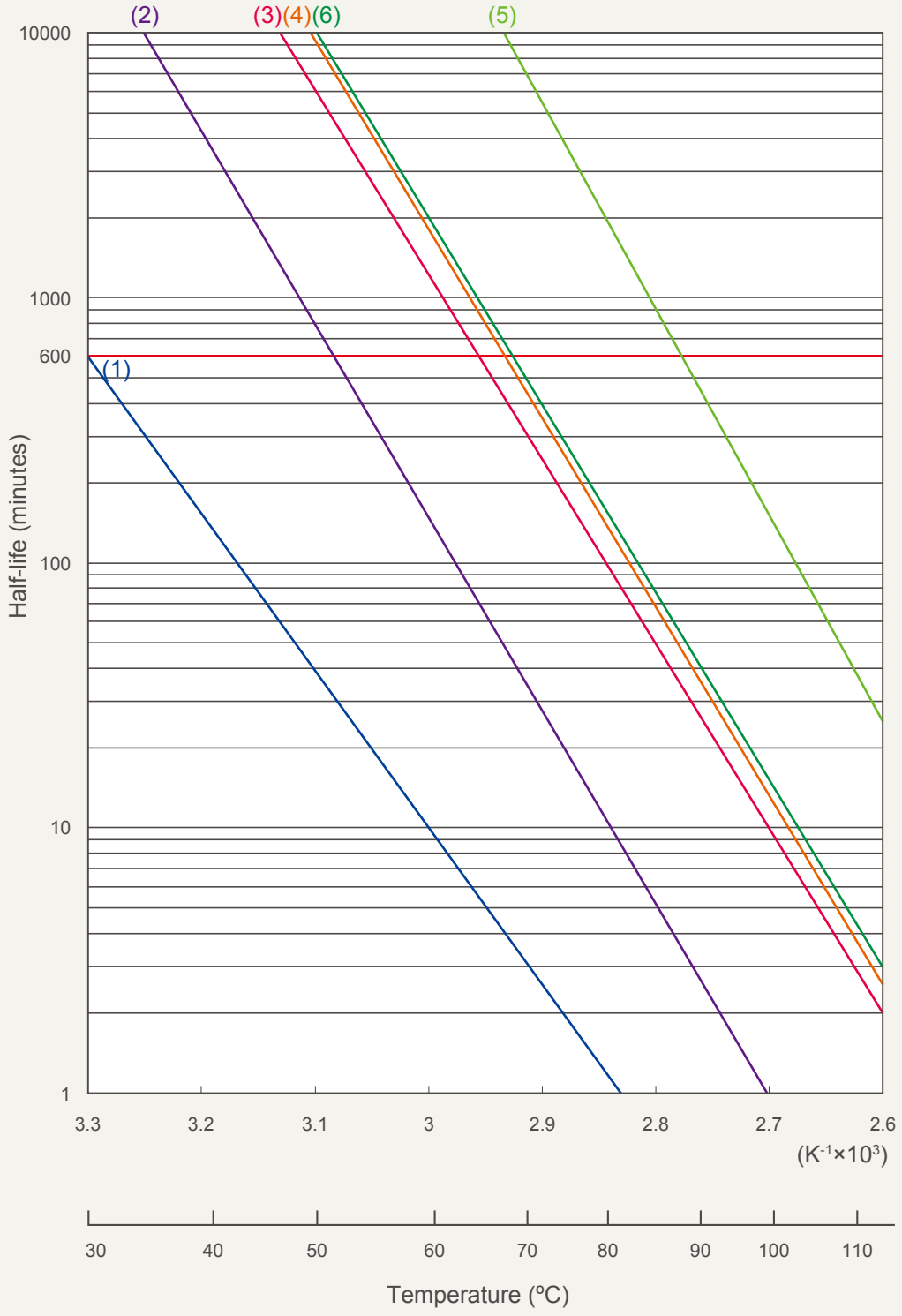
Applicable Laws and Regulations

Item	
TSCA	Listed
EINECS	Listed

Packaging and Storage Requirements

Item	
Packaging	500 g
	10 kg
Storage requirement	Please keep at 20 ºC or less.

Half-life of Azo Nitriles in Solution

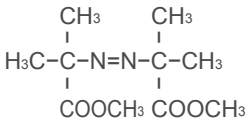


(1) V-70 **(2)** V-65 **(3)** AIBN **(4)** V-59 **(5)** V-40 **(6)** V-501

2. Azo Ester

V-601

Dimethyl 2,2'-azobis(2-methylpropionate)



Characteristics:

V-601 is a nitrile-free oil-soluble azo polymerization initiator which has similar level of polymerization activity as AIBN. A safer developed as alternative to AIBN, V-601 decomposition results in much less toxic byproducts. As a nitrile-free azo initiator, V-601 displays excellent solubility characteristics in organic solvents. Since the volatility of the decomposition product is higher than that of others, such a product can be removed in the process of polymer manufacturing. Being of non-nitrile type, the polymerized polymers are highly transparent, therefore, semiconductors and LCDs applications are expected.

Properties

Item	
Molecular formula	$C_{10}H_{18}N_2O_2$
Molecular weight	230.26
CAS No.	2589-57-3
Form	slight yellow or pale yellow, crystals or oily
Melting point	22-28 °C
10-hour half life temperature	66 °C (Toluene)
Solubilities	water : insoluble. benzene, Ethanol, N,N-Dimethylformamide, dioxane, DMSO : freely soluble. methanol, toluene, chloroform, hexane : soluble.

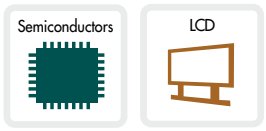
Applicable Laws and Regulations

Item	
TSCA	Listed (Listed under 5e Consent Order)
EINECS	Listed

Packaging and Storage Requirements

Item	
Packaging	500 g
	10 kg
Storage requirement	Please keep at 10 °C or less.

V-601HP (Metal-content-control-grade products)



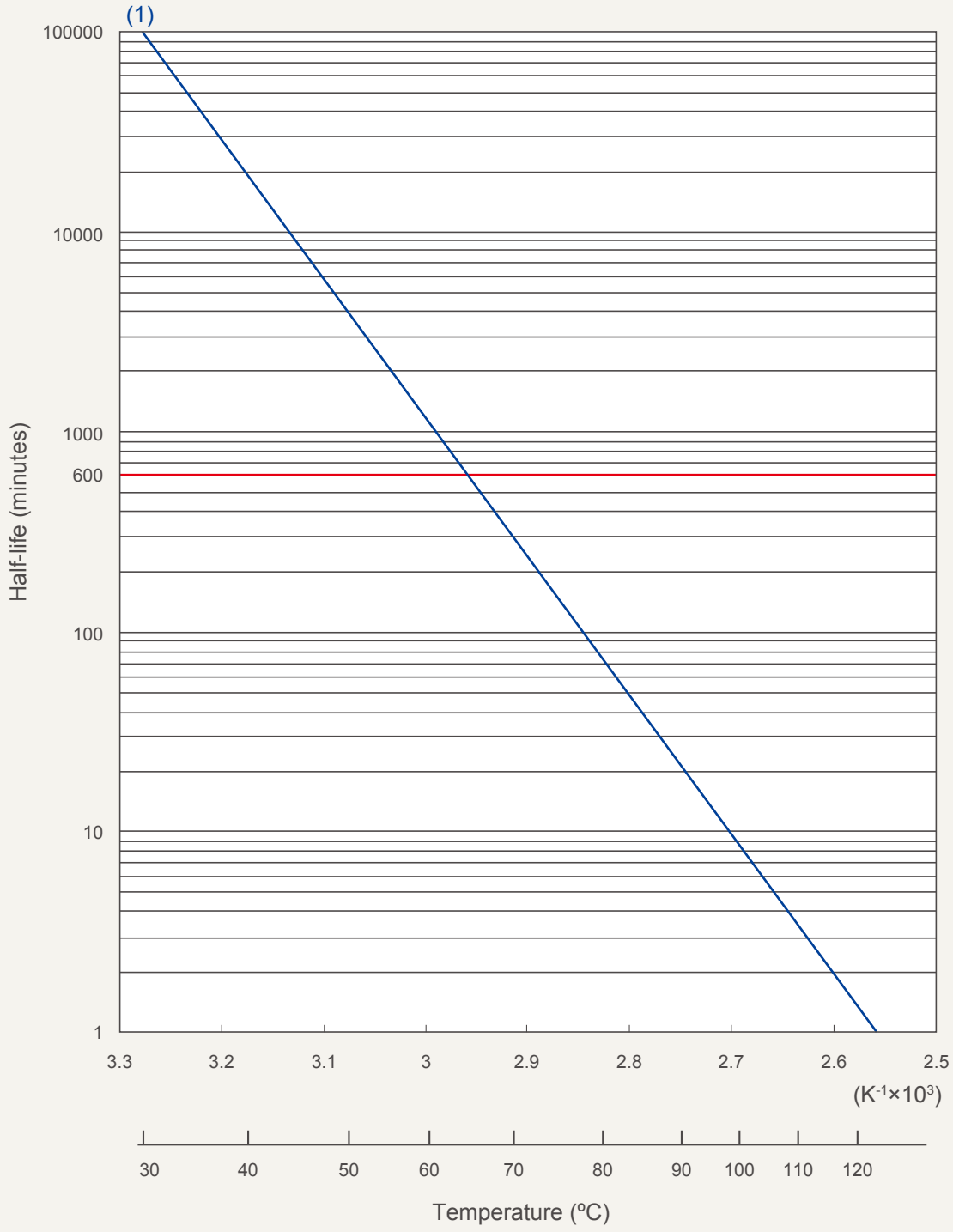
Packaging and Storage Requirements

Item	
Packaging	500 g
	10 kg
Storage requirement	Please keep at 10 °C or less.

Metal Content

Na	200 ppb or less
Li,Mg,Al	100 ppb or less
K,Ca,Cr	
Mn,Fe,Ni	
Cu,Zn,Zr	
Pb,Sn	

Half-life of Azo Esters in Solution

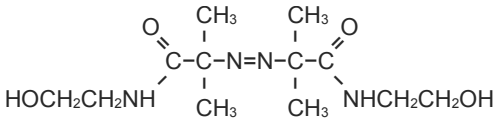


(1) V-601

3. Azo amide

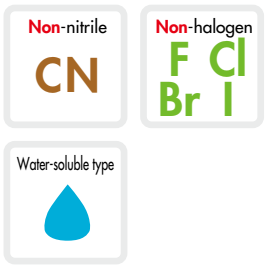
VA-086

2,2'-Azobis[2-methyl-*N*-(2-hydroxyethyl)propionamide]



Characteristics:

VA-086 is a non-ionic and non nitrile water-soluble azo polymerization initiator having a hydroxyl group at the end. The 10-hour half-life temperature is as high as 86 ºC, therefore, reduction of residual monomer can be expected by co-using it with another initiator.



Properties

Item	
Molecular formula	$C_{12}H_{24}N_4O_4$
Molecular weight	288.35
CAS No.	61551-69-7
Form	white - slightly yellow, crystalline powder
Melting point	138-145(dec.) °C
10-hour half life temperature	86 ºC (Water)
Solubilities	water, methanol : soluble. chloroform : slightly soluble

Applicable Laws and Regulations

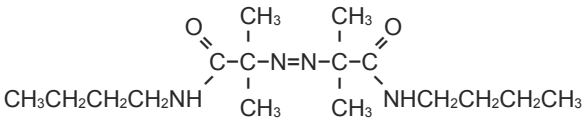
Item	
TSCA	Listed
EINECS	Not Listed

Packaging and Storage Requirements

Item	
Packaging	500 g
	5 kg
Storage requirement	Please keep at 25 ºC or less.

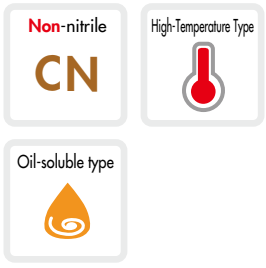
VAm-110

2,2'-Azobis (*N*-butyl-2-methylpropionamide)



Characteristics:

VAm-110 is an oil-soluble azo polymerization initiator which is active in high temperatures, the 10-hour half-life temperature is as high as 110 ºC. This product has characteristics which show high solubility to different organic solvents.



Properties

Item	
Molecular formula	$C_{16}H_{32}N_4O_2$
Molecular weight	312.46
CAS No.	195520-32-2
Form	slight yellow powder
Melting point	65 °C
10-hour half life temperature	110 ºC (Ethylbenzene)
Solubilities	Water : insoluble. methanol, ethyl acetate, toluene, methyl ethyl ketone : freely soluble.

Applicable Laws and Regulations

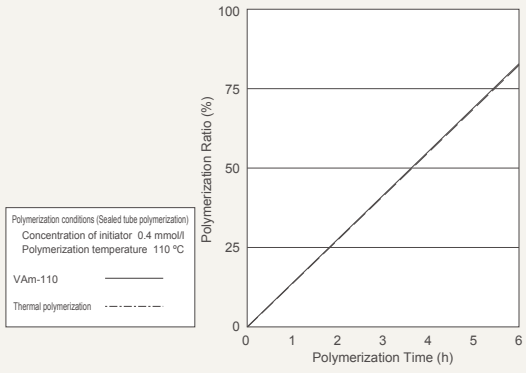
Item	
TSCA	Not Listed
EINECS	Not Listed

Packaging and Storage Requirements

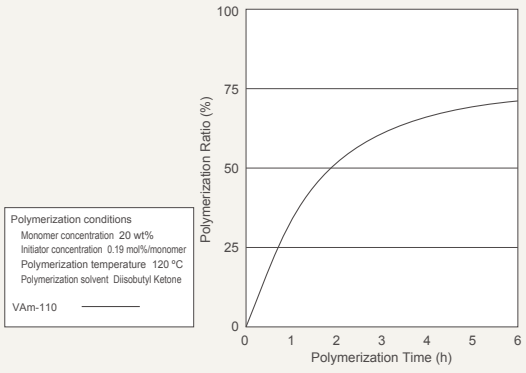
Item	
Packaging	500 g
	5 kg
Storage requirement	Please keep at 25 ºC or less.

Examples of polymerization

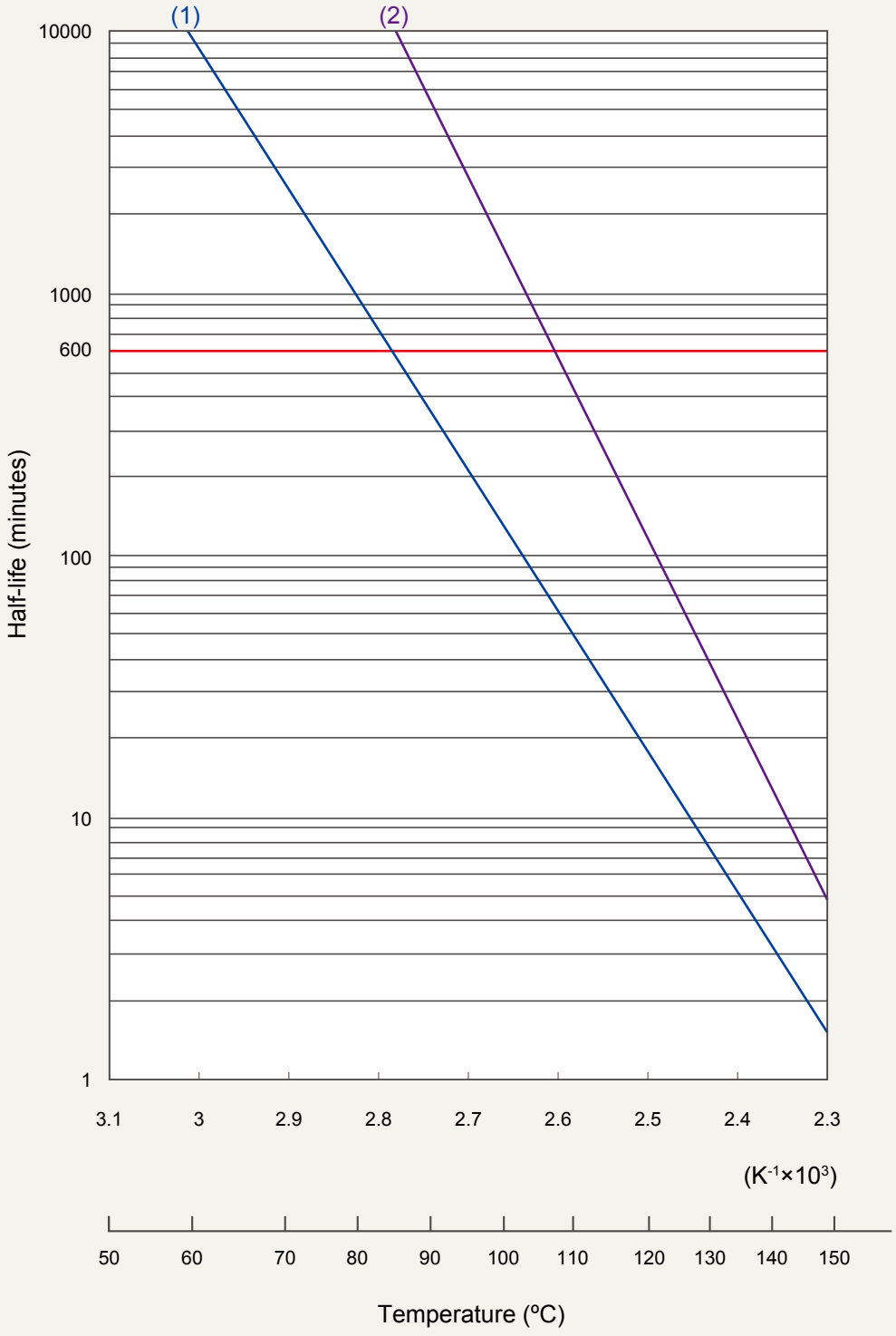
Bulk Polymerization of Styrene



Solution Polymerization of n-Butyl methacrylate



Half-Life of Azo Amides in Solution

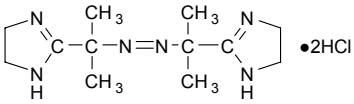


(1) VA-086 (2) VAm-110

4. Azo Imidazolin

VA-044

2,2'-Azobis[2-(2-imidazolin-2-yl)propane]dihydrochloride



Characteristics: VA-044 is a non-nitrile, cationic water-soluble azo polymerization initiator. It is highly effective for the polymerization of water-soluble vinyl monomer. The 10-hour half-life temperature is as low as 44 ºC, and the product is active at low temperatures.

Non-nitrile CN

Low-temperature type

Water-soluble type

Properties

Item	
Molecular formula	$C_{12}H_{24}Cl_2N_2$
Molecular weight	323.27
CAS No.	27776-21-2
Form	white - light yellow crystals or crystalline powder
Melting point	188-193(dec.) °C
10-hour half life temperature	44 ºC (Water)
Solubilities	water : free soluble. methanol : sparingly soluble. Ethanol : very slightly soluble. acetone, toluene : insoluble.

Applicable Laws and Regulations

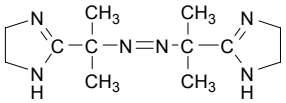
Item	
TSCA	Listed
EINECS	Listed

Packaging and Storage Requirements

Item	
Packaging	500 g
	20 kg
Storage requirement	Please keep at 40 ºC or less.

VA-061

2,2'-Azobis[2-(2-imidazolin-2-yl)propane]



Characteristics: VA-061 is the free base of VA-044 and VA-046B, which are water-soluble azo polymerization initiators. By forming salts with different organic acids, the product dissolves in water, creating a highly effective initiator for polymerization of water-soluble vinyl monomers.

Non-nitrile CN

Non-halogen F Cl Br I

Water-soluble type

Properties

Item	
Molecular formula	$C_{12}H_{22}N_6$
Molecular weight	250.35
CAS No.	20858-12-2
Form	slightly yellowish white, crystalline powder
Melting point	115-125(dec.) °C
10-hour half life temperature	61 ºC (Methanol)
Solubilities	water : practically insoluble. methanol : soluble. Ethanol, chloroform : slightly soluble. toluene : insoluble. *Acid: Soluble

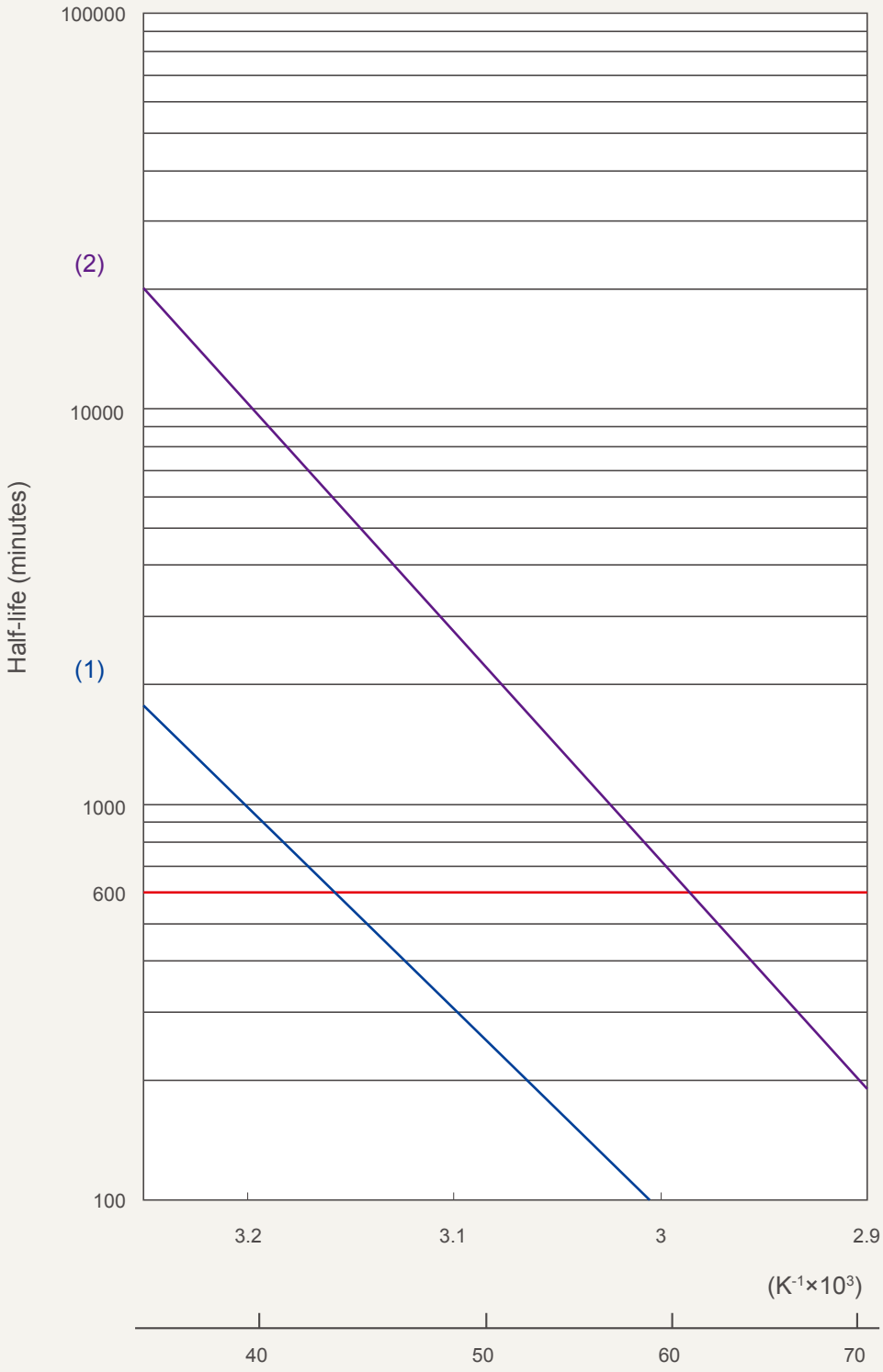
Applicable Laws and Regulations

Item	
TSCA	Listed
EINECS	Listed

Packaging and Storage Requirements

Item	
Packaging	500 g
	5 kg
Storage requirement	Please keep at 10 ºC or less.

Half-Life of Azo Imidazolines in Solution

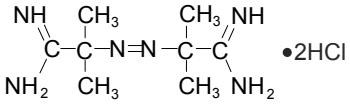


(1) VA-044 (2) VA-061

5. Azo Amidine

V-50

2,2'-Azobis(2-methylpropionamidine)dihydrochloride



Characteristics:

V-50 is a highly active water-soluble azo polymerization initiator. A variety of polymerization applications can be expected. This product is uniquely characterized by the amidine group which is cationic. Cationic emulsions, latex, etc. can be synthesized easily and in a stable manner, therefore an excellent effect can be expected for emulsion polymerization of synthetic rubber, adhesives, etc.

Properties

Item	
Molecular formula	$C_8H_{20}Cl_2N_6$
Molecular weight	271.19
CAS No.	2997-92-4
Form	nearly white, Granular
Melting point	160-169(dec.) °C
10-hour half life temperature	56 °C (Water)
Solubilities	water : freely soluble. methanol, Ethanol, acetone, N,N-Dimethylformamide, dioxane : practically insoluble.

Applicable Laws and Regulations

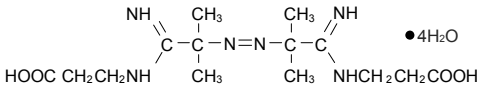
Item	
TSCA	Listed
EINECS	Listed

Packaging and Storage Requirements

Item	
Packaging	500 g
	5 kg
	20 kg
Storage requirement	Please keep at 40 °C or less.

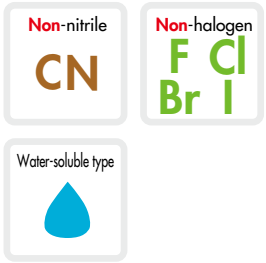
VA-057

2,2'-Azobis[*N*-(2-carboxyethyl)-2-methylpropionamidine]tetrahydrate



Characteristics:

VA-057 is a water-soluble azo polymerization initiator which has a zwitterinoic structure. The 10-hour half-life temperature is 57 °C, which allows a polymerization under a mild condition. As a non-halogenated initiator, VA-057 is uniquely characterized by not causing any concerns about coloring of polymer or corrosion of polymerization facilities with halogen. Since the product has a zwitterionic structure, formation of both cationic and anionic latex is expected.



Properties

Item	
Molecular formula	$C_{14}H_{34}N_6O_8$
Molecular weight	414.46
CAS No.	1041483-94-6 (n-hydrate)
Form	white - pale yellow powder - crystalline powder
Melting point	97(dec.) °C
10-hour half life temperature	57 °C (Water)
Solubilities	water, methanol : free soluble. Ethanol, isopropanol, acetone, toluene : very slightly soluble.

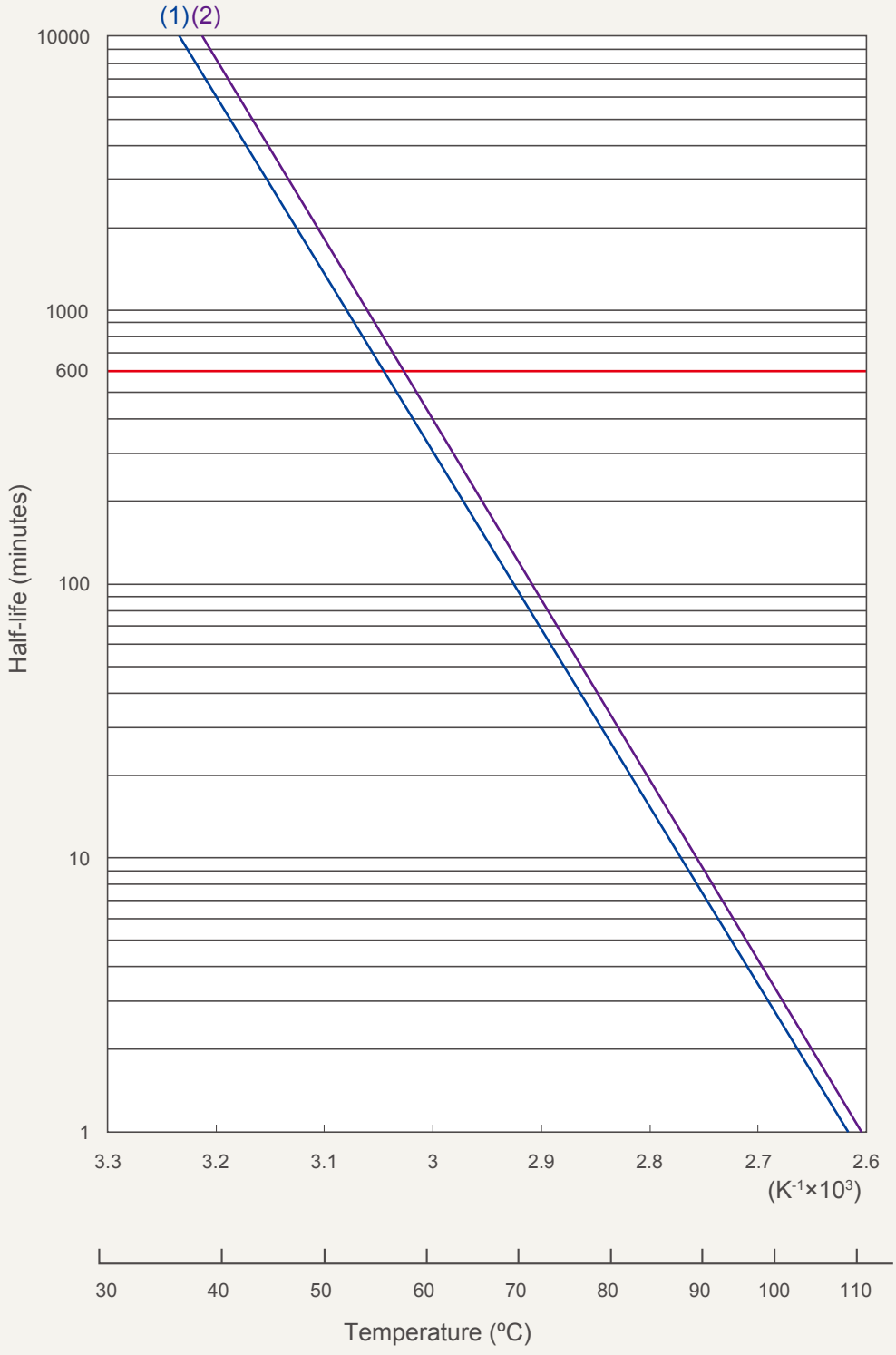
Applicable Laws and Regulations

Item	
TSCA	Not Listed
EINECS	Not Listed

Packaging and Storage Requirements

Item	
Packaging	500 g
	5 kg
Storage requirement	Please keep at 10 °C or less.

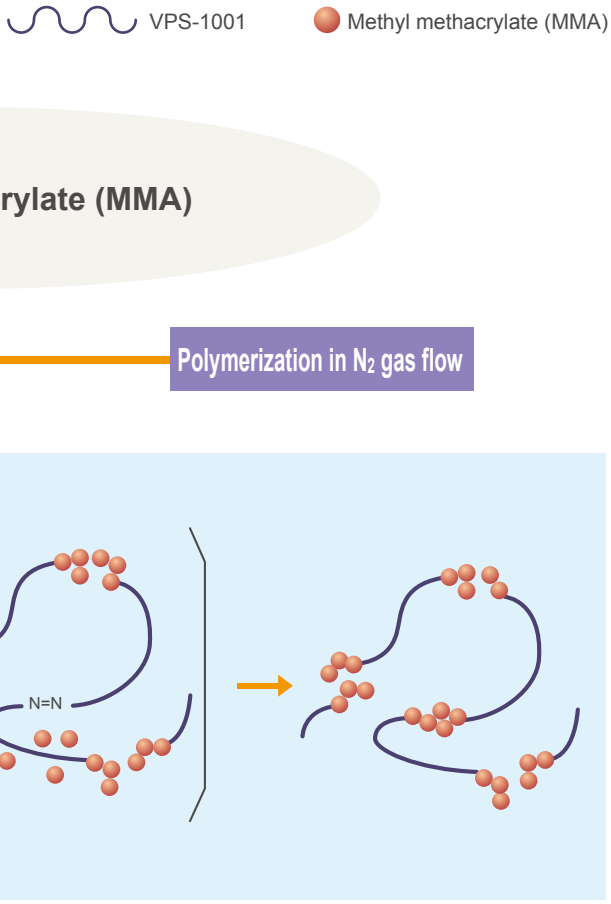
Half-Life of Azo Amidines in Solution



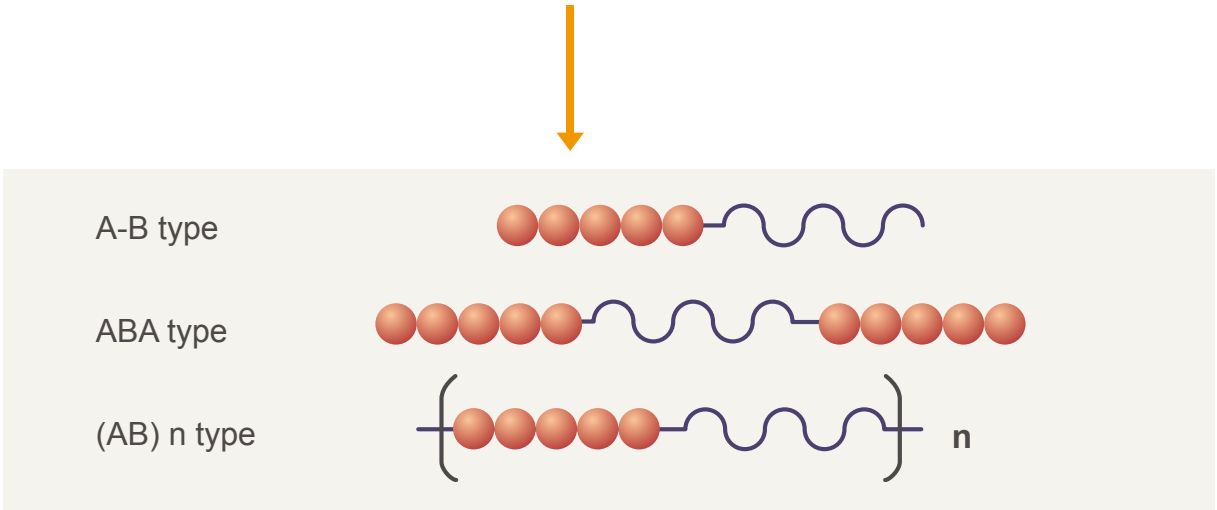
(1) V-50 (2) VA-057

What is a Macro Azo Initiator?

Macro Azo Initiator (MAI) is a unique azo compound which gives block polymer easily through a polymerization with different vinyl monomers. MAI has a structure in which polymer segment and azo group are repeatedly bonded, and there are several radical forming points in a molecule. Therefore, when monomers are polymerized, polymers with high blocking efficiency can be designed. Since this product is soluble in different solvents, various polymerization methods (solution polymerization, suspension polymerization and emulsion polymerization) can be adopted. This product offers a wide range of options of monomers for co-polymerization, and allows molecule design and structure control of block polymers fit for the purpose.



The process from the start of polymerization with azo groups in polymers to the growing of block polymers is shown in a schematic drawing.

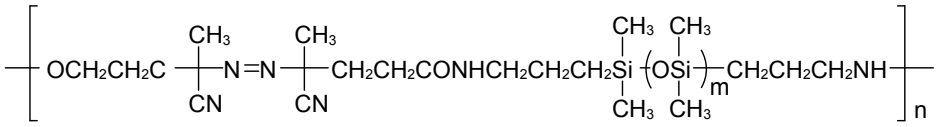


Conceptual Drawing

6. Macro Azo Initiator (MAI : Macro Azo Initiator)

VPS-1001 VPS-1001N

4,4-Azobis(4-cyanovaleric acid),polymer with alpha, omega-bis(3-aminopropyl)polydimethylsiloxane



Characteristics:

In the block polymer obtained by this product, polydimethylsiloxane and vinyl polymer are chemically bonded. Therefore, the product is completely new co-polymer having the characteristics of the two materials. This product has fundamentally different characteristics from a polymer alloy, which is formed only by blending. The largest advantage of this product is its ability to combine polydimethylsiloxane with a polymer material which hardly has a compatibility, therefore the properties of polydimethylsiloxane (heat resistance, cold resistance, weathering resistance, abrasion resistance, water repellency, electric insulation, bio-affinity, gas permeability, lubricity, surface gloss, etc.) are possibly reflected to the material.

Emulsion polymerization

Suspension polymerization

Solution polymerization

Applicable Laws and Regulations

Item	
TSCA	Not Listed
EINECS	Not Listed

Forms and molecular weight of different types

Item	VPS-1001	VPS-1001N (solvent contained)
Molecular formula	$[C_{20}H_{34}N_6O_2Si(C_2H_6Si)m]n$	
CAS No.	158947-07-0	
Form	clear gum	white
Molecular weight of macro initiator (Mn)	Approximately 80,000 to 120, 000	
Molecular weight of polydimethylsiloxane	Approximately 10,000	
Molecular number of azo group per 1 g of VPS	Approximately 0.1 mmol/g (1/60 of AIBN)	
10-hour half life temperature	65 - 70 ºC	

*Compared with mol number of azo group per 1 g of AIBN (M.W.: 164.21) = 6 mmol/g.

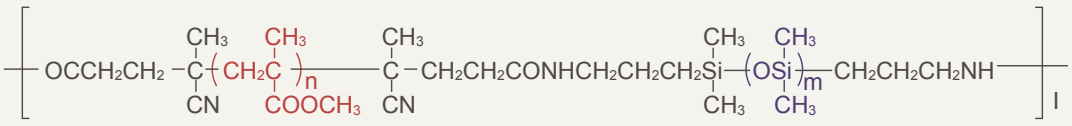
Packaging and Storage Requirements

Item	VPS-1001	VPS-1001N
Packaging	500 g	Net 5 kg
	5 kg	
Storage requirement	Please keep at 10 ºC or less.	

Example of polymerization

In a four necked flask equipped with a thermometer, nitrogen gas induction tube, mixer, and reflux condenser, 25 g of VPS-1001, 100 g of methyl methacrylate (MMA) as monomer, and 260 g of toluene as solvent are charged and polymerized under the nitrogen gas flow at 70 ºC and for five hours.

[Formed Block Polymer (BP)]



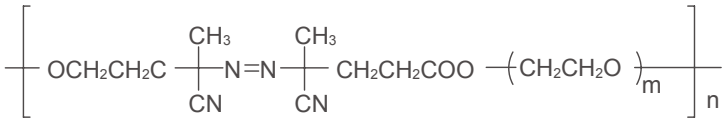
Methyl polymethacrylate segment

Polydimethylsiloxane segment

Formed Block Polymer – Molecular Weight Data			
Mn	Mw	Mw/Mn	Content of polydimethylsiloxane segment in BP
80,700	149,000	1.85	31 %

VPE-0201

4,4'-Azobis(4-cyanopentanoicacid)·Polyethyleneglycolpolymer



Characteristics:

This product is an amphipathic macro azo initiator which is soluble both in water-base and organic solvent-base solvents, having a structure in which several polyethylene oxide segments are combined by the intermediary of azo group. When used for polymerization of vinyl monomers, this product forms a block polymer with a structure in which polyethylene oxide and vinyl polymers are chemically bonded, therefore the properties of polyethylene oxide (hydrophilicity of polymer, prevention of static charge, improvement of dispersity, addition of compatibility, prevention of dulling, etc.) are possibly reflected to the material.

Emulsion polymerization | Suspension polymerization | Solution polymerization

Applicable Laws and Regulations

Item	
TSCA	Not Listed
EINECS	Not Listed

Forms and molecular weight of different types

Item	
Molecular formula	$[C_{12}H_{14}N_4O_3(C_2H_4O)m]n$
CAS No.	105744-24-9
Form	white, powder
Molecular weight of macro initiator (Mn)	Approximately 15,000 to 30, 000
Molecular weight of polyethylene oxide	Approximately 2,000
Molecular number of azo group per 1 g of VPE	Approximately 0.45 mmol/g (1/14 of AIBN)
10-hour half life temperature	65 - 70 ºC

*Compared with mol number of azo group per 1 g of AIBN (M.W.: 164.21) = 6 mmol/g.

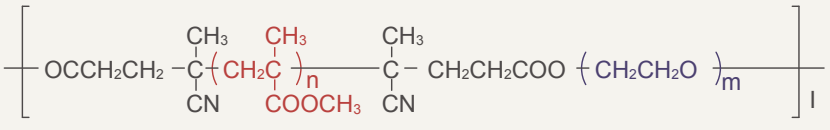
Packaging and Storage Requirements

Item	
Packaging	500 g 5 kg
Storage requirement	Please keep at 10 ºC or less.

Example of polymerization

In a four necked flask equipped with a thermometer, nitrogen gas induction tube, mixer, and reflux condenser, 20 g of VPE-0201, 80 g of methyl methacrylate (MMA) or styrene as monomer, and 300 g of toluene as solvent are charged and polymerized under the nitrogen gas flow at 80 ºC and for eight hours.

[Formed Block Polymer (BP)] *When using methyl methacrylate (MMA) as monomer



Methyl polymethacrylate segment

Polyethylene oxide segment

Formed Block Polymer – Molecular Weight Data				
Monomer	Mn	Mw	Mw/Mn	Content of polyethylene oxide segment in BP
MMA	53,200	77,800	1.46	21 %
Styrene	61,200	160,200	2.62	21 %

■ Reference Data on Polymerization

Change of Polymerization Ratio in Solution Polymerization

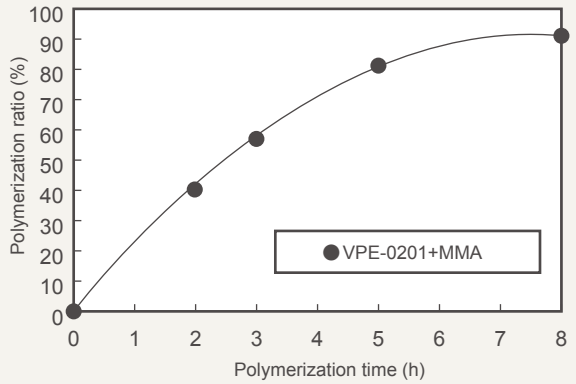
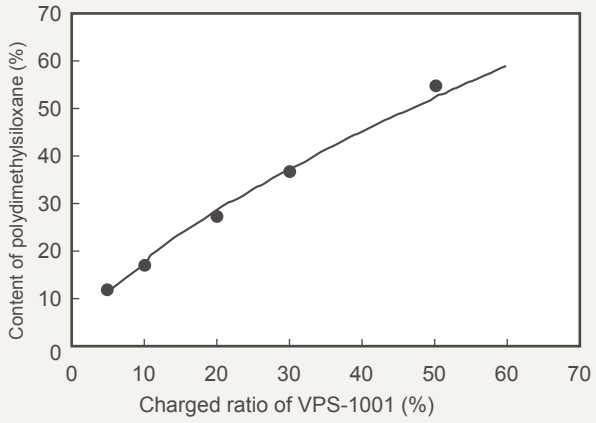


Figure 2: Change of Polymerization Ratio in Solution Polymerization

[Polymerization conditions]

VPE-0201	:	12.5 g
MMA	:	100 g
Toluene	:	260 g
Polymerization temperature	:	70 ºC

Control of Polydimethylsiloxane Amount Introduced to Block Polymer



[Polymerization conditions]

Initiator : VPS-1001
Monomer : MMA
Solvent : Toluene

Charged ratio : (Initiator + Monomer)/Solvent = 1/2
Polymerization temperature : 70 ºC
Polymerization time : 8 hours
Purification by crystallization with methanol

*Cautions at the time of Block Polymer Structure Design

Macro Azo Initiator can quantitatively introduces its segment into the block polymer in accordance with the charged amount of macro azo initiator under the selected polymerization conditions.

However, when compared with general low monocular azo polymerization initiator, the number of azo group per unit weight is smaller. Therefore, the charge amount of macro azo initiator should be considered based on the concentration of the azo group fit for polymerization. For example, when conducting a toluene solvent polymerization of VPS-1001, the charge ratio of VPS-1001 is generally to be set to 10 to around 70 % of the block polymer ingredients (polymer azo initiator + monomer).

Product List

■Azo Polymerization Initiators

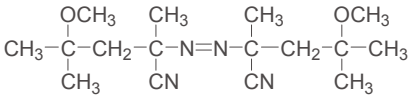
Azo Nitriles

Oil-soluble type

V-70 2,2'-Azobis(4-methoxy-2,4-dimethylvaleronitrile)

CAS No. 15545-97-8

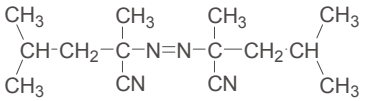
100 g	
25 kg	



V-65 2,2'-Azobis(2,4-dimethylvaleronitrile)

CAS No. 4419-11-8

500 g	
25 kg	



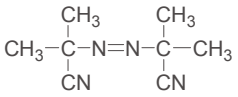
V-65HP (Metal-content-control-grade products)

500 g	
10 kg	

AIBN 2,2'-Azobis(isobutyronitrile)

CAS No. 78-67-1

20 kg	



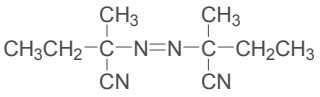
AIBN-HP (Metal-content-control-grade products)

500 g	
10 kg	

V-59 2,2'-Azobis(2-methylbutyronitrile)

CAS No. 13472-08-7

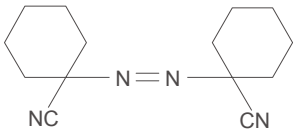
500 g	
10 kg	
25 kg	



V-40 1,1'-Azobis(cyclohexane-1-carbonitrile)

CAS No. 2094-98-6

500 g	
20 kg	

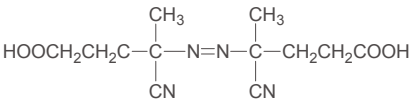


Water-soluble type

V-501 4,4'-Azobis(4-cyanovaleric acid)

CAS No. 2638-94-0

500 g	
10 kg	



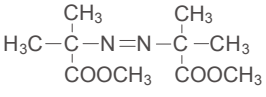
Azo Esters

Oil-soluble type

V-601 Dimethyl 2,2'-azobis(2-methylpropionate)

CAS No. 2589-57-3

500 g	
10 kg	



V-601HP (Metal-content-control-grade products)

500 g	
10 kg	

Product List

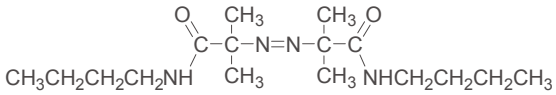
Azo Amides

Oil-soluble type

VAm-110 2,2'-Azobis(*N*-butyl-2-methylpropionamide)

CAS No. 195520-32-2

500 g
5 kg

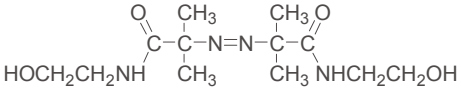


Water-soluble type

VA-086 2,2'-Azobis[2-methyl-*N*-(2-hydroxyethyl)propionamide]

CAS No. 61551-69-7

500 g
5 kg



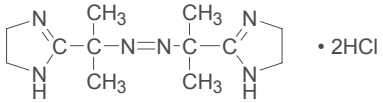
Azo Imidazolines

Water-soluble type

VA-044 2,2'-Azobis[2-(2-imidazolin-2-yl)propane]dihydrochloride

CAS No. 27776-21-2

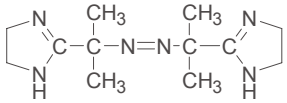
500 g
20 kg (4×5 kg)



VA-061 2,2'-Azobis[2-(2-imidazolin-2-yl)propane]

CAS No. 20858-12-2

500 g
5 kg



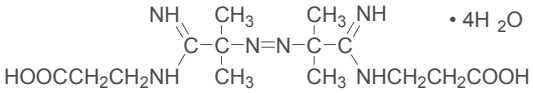
Azo Amidines

Water-soluble type

VA-057 2,2'-Azobis[*N*-(2-carboxyethyl)-2-methylpropionamidine]tetrahydrate

CAS No. 1041483-94-6 (n-hydrate)

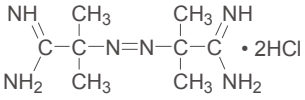
500 g
5 kg



V-50 2,2'-Azobis(2-methylpropionamidine)dihydrochloride

CAS No. 2997-92-4

500 g
5 kg
20 kg (4×5 kg)



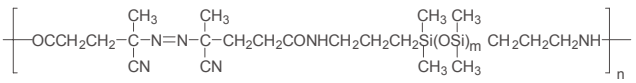
Macro Azo Initiators

Oil-soluble type

VPS-1001 4,4-Azobis(4-cyanovalericacid),polymer withalpha,omegabis(3-aminopropyl)polydimethylsiloxane

CAS No. 158947-07-0

500 g
5 kg



VPS-1001N

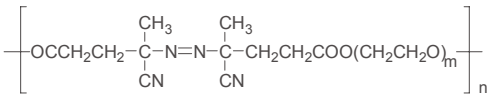
Net5 kg

Water-soluble type

VPE-0201 4,4'-Azobis(4-cyanopentanoicacid) • Polyethyleneglycolpolymer

CAS No. 105744-24-9

500 g
5 kg

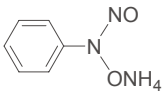


List of Related Items

■Polymerization Inhibitors

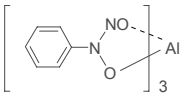
Q-1300 Ammonium *N*-nitrosophenylhydroxylamine

CAS No. 135-20-6			
	032-04902	25g	reagent product
	872-40408	500g	
	874-40402	5kg	



Q-1301 *N*-Nitrosophenylhydroxylamine aluminium salt

CAS No. 15305-07-4			
	143-04562	25g	reagent product
	872-40501	1kg	
	870-40502	5kg	



TBHQ 2-*tert*-Butylhydroquinone

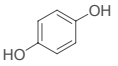
CAS No. 1948-33-0			
	027-07212	25g	reagent product
	021-07215	500g	reagent product
	905-41706	15kg	

p-Benzoquinone

CAS No. 106-51-4			
	171-00242	25g	reagent product
	175-00245	500g	reagent product

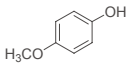
Hydroquinone

CAS No. 123-31-9			
	085-01212	25g	reagent product
	089-01215	500g	reagent product



p-Methoxyphenol

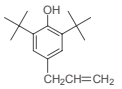
CAS No. 150-76-5			
	084-01282	25g	reagent product
	088-01285	500g	reagent product



■Resin Modifiers

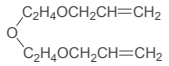
TRIAM®-100 4-Ally-2,6-di-*tert*-butylphenol

CAS No. 13677-69-5			
	741-10436	100g	



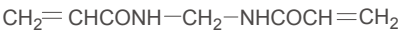
TRIAM®-501 Diethyleneglycol diallyl ether

CAS No. 57947-82-7			
	902-11600	500g	



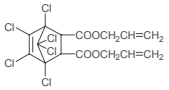
TRIAM®-507 *N*,*N*' -Methylenebis(acrylamide)

CAS No. 110-26-9			
	904-41411	1kg	
	902-41412	5kg	



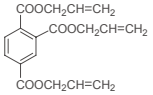
TRIAM®-605 Diallyl chlorendate

CAS No. 3232-62-0			
	904-40534	20kg	



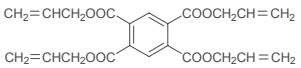
TRIAM®-705 Triallyl trimellitate

CAS No. 2694-54-4			
	909-40246	500g	
	903-40244	20kg	



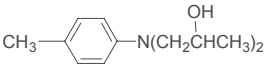
TRIAM®-805 Tetraallyl pyromellitate

CAS No. 13360-98-0			
	863-43710	500g	
	868-43726	3kg	



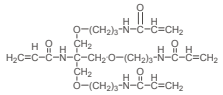
Accelerator A *N*,*N*-Bis(2-hydroxypropyl)-p-toluidine

CAS No. 38668-48-3			
	715-10333	10kg	



N-[Tris(3-acrylamidopropoxymethyl)methyl]acrylamide

CAS No. 1393329-90-2			
	201-20051	5g	reagent product
	209-20052	25g	reagent product



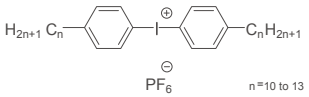
List of Related Items

■Photo Cationic Initiators (WPI Series)

WPI-113 (50 % Propylene carbonate solution) Bis[4-*n*-alkyl (C10 to 13) phenyl]iodonium hexafluorophosphate

CAS No. 477602-76-9

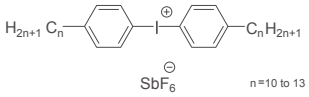
932-11706	100g	



WPI-116 (50 % Propylene carbonate solution) Bis[4-*n*-alkyl (C10 to 13) phenyl]iodonium hexafluoroantimonate

CAS No. 71786-70-4

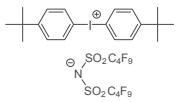
930-12606	10g	



WPI-169 Bis (4-*tert*-butylphenyl) iodonium bis (perfluorobutansulfonyl) imide

CAS No. 524067-97-8

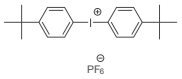
865-26310	100g	



WPI-170 Bis (4-*tert*-butylphenyl) iodonium hexafluorophosphate

CAS No. 61358-25-6

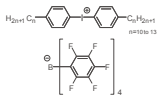
937-40809	5g	



WPI-124 (50 % Propylene carbonate solution) Bis[4-*n*-alkyl (C10 to 13) phenyl]iodonium tetrakispentafluorophenylborate

CAS No. 210290-42-9

934-12506	10g	
932-12507	100g	

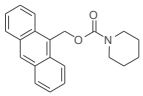


■Photo Base Generators (WPBG Series)

WPBG-015 9-Anthrylmethyl Piperidine-1-carboxylate

CAS No. 1228312-02-4

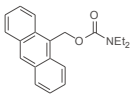
359-33631	1g	reagent product
355-33633	5g	reagent product



WPBG-018 9-Anthrylmethyl *N*,*N*-diethylcarbamate

CAS No. 1228312-05-7

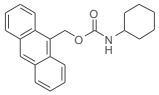
356-33641	1g	reagent product
352-33643	5g	reagent product



WPBG-041 9-Anthrylmethyl *N*-cyclohexylcarbamate

CAS No. 501003-75-4

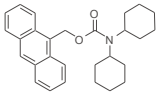
353-33651	1g	reagent product
359-33653	5g	reagent product



WPBG-172 9-Anthrylmethyl *N*,*N*-dicyclohexylcarbamate

CAS No. 1421440-13-2

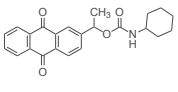
350-33661	1g	reagent product
356-33663	5g	reagent product



WPBG-174 1-(Anthraquinon-2-yl)ethyl *N*-cyclohexylcarbamate

CAS No. 1421440-15-4

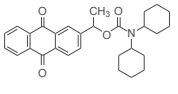
351-33691	1g	reagent product
357-33693	5g	reagent product



WPBG-166 1-(Anthraquinon-2-yl)ethyl *N*,*N*-dicyclohexylcarbamate

CAS No. 1421440-01-8

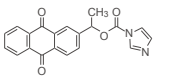
354-33681	1g	reagent product
350-33683	5g	reagent product



WPBG-140 1-(Anthraquinon-2-yl)ethyl imidazole-1-carboxylate

CAS No. 1418139-51-1

357-33671	1g	reagent product
353-33673	5g	reagent product

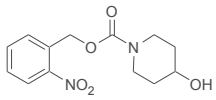


List of Related Items

WPBG-158 (2-Nitrophenyl)methyl 4-hydroxypiperidine-1-carboxylate

CAS No. 1418139-52-2

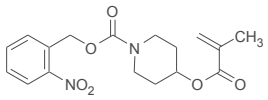
358-33721	1g	reagent product
354-33723	5g	reagent product



WPBG-165 (2-Nitrophenyl)methyl 4-(methacryloyloxy)piperidine-1-carboxylate

CAS No. 1292812-05-5

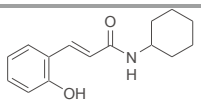
355-33731	1g	reagent product
351-33733	5g	reagent product



WPBG-025 (*E*)-*N*-Cyclohexyl-3-(2-hydroxyphenyl)acrylamide

CAS No. 224432-97-7

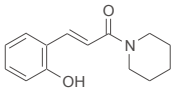
354-33701	1g	reagent product
350-33703	5g	reagent product



WPBG-027 (*E*)-1-Piperidino-3-(2-hydroxyphenyl)-2-propen-1-one

CAS No. 1203424-93-4

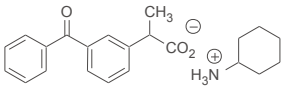
351-33711	1g	reagent product
357-33713	5g	reagent product



WPBG-168 Cyclohexylammonium 2-(3-benzoylphenyl)propionate

CAS No. 81928-83-8

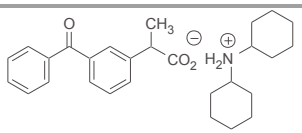
359-33751	1g	reagent product
355-33753	5g	reagent product



WPBG-167 Dicyclohexylammonium 2-(3-benzoylphenyl)propionate

CAS No. 24021-57-6

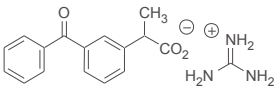
356-33761	1g	reagent product
352-33763	5g	reagent product



WPBG-082 Guanidinium 2-(3-benzoylphenyl)propionate

CAS No. 1418139-48-6

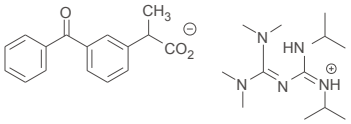
352-33741	1g	reagent product
358-33743	5g	reagent product



WPBG-266 1,2-Diisopropyl-3-[bis(dimethylamino)methylene]guanidium 2-(3-benzoylphenyl)propipnate

CAS No. 1632211-89-2

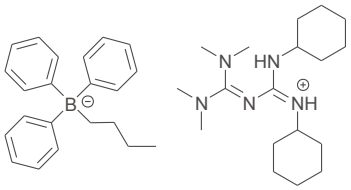
932-12306	5g	



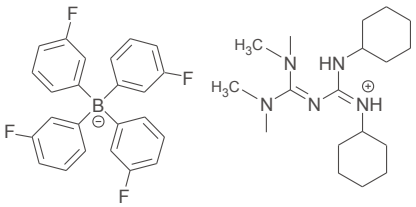
WPBG-300 1,2-Dicyclohexyl-4,4,5,5-tetramethylbiguanidium n-butyltriphenylborate

CAS No. 1801263-71-7

938-12406	5g	



WPBG-345 (Z)-{[Bis(dimethylamino)methylidene]amino}-N-cyclohexyl(cyclohexylamino)methaniminium tetrakis(3-fluorophenyl)borate



List of Related Items

■Photo Base Generators (WPBG Series)-related Reagents

Silicic Acid Ester

Tetraethyl Orthosilicate

CAS No. 78-10-4

053-03476	500mℓ	reagent product

Methyltrimethoxysilane

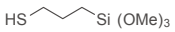
CAS No. 1185-55-3

305-60101	100g	reagent product

(3-Mercaptopropyl)trimethoxysilane

CAS No. 4420-74-0

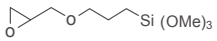
505-62302	25g	reagent product



3-Glycidoxypropyltrimethoxysilane

CAS No. 2530-83-8

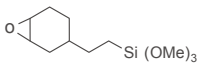
302-60432	25g	reagent product



[2-(3,4-Epoxycyclohexyl)ethyl]trimethoxysilane

CAS No. 3388-04-3

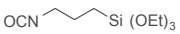
321-91252	25g	reagent product
329-91253	100g	reagent product



3-(Triethoxysilyl)propyl Isocyanate

CAS No. 24801-88-5

324-91242	25g	reagent product
322-91243	100g	reagent product

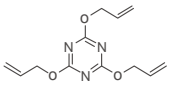


Crosslinking Agents

2,4,6-Tris(allyloxy)-1,3,5-triazine

CAS No. 101-37-1

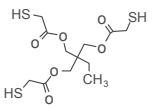
201-02292	25g	reagent product
205-02295	500g	reagent product



Trimethylolpropane Tris(mercaptoacetate)

CAS No. 10193-96-1

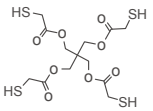
327-21642	25g	reagent product
321-21645	500g	reagent product



Pentaerythritol Tetrakis(mercaptoacetate)

CAS No. 10193-99-4

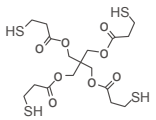
326-21612	25g	reagent product
320-21615	500g	reagent product



Pentaerythritol Tetrakis(3-mercaptopropionate)

CAS No. 7575-23-7

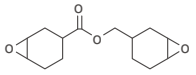
329-21722	25g	reagent product
323-21725	500g	reagent product



3,4-Epoxycyclohexylmethyl 3',4'-Epoxycyclohexanecarboxylate

CAS No. 2386-87-0

326-64072	25g	reagent product
320-64075	500g	reagent product



Methyl-5-norbornene-2,3-dicarboxylic Anhydride

CAS No. 25134-21-8

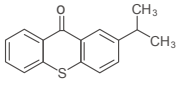
134-05951	200g	reagent product
136-05955	500g	reagent product

Photosensitizers

2-Isopropylthioxanthone

CAS No. 5495-84-1

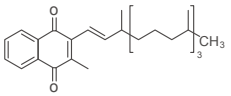
352-28932	25g	reagent product
350-28933	100g	reagent product



Vitamin K1

CAS No. 84-80-0

221-00371	1g	reagent product
227-00373	5g	reagent product



List of Applicable Law

	Azo Compounds	CAS No.	TSCA	EINECS
Azo Nitriles	V-70	15545-97-8	Listed	Listed
	V-65	4419-11-8	Listed	Listed
	AIBN	78-67-1	Listed	Listed
	V-59	13472-08-7	Listed	Listed
	V-40	2094-98-6	Listed	Listed
	V-501	2638-94-0	Listed	Listed
Azo Esters	V-601	2589-57-3	Listed*	Listed
Azo Amides	VA-086	61551-69-7	Listed	Listed
	VAm-110	195520-32-2	Not Listed	Not Listed
Azo Imidazolines	VA-044	27776-21-2	Listed	Listed
	VA-061	20858-12-2	Listed	Listed
Azo Amidines	V-50	2997-92-4	Listed	Listed
	VA-057	1041483-94-6 n-hydrate	Not Listed	Not Listed
Macro Azo Initiators	VPS-1001	158947-07-0	Not Listed	Not Listed
	VPS-1001N	158947-07-0	Not Listed	Not Listed
	VPE-0201	105744-24-9	Not Listed	Not Listed

*Listed under 5e Consent Order

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