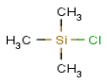
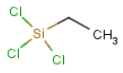
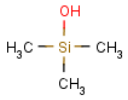
SIDS INITIAL ASSESSMENT PROFILE

Category Name	Alkyl chlorosilanes (Chlorotrimethylsilane, Dichlorodimethylsilane, Trichloromethylsilane, and Trichloroethylsilane) Category
CAS Nos.	**Sponsored Substances** 75-77-4 75-78-5 75-79-6 115-21-9 **Hydrolysis Products** 1066-40-6 1066-42-8 2445-53-6 5651-16-1 7647-01-0 **Analogue Substance** 1185-55-3
Chemical Names	**Sponsored Substances** Chlorotrimethylsilane (CTMS) Dichlorodimethylsilane (C2DMS) Trichloromethylsilane (C3MS) Trichloroethylsilane (C3ES) **Hydrolysis Products** Trimethylsilanol (TMS) Dimethylsilanediol (DMSD) Methylsilanetriol (MST) Ethylsilanetriol (EST) Hydrogen Chloride (HCl) **Analogue Substance** Methyltrimethoxysilane (MTMS)
Structural Formulae	75-77-4  75-78-5  75-79-6 

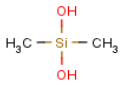
1.1	115-21-9	

Hydrolysis Products

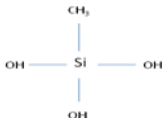
1066-40-6



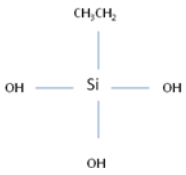
1066-42-8



2445-53-6



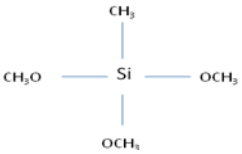
5651-16-1



7647-01-0

Analogue substance

1185-55-3



SUMMARY CONCLUSIONS OF THE SIAR

Category/Analogue Justification

The category consists of four sponsored chlorosilanes: chlorotrimethylsilane (CTMS, CAS No. 75-77-4), dichlorodimethylsilane (C2DMS, CAS No. 75-78-5), trichloromethylsilane (C3MS, CAS No. 75-79-6), and trichloroethylsilane (C3ES, CAS No. 115-21-9). These chemicals are grouped into a category based on similar molecular structure, high reactivity, physicochemical and toxicological properties.

Similar High Reactivity

The chlorine group is the most active functional group on these molecules and determines many aspects of the behaviour of the category members. These chlorosilanes undergo rapid hydrolysis in the presence of water to form one to three moles of hydrochloric acid and one mole of silanol, depending on the parent substance. Hydrolysis is the primary reaction in aqueous systems and has been shown to occur very quickly (half-life <17 seconds) for CTMS, C2DMS, and C3MS. No data is available for C3ES.

Similar Chemical/Physical Properties

All category members are liquids with melting points, boiling points and vapour pressures that are largely dependent on molecular weight. Due to their high reactivity with water, water solubility and partition coefficient are not relevant endpoints.

Similar Toxicological Properties

These category members are severely irritating and corrosive at the site of contact (i.e., respiratory tract, skin, and eyes).

The approach to address the SIDS endpoints for these chlorosilanes is to utilize available data from the four category members and three hydrolysis products, including hydrogen chloride. Chlorosilanes react rapidly when exposed to water or polar reagents, producing hydrogen chloride (HCl; CAS No. 7647-01-0) and the corresponding silanols. The primary hydrolysis products for these sponsored chlorosilanes are hydrogen chloride (HCl; CAS No. 7647-01-0), common to the hydrolysis of all chlorosilanes and the corresponding silanol. Data are available for two of the silanol hydrolysis products: trimethylsilanol (TMS; CAS No. 1066-40-6) and dimethylsilanediol (DMSD; CAS No. 1066-42-8).

Repeated-dose and reproductive toxicity endpoints for the category members are characterized through the use of data from HCl, and two of the silanol hydrolysis products; TMS and DMSD. Aquatic toxicity endpoints are also characterized with data from the hydrolysis products (HCl, TMS and DMSD) and the structural analogue methyltrimethoxysilane (MTMS: CAS No. 1185-55-3) (which produces methylsilanetriol on hydrolysis, the hydrolysis product of C3MS). MTMS has previously been assessed in the OECD HPV programme: http://webnet.oecd.org/hpv/ui/Search.aspx. Hydrogen chloride has also previously been assessed in the OECD HPV programme: http://www.chem.unep.ch/irptc/sids/oecdsids/sidspub.html.

Physical-chemical properties

The EPISuite program (v 4.0) developed by the U.S. Environmental Protection Agency and Syracuse Research Corporation has not been validated for chemicals that contain silanes in their molecular structure (although some measured data are included in the training set); therefore, there is greater uncertainty associated with the calculated values and they should be used with caution whenever they are reported below.

These chlorosilanes are very reactive and hydrolytically unstable; they are liquids at normal temperature and pressure. Hydrolysis studies (OECD TG 111) were conducted on three category members. The melting points range from -57.7°C (CTMS) to -105.6 °C (C3ES); boiling points range from 57.6°C at 1013 hPa (CTMS) to 97.9°C at 1013 hPa (C3ES). Vapour pressures of these chlorosilanes range from 47.83 hPa at 20°C (C3ES) to 250.3 hPa at 25°C (CTMS). The water solubility and partition coefficient estimates are not reliable because these chlorosilanes are hydrolytically unstable. The water solubility values of the silanol hydrolysis products TMS and DMSD are 920 mg/L and 2790 mg/L, respectively. The water solubility of HCl is 673 g/L at 30°C. The log of the 1-octanol/water partition coefficient (K_{ow}) of the silanol hydrolysis product, TMS is 1.19.

Human Health

There were no data for toxicokinetics of these chlorosilanes. However, chlorosilanes rapidly hydrolyze on contact with water. The hydrolysis products, TMS and DMSD, penetrated through human skin when applied neat in an *in vitro* test system. Also, the systemic effects found in an acute dermal toxicity study in rabbits with CTMS (discoloration of liver and lungs) provide evidence that chlorosilanes or their hydrolysis products can penetrate

through the skin. These chlorosilanes may be absorbed via inhalation at high doses based on discoloration in the liver (and spleen for C2DMS) observed in acute inhalation studies. HCl -, a hydrolysis product of all chlorosilanes, will rapidly dissociate in the presence of water; its effects on skin are thought to be a result of pH change.

The range of 1 hour acute inhalation (OECD 403) LC_{50}'s in rats for the category members was 8.35 mg/L (C3MS) to 18.92 mg/L (CTMS). The 4-hr nose-only LC_{50} for C3MS was 5.43 mg/L in rats. The acute inhalation hazard posed by an individual chlorosilane, as defined by an LC_{50} value, is directly proportional to its chlorine content and subsequently to the HCl that is liberated during hydrolysis. The principal clinical signs were indicative of respiratory and ocular effects. The dermal LD_{50} for CTMS applied without vehicle using methods similar to OECD TG 402 in rabbits was 1513 (females) and 2030 (males) mg/kg bw; for C3MS (no vehicle; similar to OECD TG 402) the dermal LD_{50} in rabbits was 1068 (females) and 1719 (males) mg/kg bw. Necrosis, irritation and loss of body weight were common clinical signs for both substances. The primary necropsy findings for CTMS included various discolorations of the liver or lungs; no remarkable findings were noted for C3MS.

The oral (similar to OECD TG 401) LD_{50} for CTMS in rats was 5636 (females) and 4811 (males) mg/kg bw; for C3MS the oral LD_{50} in rats was 3594 (females) and 2057 (males) mg/kg bw. Necrosis, irritation and loss of body weight were common clinical signs for both substances; chlorosilanes are widely recognized as corrosive and considered irritants. The primary necropsy findings for CTMS included various discolorations of the liver or lungs; no remarkable findings were noted for C3MS. Reported signs of toxicity for both substances in surviving animals included sluggishness, salivation, dyspnea, rales, prostration, and/or staining/greasy texture of the fur. Body weight gains were reported for all groups of surviving animals exposed to either CTMS or C3MS. There were no remarkable findings at necropsy for surviving animals for either CTMS or C3MS with the exception of the finding of lungs with dark red patches in females dosed with CMS at 2540 mg/kg bw.

Acute toxicity of the hydrolysis products TMS and DMSD in rats resulted in a 4-hour LC_{50} of 3151 ppm (11.6 mg/L) and an LD_{50} of >2000 mg/kg respectively. For TMS, common clinical signs included effects on respiration, activity, urogenital and facial staining, increased lacrimation, partial closure of eyes, and decreased urination and defecation. Necropsy findings included discoloration of the lungs, kidney, adrenal gland, liver, spleen and urinary bladder, distension of the urinary bladder, and clear fluid in uterus. For DMSD, clinical signs included impaired equilibrium, hypoactivity, and decreased respiration. There were no remarkable findings at necropsy. These sponsored chlorosilanes are corrosive and highly irritating to the skin, eyes and respiratory tract; these effects are likely due to the rapid production of HCl following hydrolysis. Similar effects are seen following exposure to HCl. The hydrolysis product, TMS, was non-irritating to the skin and slightly irritating to the eyes of rabbits. No data were available on the sensitisation potential of the alkyl chlorosilanes or their hydrolysis products.

Repeated dose toxicity data for these chlorosilanes were not available. Based on their rapid hydrolysis, data from the primary hydrolysis products were used to fill the repeated dose toxicity endpoint. In 90-day inhalation studies in rats and mice exposed to 0, 0.015, 0.030 or 0.075 mg/L HCl, local effects of irritation were observed at 0.015 mg/L and above. The NOAEL for systemic toxicity for HCl, excluding the local effects of irritation, has been determined to be 0.030 mg/L for rats and mice based on decreased body weight gain (mice; male rats) and decreased liver weights (male mice). In a combined inhalation repeated-dose/reproductive/developmental toxicity screening test in rats exposed to 0.22, 1.10 or 2.20 mg/L/day hydrolysis product, TMS, there were no treatment-related effects observed up to 2.2 mg/L/day. The NOAEL for inhalation systemic toxicity of TMS was 2.20 mg/L (highest concentration tested). In a combined oral gavage repeated-dose/reproductive/developmental toxicity screening test in rats treated with 0, 80, 250 or 750 mg/kg-bw/day hydrolysis product, TMS, liver effects (increased relative liver weights of 17-21% in females and histopathological changes) and clinical signs of toxicity (staggering gait) were observed at 750 mg/kg-bw/day. The NOAEL for oral systemic toxicity of TMS was 250 mg/kg-bw/day. In a combined oral gavage repeated-dose/reproductive/developmental toxicity screening test in rats treated with 0, 50, 250 or 500 mg/kg-bw/day hydrolysis product, DMSD, clinical signs of toxicity included abdominal, urogenital and muzzle soiling in males at 250 and 500 mg/kg-bw/day and muzzle soiling in females at 500 mg/kg-bw/day. Based on liver porphyria in male rats and liver vacuolation in female rats at 500 mg/kg-bw/day, the NOAEL for oral systemic toxicity of DMSD was 250 mg/kg-bw/day.

Data for mutagenicity *in vitro* are available for all category members. *In vitro* chromosome aberration data are available for CTMS, C2DMS and C3MS. *In vivo* micronucleus studies are available for CTMS, C2DMS and C3MS. In reverse-mutation assays, CTMS, C2DMS, C3MS and C3ES were negative for mutagenicity in all S*almonella typhimurium* and E. *coli* strains tested. CTMS, C2DMS and C3MS were negative for mutagenicity in DNA damage and repair assays and/or mammalian cell gene mutation tests with L5178Y mouse lymphoma cells. CTMS and C2DMS were also negative in a sister chromatid exchange (SCE) assay with L5178Y mouse lymphoma cells; C3MS was positive for sister chromatid exchanges (SCEs) with and without metabolic activation. CTMS, C2DMS and C3MS were negative in rat micronucleus assays *in vivo*. CTMS and C2DMS were negative in a chromosome aberration test with L5178Y mouse lymphoma cells; C3MS was considered to have weak clastogenic activity at cytotoxic concentrations. Based on these data, these chlorosilanes are not expected to be genotoxic. No data were available for carcinogenicity on these chlorosilanes.

No data were available on the reproductive toxicity of these chlorosilanes. However; data are available for hydrolysis products, TMS (inhalation route), DMSD (oral route) and HCl. In a combined repeated-dose/reproductive/developmental toxicity screening test (OECD TG 422), no treatment-related effects on reproduction or development were observed in rats exposed whole-body to TMS at concentrations up to 2.20 mg/L. The NOAEC for reproductive toxicity was 2.20 mg/L (highest concentration tested). The NOAEC for maternal and developmental toxicity was 2.20 mg/L (highest concentration tested). In a combined repeated-dose/reproductive/developmental toxicity screening test (OECD TG 422), no treatment-related effects on reproduction or development were observed in rats exposed via oral gavage to DMSD at doses up to 500 mg/kg bw/day. The NOAEL for reproductive toxicity was 500 mg/kg bw/day (highest dose tested). The NOAEL for maternal and developmental toxicity was 500 mg/kg bw/day (highest dose tested). No reliable studies have been reported regarding toxicity to reproduction and development in animals after oral, dermal or inhalation exposure to hydrogen chloride/hydrochloric acid. However, no effects on the gonads were observed in a 90-day repeated-dose inhalation study. Based on data for the hydrolysis products, these chlorosilanes are not expected to be reproductive toxicants and are unlikely to result in developmental toxicity.

These sponsored chlorosilanes possess properties indicating a hazard for human health (lethality from acute inhalation, severe skin, eye and respiratory tract irritation, corrosivity). Adequate screening-level data are available to characterize the human health hazard for the purposes of the OECD HPV Programme.

Environment

The chlorine group is the most active functional group on these molecules and determines many aspects of the behaviour of the category members. These chlorosilanes undergo rapid hydrolysis in the presence of water to form one to three moles of hydrochloric acid and one mole of silanol, depending on the parent substance. Hydrolysis is the primary reaction in aqueous systems and has been shown to occur very quickly (half-life <17 seconds) for CTMS, C2DMS, and C3MS. No data were available for C3ES but the reaction is expected to be as quick as for the other category members.

The overall rate constants for reaction with OH radicals in the atmosphere for these chlorosilanes and resulting half-lives (12 hr day) due to indirect photolysis are estimated to range from 0.15 x 10^{-12} cm^3/molecule-sec and 71 d (C3MS) to 1.2 x 10^{-12} cm^3/molecule-sec and 8.9 d (Cl3ES). Photodegradation as a mode of removal is unlikely as the alkyl chlorosilanes are hydrolytically unstable. It is assumed that reaction with water vapour is the predominant degradation process in air. CTMS, C2DMS and C3MS hydrolyzed to HCl and the corresponding silanol in less than 17 seconds at pH 4, 7, and 9 and 1.5ºC These chlorosilanes hydrolyze to form one mole of their respective silanol hydrolysis products (TMS, DMSD, methylsilanetriol, and ethylsilanetriol and one to three moles of HCl. The products resulting from hydrolysis (silanol hydrolysis products) in the atmosphere are expected to further react with hydroxyl radicals. The half-lives (12 hr day) due to the atmospheric oxidation from indirect photolysis of the silanol hydrolysis products were 0.9 d (Ethylsilanetriol) to 2.5 d (TMS); the overall OH rate constants were 3.95 x 10^{-12} cm^3/molecule-sec (TMS) and 7.19 x 10^{-12} cm^3/molecule-sec (DMSD). HCl can react with hydroxyl radicals to form chloride free radical and water and its half-life time is calculated as 11 d. Level III Fugacity modeling, using loading rates of 1000 kg/h each for air, soil, and water, shows the following percent distribution range for the alkyl chlorosilanes: Air = 40.2 (C3ES) to 53.2 (CTMS); Soil = 1.74 (CTMS) to 17.3 (C3ES); Water = 39.7 (C3MS) to 44.9 (CTMS); Sediment = 0.145 (C3MS) to 0.225 (C3MS). However, because these chlorosilanes are very reactive and hydrolytically unstable, the substances are unlikely to be found in the environment. Therefore, Level III Fugacity modelling for the hydrolysis products (TMS, DMSD, methylsilanetriol, and ethylsilanetriol) was conducted using loading rates of 1000 kg/h each for air, soil, and water. The model estimated the following percent distribution ranges, when the silanol hydrolysis products are released simultaneously to all three compartments: Air <1.0 (all, except TMS) to 5.26 (TMS); Soil = 64.7 (TMS) to 80.1 (Ethylsilanetriol), Water = 19.8 (Ethylsilanetriol) to 29.9 (TMS); and Sediment <1.0 (all silanols). The fugacity model cannot be applied for ionized substances such as HCl. The biodegradation of these chlorosilanes was not determined due to their rapid hydrolysis; any potential for biodegradation is likely to be of the hydrolysis products. Consequently, the only potentially biodegradable materials in the test system will be silanols.

The biodegradation of MTMS was not determined due to its rapid hydrolysis; methylsilanetriol is not expected to be readily biodegradable In an OECD TG 310, TMS was not readily biodegradable (0% degradation after 29 days). HCl is an inorganic compound and OECD guideline tests for biodegradation are not applicable. Bioaccumulation is not anticipated since these chlorosilanes are hydrolytically unstable. The estimated BCF values for these chlorosilanes range from 9.8 to 20.6 L/kg wet-wt, suggesting low bioaccumulation potential of the substances. The estimated BCF values for these chlorosilane hydrolysis products range from 2.6 to 3.2 L/kg wet-wt.

Aquatic toxicity data were not available for these chlorosilanes; the substances undergo rapid hydrolysis, which occurs during testing; exposures to the parent chlorosilane is most likely irrelevant and observed toxicity is likely due to HCl and the corresponding silanol hydrolysis product.

The following acute toxicity test results for similar materials and hydrolysis products have been determined for

aquatic species:

Test substance	Guideline; Test type	Species	Result (mg/L)
Fish			
Analogous substance – similar structure			
MTMS	OECD TG 203; flow-through	Rainbow trout (*Oncorhynchus mykiss*)	96-hr LC_{50} >110 (measured) 96-h LC_{50} >62 (calculated methylsilanetriol concentration)
MTMS	ECOSAR	Fish	96-hr LC_{50} = 45 (alkoxy silane category) 96-hr LC_{50} = 9130 (neutral organic category)
Analogous substance – hydrolysis product			
TMS	OECD TG 203; semi-static	Rainbow trout (*Oncorhynchus mykiss*)	96-hr LC_{50} = 271(measured)
TMS	Environment Federal Bureau Berlin; static	Zebra-fish (*Brachydanio rerio)*	96-hr LC_{50} >519 (measured)
TMS	ECOSAR	Fish	96-hr LC_{50} = 395
DMSD	OECD TG 203; static	Rainbow trout (*Oncorhynchus mykiss*)	96-hr LC_{50} >126 (measured)
DMSD	ECOSAR	Fish	96-hr LC_{50} = 9320
Ethylsilanetriol	ECOSAR	Daphnid	48-hr EC_{50} = 13,000
Methylsilanetriol	ECOSAR	Daphnid	48-hr EC_{50} = 1000
HCl	OECD TG 203; semi-static	Rainbow trout (*Oncorhynchus mykiss*)	96-hr LC_{50} = 4.92 mg/L at pH4.
Aquatic invertebrates			
Analogous substance – similar structure			
MTMS	OECD TG 202; flow-through	*Daphnia magna*	48-hr EC_{50}>122 (measured) 48-h EC_{50} >57 (calculated methylsilanetriol concentration)
MTMS	ECOSAR	Daphnid	96-hr LC_{50} = 16 (alkoxy silane category) 96-hr LC_{50} = 7990 (neutral organic category)
Analogous substance – hydrolysis product			
TMS	OECD TG 202; semi-static	*Daphnia magna*	48-hr EC_{50} = 124 (measured)
TMS	ECOSAR	Daphnid	48-hr EC_{50} = 196
DMSD	OECD TG 202; static	*Daphnia magna*	48-hr EC_{50} >117 (measured)

DMSD	ECOSAR	Daphnid	48-hr EC_{50} = 3680
Ethylsilanetriol	ECOSAR	Daphnid	48-hr EC_{50} = 7700
Methylsilanetriol	ECOSAR	Daphnid	48-hr EC_{50} = 48,000
HCl	OECD TG 202	*Daphnia magna*	48-hr EC_{50} = 0.492 mg/L at pH 5.3
Algae			
Analogous substance – similar structure			
MTMS	OECD TG 201; static	*Pseudokirchneriella subcapitata*	72-hr EC_{50}>120 (nominal) 72-hr EC_{50}>3.6 (measured); 72-hr EC_{50}>80 (calculated methylsilanetriol concentration)
Analogous substance – hydrolysis product			
TMS	OECD TG 201; static	*Pseudokirchneriella subcapitata*	72-hr EC_{50} = 555, 72-hr E_bC_{50} = 566, 72-hr E_rC_{50} > 1053 (measured)
TMS	Similar to OECD TG 201; static	*Desmodesmus subspicatus*	72-hr E_bC_{50} = 806 (nominal)
TMS	ECOSAR	Green Algae	96-hr EC_{50} = 64
DMSD	OECD TG 201; static	*Pseudokirchneriella subcapitata*	72-hr E_yC_{50} and E_rC_{50} >118
DMSD	ECOSAR	Green Algae	96-hr EC_{50} = 615
Ethylsilanetriol	ECOSAR	Green Algae	96-hr EC_{50} = 5981
Methylsilanetriol	ECOSAR	Green Algae	96-hr EC_{50} = 577
HCl	OECD TG 201; static	*Selenastrum capricornutum*	72-hr EC_{50} = 0.492 mg/L at pH 5.3

Hydrogen Chloride (HCl)

The hazard of hydrochloric acid for the environment is caused by the proton (pH effect). For this reason the effect of hydrogen chloride on the organisms depends on the buffer capacity of the aquatic ecosystem. Also the variation in acute toxicity for aquatic organisms can be explained for a significant extent by the variation in buffer capacity of the test medium. For example, LC_{50} values of acute fish toxicity tests varied from 4.92 to 282 mg/L. The toxicity values to *Selenastrum capricornutum* 72h-EC50 is 0.780 mg/L at pH 5.1 for biomass, 0.492 mg/L at pH 5.3 for growth rate and the 72h-NOEC is 0.097 mg/L at pH 6.0 for biomass and growth rate. The 48h-EC50 for *Daphnia magna* is 0.492 mg/L at pH 5.3 based on immobilization.

These chlorosilanes exhibit very rapid hydrolysis in the environment, hence any ecotoxicity will result from their hydrolysis products. Structural analogues of the parent chlorosilane compounds, and silanol hydrolysis products show low toxicity. Another byproduct of the hydrolysis of these chlorosilanes, HCl, has properties that can result in toxicity of < 1 mg/L to aquatic organisms in poorly buffered systems, mainly due to acidification of the test medium. These sponsored chlorosilanes and their hydrolysis products have low potential for bioaccumulation. Silanol degradation products are not biodegradable . Adequate screening-level data are available to characterize the hazard for the environment for the purposes of the OECD HPV

Programme.

Exposure

Chlorosilanes react rapidly when exposed to moisture or polar reagents; this reaction is normally heterogeneous, highly exothermic, and potentially difficult to control, requiring close control of the reaction. To prevent the rapid hydrolysis and subsequent loss of material or exposure of the reactants to atmospheric moisture, chlorosilanes are handled in closed pipes or containers. The following summarizes the 2005 production volumes in tonnes of these chlorosilanes for the North America, Europe and Japan; ranges are provided in order to protect confidential business information.

Sponsored substance	North America	Europe	Japan
CTMS (CAS No. 75-77-4)	13608 - 27216	22680 - 34019	4536-13608
C2DMS (CAS No. 75-78-5)	272155 - 680389	226796- 340194	111130-290299
C3MS (CAS No 75-79-6)	22680 - 45359	11398- 294835	9072 -20412
C3ES (CAS No. 115-21-9)	907-2041	227-680	0

These chlorosilanes are produced and processed in closed systems. Due to the dynamic and exothermic nature of the hydrolysis processes for producing siloxane oligomers and polymers from these chlorosilanes, many engineering controls are in place to prevent occupational exposure such as local ventilation; water scrubber devices and related equipment; and closed sampling systems. Employees involved in chlorosilane production and application are required to use personal protective equipment (PPE) such as safety glasses or goggles, steel-tipped shoes, flame-resistant clothing, hard hat, chemical resistant gloves, and respirator mask. For any situation (e.g. equipment maintenance and repair) where potential exposure to chlorosilanes is expected, the use of acid resistant protective equipment, respiratory equipment and face shield is recommended because of their irritating or corrosive properties. Drivers who transport these chemicals must always have this equipment ready for immediate use. Potential routes of occupational exposure include inhalation and dermal exposure. All of these chlorosilanes are used as chemical intermediates in closed systems and worker, and general public exposure is expected to be low. There are no consumer uses of these chlorosilanes.