

# Metal Alkyls

Our products and capabilities

AkzoNobel 



# Welcome to AkzoNobel



AkzoNobel creates everyday essentials to make people's lives more liveable and inspiring.

As a leading global paints and coatings company and a major producer of specialty chemicals, we supply essential ingredients, essential protection and essential color to industries and consumers worldwide.

We have approximately 45,000 people in around 80 countries and are dedicated to energizing cities and communities while creating a protected, colorful world where life is improved by what we do.



We supply customers around the world with ingredients for the manufacture of life's essentials. Specialty chemicals are used in, among others, paints, detergents, foods, plastics, cosmetics, construction, pulp and paper, pharmaceuticals, electronics, agriculture and for plastics.

Our products can be used in a variety of ways. For example, as basic building blocks of manufactured products, in the processing of raw materials, as intermediates used to produce finished goods, or they may be used to enhance the functionality and durability of manufactured products. You'll find us in the food you eat, the buildings you live and work in, the vehicles and roads you use to move around, as well as everyday items such as paper products and your children's toys.



We produce everyday essentials for the global polymer and electronic industries. Our product portfolio includes organic peroxides, metal alkyls, organometallic specialties and polymer additives, which are essential ingredients for the thermoplastic, composite and rubber industries.

We have a long history in metal alkyls, starting with large-scale production of aluminum alkyls in 1959, using technology licensed by Nobel laureate Karl Ziegler. Since then we have added many new metal alkyls to our product portfolio, with the growth of plastics in everyday life.

Today, we're one of the world's top producers with a broad range of metal alkyls, including aluminum, magnesium, boron and zinc alkyls. Each year, millions of tons of polypropylene, polyethylene, and several types of synthetic rubber are manufactured with our products. These polymers find their way into a wide variety of consumer products such as plastic packaging, toys and automotive parts.

Our products are also used in chemical synthesis of medicines and fine chemicals. In fact, some of the world's best selling active pharmaceutical ingredients are synthesized using our organometallic specialties.

AkzoNobel is consistently ranked as one of the Chemicals industry leaders on the Dow Jones Sustainability World Indexes (DJSI), showing that we take our obligations seriously - to the planet, to our customers, to our own people. We believe the only way to grow is by developing sustainable, innovative solutions that benefit our customers. And we're constantly looking for ways to reduce our impact on the environment.

We're committed to Responsible Care®. Product Stewardship and REACH.



# A secure partner

We also offer excellent capabilities in the synthesis of single site catalysts, metallocenes, and complex organics such as specialty chemicals that are used in the polyolefin, pharmaceutical and fine chemical industries. Our service includes the development of efficient synthetic routes, product synthesis on laboratory and pilot scale up to commercial production.

We supply a broad range of metal alkyls from our La Porte (Tx - USA) and Rotterdam (the Netherlands) sites, as well as from smaller facilities in China, India and Brazil. Our global distribution network allows us to deliver products to you anywhere in the world. That's how we ensure security of supply and easy access to quality products wherever you are.

All our sites are ISO 9001 and ISO 14001 certified to ensure the highest product quality and strict compliance with environmental regulations. Additionally, La Porte is an OSHA VPP Star site and both Rotterdam and Paulinia have achieved OHSAS 18001 certification. Our sites in the Americas have achieved RC 14001 certification as well.



# A broad range of organometallics

Organometallics are used in a wide range of applications. The main area of application of metal alkyls is the polymerization of olefins and dienes by Ziegler-Natta (ZN) catalyst systems. Metal alkyls and aluminoxanes are also used as (co)catalyst in a variety of related technologies that are extensions of Ziegler chemistry. These include oligomerization of ethylene, dimerization and cyclodimerization of olefins and dienes, and ring opening polymerization.

In pharmaceutical and fine chemical synthesis, our products are especially useful in reduction, addition, alkylation and deprotonation, where they facilitate various asymmetric steps. Some of our products are presently used in the production of some of the world's leading blockbuster drugs. Our products can be provided as neat metal alkyls, as blends in solvents, or custom mixtures of metal alkyls.

We bring you solutions. Whatever your particular requirements, we can develop the product to match. This product guide provides an overview of our main commercially available metal alkyls and aluminoxanes.

For detailed properties of metal alkyls, please refer to our Product Data Sheets which are available at [www.akzonobel.com/polymer](http://www.akzonobel.com/polymer).

Aluminum alkyls				
Chemical name	Acronym	Molecular formula	CAS No.	EINECS/ELINCS No.
Trimethylaluminum	TMAL	(CH <sub>3</sub> ) <sub>3</sub> Al	75-24-1	200-853-0
Triethylaluminum	TEAL	(C <sub>2</sub> H <sub>5</sub> ) <sub>3</sub> Al	97-93-8	202-619-3
Triisobutylaluminum	TIBAL	(i-C <sub>4</sub> H <sub>9</sub> ) <sub>3</sub> Al	100-99-2	202-906-3
Tri-n-hexylaluminum	TNHAL	(n-C <sub>6</sub> H <sub>13</sub> ) <sub>3</sub> Al	1116-73-0	214-241-6
Tri-n-octylaluminum	TNOAL	(n-C <sub>8</sub> H <sub>17</sub> ) <sub>3</sub> Al	1070-00-4	213-964-4
Diethylaluminum ethoxide	DEAL-E	(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> AlOC <sub>2</sub> H <sub>5</sub>	1586-92-1	216-447-1
Diisobutylaluminum hydride	DIBAL-H	(i-C <sub>4</sub> H <sub>9</sub> ) <sub>2</sub> AlH	1191-15-7	214-729-9
Isoprenylaluminum	ISOPRENYL	(i-C <sub>4</sub> H <sub>9</sub> ) <sub>m</sub> Al(C <sub>5</sub> H <sub>10</sub> ) <sub>n</sub>	70024-64-5	274-261-6
Diethylaluminum chloride	DEAC	(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> AlCl	96-10-6	202-477-2
Ethylaluminum sesquichloride	EASC	(C <sub>2</sub> H <sub>5</sub> ) <sub>3</sub> Al <sub>2</sub> Cl <sub>3</sub>	12075-68-2	235-137-7
Ethylaluminum dichloride	EADC	C <sub>2</sub> H <sub>5</sub> AlCl <sub>2</sub>	563-43-9	209-248-6
Diisobutylaluminum chloride	DIBAC	(i-C <sub>4</sub> H <sub>9</sub> ) <sub>2</sub> AlCl	1779-25-5	217-216-8
Isobutylaluminum dichloride	MONIBAC <sup>a</sup>	i-C <sub>4</sub> H <sub>9</sub> AlCl <sub>2</sub>	1888-87-5	217-563-5

a) From monoisobutylaluminum dichloride



Aluminoxanes					
Chemical name	Acronym	Standard solvent <sup>b</sup>	Molecular formula	CAS No.	EINECS/ELINCS No.
Modified methylaluminoxane, Type 3A	MMAO-3A	Heptane	$[(CH_3)_{0.7}(i-C_4H_9)_{0.3}AlO]_n$	146905-79-5	c
Modified methylaluminoxane, Type 7	MMAO-7	Isopar <sup>®</sup> E	$[(CH_3)_{0.86}(n-C_8H_{17})_{0.14}AlO]_n$	206451-54-9	c
Modified methylaluminoxane, Type 12	MMAO-12	Toluene	$[(CH_3)_{0.95}(n-C_8H_{17})_{0.05}AlO]_n$	206451-54-9	c
Isobutylaluminoxane, Type 65	IBAO-65	Hexane	$[i-C_4H_9AlO]_n$	220326-29-4	c
Bis(diisobutylaluminum) oxide	DIBAL-O	Hexane	$(i-C_4H_9)_2AlOAl(i-C_4H_9)_2$	998-00-5	213-646-5

b) Aluminoxanes are only available in hydrocarbons

c) Regarded as polymeric substance which does not require EINECS/ELINCS notification

Magnesium alkyls				
Chemical name	Acronym	Molecular formula	CAS No.	EINECS/ELINCS No.
n-Butylethylmagnesium <sup>d</sup>	MAGALA <sup>®</sup> BEM	$n-C_4H_9MgC_2H_5$	62202-86-2	263-454-0
Di-n-butylmagnesium	MAGALA DNBM	$(n-C_4H_9)_2Mg$	1191-47-5	214-736-7

d) Also available in formulations containing approx. 0.5% and approx. 1.0% (molar) of butylated hydroxytoluene. These formulations are called BEM-2436 and BEM-4436, respectively. Note: All Magnesium alkyls are in heptane, but can in principle be supplied in any other solvent

Boron alkyls				
Chemical name	Acronym	Molecular formula	CAS No.	EINECS/ELINCS No.
Triethylborane	TEB	$(C_2H_5)_3B$	97-94-9	202-620-9

Zinc alkyls				
Chemical name	Acronym	Molecular formula	CAS No.	EINECS/ELINCS No.
Dimethylzinc	DMZ	$(CH_3)_2Zn$	544-97-8	208-884-1
Diethylzinc	DEZ	$(C_2H_5)_2Zn$	557-20-0	209-161-3

With respect to REACH we can state the following: We have filed all of the appropriate registrations for tier 1 and 2 with the European Chemicals Agency (ECHA). We are on the path to register the relevant tier 3 substances in the products that we supply. If applicable, exposure scenarios are provided as part of an extended Safety Data Sheet (eSDS).

# Custom synthesis

We offer custom-manufactured complex organics, such as ligands, metallocenes, single site catalysts and other specialty chemicals. We provide proprietary technology, scale-up expertise, pilot facilities and commercial scale production.

We have developed significant capabilities in this field, using synergies with AkzoNobel's organic synthesis strengths.

Our expertise and facilities find growing use in the synthesis of (single site) catalysts and specialty chemicals, that are used in polyolefin, elastomer, pharmaceutical, and fine chemical industries.

Our core competencies are in complex and hazardous chemistries, and the handling of highly reactive chemicals (incl. metal alkyls, titanium tetrachloride, Grignard reagents). We have the expertise to work in an oxygen and water free environment. We strive for the highest product purity and consistency.

We have broad experience in developing and optimizing process routes, and recycling process streams, thereby reducing or eliminating waste in manufacturing.

Our custom-manufactured organometallic specialties are shipped to customers throughout the world.

We want to be your preferred supplier, producing custom specific products through arrangements protected by confidentiality agreements. From gram-scale to multiple-metric-ton level, we're happy to meet with you and discuss your target molecule.

Moreover, we manufacture non-proprietary metallocenes like bis (cyclopentadienyl) titanium dichloride (TDC, CAS No. 1271-19-8).



# Your safety, our priority

AkzoNobel is recognized as a global leader in metal alkyl safety. Our proven success in safe handling of metal alkyls and other (metal-) organic specialties is due to our long-term commitment to safety. Safety is always our top priority.

Sharing our experience in safety is one of the most important resources we offer. Through our safety programs we provide expert advice on the handling of these materials including:

- classroom training of safety and handling of metal alkyls
- consultation of metal alkyl facility design
- demonstrations on the safe use, handling and control of metal alkyls
- on-site assistance and advice regarding procedures

Our Safety Research Laboratory in Deventer, the Netherlands, is heavily involved in R&D, ensuring the development of safe products and processes. Studies are carried out, in order to ensure a high level of safety in manufacturing, handling and transport of dangerous substances. Please contact us if you are interested in such services.

Safety and technical support is mainly provided from our laboratories in Deventer and La Porte. We have a team of Technical Development Managers, who are the liason between the market and R&D. They understand your future needs and are committed to the success of our customers.



# Shipping containers

We maintain a fleet of cylinders, portable tanks, ISO containers, tank trailers and rail cars designed for the shipment of metal alkyls and organometallic specialties. Our shipping containers are designed and constructed to meet all national and international transport regulations and are tested periodically, in accordance with the appropriate regulations.



Cylinder	Volume (90% full)	Dimensions	
		Diameter	Height
Pyrosafe	0.85 l (0.225 gal)	9.0 cm (3.562 in)	26.7 cm (10.5 in)
B-2	9.8 l (2.59 gal)	23.2 cm (9.125 in)	46.4 cm (18.25 in)
B-5	19.6 l (5.18 gal)	30.8 cm (12.125 in)	53.3 cm (21 in)
B-28	98.4 l (26.0 gal)	37.1 cm (14.625 in)	129.5 cm (51 in)
B-118	405 l (107 gal)	76.2 cm (30.0 in)	145.7 cm (57.4 in)

Portable tank	Volume (90% full)	Dimensions		
		Length	Diameter	Height
C-250	829 l (219 gal)	208 cm (82 in)	81 cm (32 in)	96.5 cm (38 in)
C-430 dome type	1,465 l (387 gal)	208 cm (82 in)	107 cm (42 in)	122 cm (48 in)
C-430 saddle type	1,465 l (387 gal)	208 cm (82 in)	107 cm (42 in)	128 cm (50.5 in)
C-1980	6,745 l (1,782 gal)	305 cm (120 in)	190 cm (74.8 in)	224 cm (88.2 in)
ISO <sup>a</sup>	19,200-21,150 l (5,068-5,584 gal)	606 cm (239 in)	244 cm (96 in)	259 cm (102 in)

e) Exact volume of an ISO tank container depends on the model

Rail car (34,070 l (9,000 gal) (90% full)) and tank trailer (22,100 l (5,838 gal)) containers are available in North America only.

More detailed information on our metal alkyl shipping containers can be found at [www.akzonobel.com/polymer](http://www.akzonobel.com/polymer).

Our continuous investment in shipping containers and our global distribution network are demonstrations of our commitment to security of supply.





# Leading the way in safety

AkzoNobel is recognized as the global leader in metal alkyl and organic peroxide safety. Sharing our experience in safety is one of the most valuable resources we offer, including:

- Classroom review of safety and handling
- Consultation on unloading, storage and dosing facility design
- Demonstrations on the safe use, handling and control of our products
- On-site assistance and advice regarding procedures

[akzonobel.com/polymer](http://akzonobel.com/polymer)



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## Additional information

Product Data Sheets (PDS) and Material Safety Data Sheets (MSDS) are available at [www.akzonobel.com/polymer](http://www.akzonobel.com/polymer)

On request we also provide specific publications on subjects such as applications of metal alkyls, analytical technique, safe use and storage of metal alkyls, facilities design and maintenance, and unloading procedures.

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[www.akzonobel.com/polymer](http://www.akzonobel.com/polymer)

AkzoNobel creates everyday essentials to make people's lives more liveable and inspiring. As a leading global paints and coatings company and a major producer of specialty chemicals, we supply essential ingredients, essential protection and essential color to industries and consumers worldwide. Backed by a pioneering heritage, our innovative products and sustainable technologies are designed to meet the growing demands of our fast-changing planet, while making life easier. Headquartered in Amsterdam, the Netherlands, we have approximately 45,000 people in around 80 countries, while our portfolio includes well-known brands such as Dulux, Sikkens, International, Interpon and Eka. Consistently ranked as a leader in sustainability, we are dedicated to energizing cities and communities while creating a protected, colorful world where life is improved by what we do.

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