Nouryon

Sodium chlorate

Product information manual

Content

Introduction

Sodium chlorate ($NaClO_3$) is a powerful oxidizing agent available in both the crystal and solution forms manufactured and supplied by Nouryon.

When handled correctly, associated risks are minimal. However, like many other oxidizing chemicals, if handled incorrectly sodium chlorate can pose a serious hazard to human health, safety and the environment.
Knowledge of the possible risks, correct and appropriate safeguards, and the necessary response to situations that could arise is therefore essential for anyone dealing with this chemical. This manual contains important information on the safe handling of sodium chlorate; it has been compiled based on experience gained from many years of producing and handling this chemical.

Please do not hesitate to contact your Nouryon Representative for advice and instructions concerning the handling of sodium chlorate: https://eka.nouryon.com/contact-sales/

Applications

Sodium chlorate has a high oxidizing potential and functions as a powerful oxidizing agent. An example of this type of reaction would be the production of chlorine dioxide.

In 2012, more than 90% of all sodium chlorate produced worldwide was consumed by the pulp industry where it is used for generation of chlorine dioxide. Chlorine dioxide is a key bleaching agent and is used in the production of Elemental Chlorine-Free (ECF) bleached wood pulp all over the world.

Presented in the table below are examples of today's technologies for producing a chlorine-free chlorine dioxide solution for ECF bleaching.

The major use of sodium chlorate remains in the pulp and paper industry; it is also the preferred intermediate for sodium perchlorate and sodium chlorite manufacture.

Some common industrial applications for sodium chlorate include the surface treatment of metals and cupric chloride etch regeneration in the electronics and automotive industries.

Additional uses of sodium chlorate are as an oxidant in chemical synthesis; in the mining industry for the extraction of uranium and vanadium; in the production of oxygen candles utilized on aircraft and submarines; and by manufacturers of breathing apparatus for firefighters and mine rescue crews.

Product grades

Sodium chlorate is available in both solution and crystal forms from our network of production facilities.

Your Nouryon Representative will be pleased to help you determine which form of sodium chlorate product is appropriate for your particular application.

Process	Reaction
SVP-LITE:	$12NaClO_3 + 8H_2SO_4 + 3CH_3OH \rightarrow 12ClO_2 + 3HCOOH + 9H_2O + 4Na_3H(SO_4)_2$
SVP-HP:	$2NaClO_3 + H_2O_2 + H_2SO_4 \rightarrow 2ClO_2 + Na_2SO_4 + 2H_2O + O_2$
HP-A:	$2NaClO_3 + H_2O_2 + 2H_2SO_4 \rightarrow 2ClO_2 + 2NaHSO_4 + O_2 + 2H_2O$

Technical data and physical properties

Sodium chlorate is a white to off-white crystalline material. Crystals are similar in appearance to table salt. Sodium chlorate is odorless and very soluble in water.

In its crystal form, sodium chlorate is stable at temperatures up to 250°C. Above this temperature chlorate decomposes slowly and steadily forming salt (sodium chloride) and oxygen. Sodium chlorate in its pure form is not flammable but due to the fact it releases oxygen during decomposition it will act as an extreme combustion accelerant in the presence of flammable materials.

In liquid form, extra caution should be taken. Sodium chlorate solution is a clear odorless liquid and becomes virtually invisible (salt-like residue is often apparent) when it dries on any organic material like cloth, leather, paper or wood. All that is then required is a spark, minor friction or heat to ignite. Sodium chlorate itself does not burn but as previously stated acts as an extreme combustion accelerant by emitting oxygen. Consequently, fires involving sodium chlorate spread very rapidly and explosively and cannot be extinguished by smothering. Other substances which cause fire in mixtures containing sodium chlorate are phosphorus, sulfur, sulfides, metallic powder and ammonium salts.

When sodium chlorate is mixed with strong acids, chlorine dioxide and or chlorine gases are formed, both are toxic and when chlorine dioxide is present may become explosive. Consequently, due to this reaction potential it is recommended to store acids and sodium chlorate crystal and/or solutions separately.

Technical data and physical properties

Typical properties

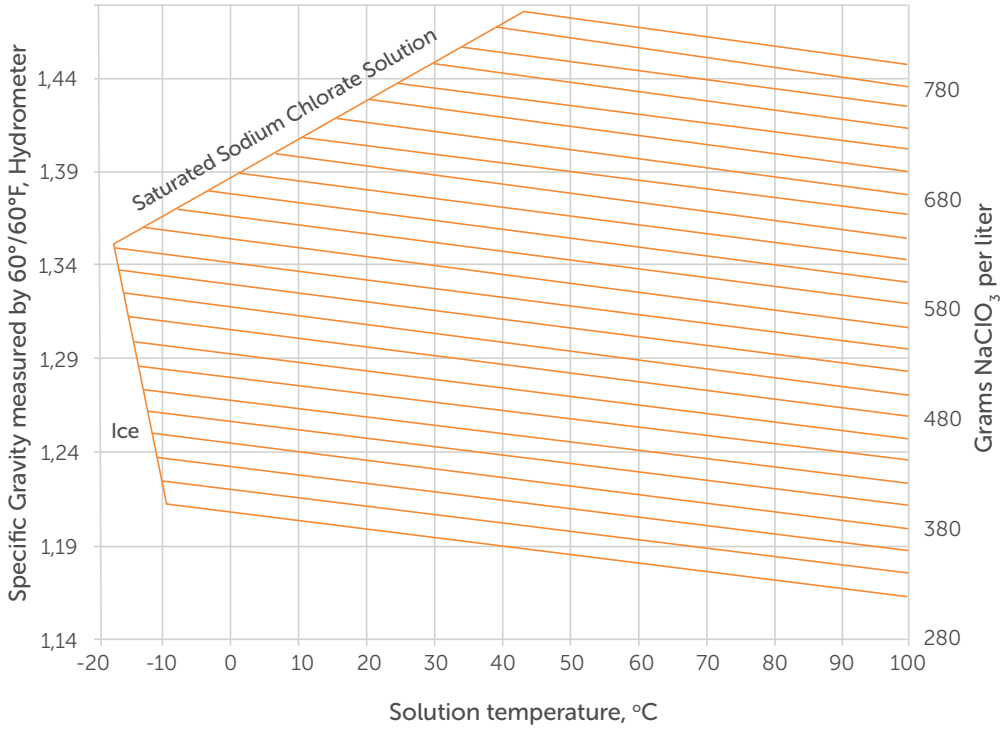
Please refer to the CURRENT sodium chlorate SDS for the CURRENT regulatory information about the physical properties for this product. Your Nouryon Representative will be able to provide you with this document.

Sodium chlorate

Chemical formula	$NaClO_3$
Molecular weight	106.4 g/mole
Appearance	white to off-white crystalline material, odorless
Melting point	248–250 °C
Boiling point	none, is decomposed at temperatures higher than 250–300°C into sodium chloride and oxygen gas
Bulk density	approximate 1500 kg/m^3
Solubility	soluble in water, refer to diagram on the following page
pH	neutral, assumes the pH of the solvent

Solubility of sodium chlorate in water

An illustration of the density of sodium chlorate solution at different temperatures and concentrations.



Safety and handling

Please refer to the latest product SDS in your local language for the most current regulatory information about the safety and handling of sodium chlorate. Your Nouryon Representative will be able to provide you with this document. The following are guidelines for the handling and use of sodium chlorate solutions. You should assess how to use the product safely in your particular manufacturing setting.

Mandatory protective equipment when handing sodium chlorate

Because sodium chlorate should never come in contact with organic materials like cloth and leather, make sure all personnel are provided with, and required to wear, the following items:

1. A protective suit (preferred anti-flammable treated) made of vinyl, neoprene, or PVC.
2. A pair of vinyl or neoprene boots.
3. Protective goggles that fit snugly over the eyes.
4. Rubber gloves.
5. Dust mask or in instances of high dust concentrations a dust respirator.
6. A hardhat with a full-face safety visor.

Nouryon recommends a number of other safeguards and procedures be observed:

1. Safety showers or jump tanks and eye wash stations should be located close to where sodium chlorate is unloaded, stored and used.
2. Do not allow sodium chlorate to accumulate. Promptly clean up spills/leaks using copious amounts of water.
3. Keep sodium chlorate areas free of any combustible organic materials, including cloth, paper, leather, paint, wood, sawdust, solvents, grease and oils.
4. Wood and leather are especially porous and absorb sodium chlorate solution so thoroughly it can't be washed out. We recommend non-leather clothing be professionally laundered before reuse, but shoes, pallets or any other organic material that gets soaked with sodium chlorate solution be destroyed by burning them in a safe and controlled environment.
5. To prevent the contamination and possible ignition, anything made of leather, including but not limited to shoes, belts and watchbands should not be worn when handling sodium chlorate in crystal or liquid forms.
6. Smoking is expressly prohibited in areas where sodium chlorate in crystal or liquid forms may be present. Even the smallest spark or heat source can ignite combustible materials contaminated with sodium chlorate.
7. All safety clothing should be kept separate from street clothes.
8. Clean safety clothing should be worn during each shift, then washed immediately afterwards.
9. Workers should shower with soap and water after each shift.
10. Equipment contaminated with sodium chlorate crystal or liquid should be thoroughly washed with water before being transported or moved from the controlled area.
11. Sodium chlorate should always be unloaded separately from other chemical deliveries.

Personal injuries and first aid

1. Skin: If sodium chlorate in crystal or solution form comes in direct contact with skin and/or mucous membranes, the result can be moderate to severe irritation of skin accompanied by reddening and pain. Overexposure to the chemical may cause burns.
   First aid: Immediately get under a safety shower. Thoroughly flush affected areas for at least 15 minutes while removing contaminated clothing. Then get medical attention.
2. Eyes: Getting sodium chlorate in one's eyes will be immediately apparent. Moderate to severe irritation and pain will occur. Prolonged contact may result in permanent eye damage.
   First aid: Go immediately to an eye wash station and rinse eyes thoroughly for at least 15 minutes. Then get medical attention.
3. Inhalation: Inhaling sodium chlorate dust may irritate the respiratory tract and mucous membranes. To minimize this potential make sure there is good ventilation in work areas. Workers should wear dust respirators where there are heavy concentrations of sodium chlorate dust.
   First aid: In case of inhalation, get fresh air. If breathing has stopped, give artificial respiration. If breathing is labored, give oxygen. Then seek medical attention immediately.
4. Ingestion: Swallowing sodium chlorate is harmful and, in extreme situations, could be fatal. Affected workers will exhibit abdominal pain, nausea, vomiting, diarrhea. It may cause difficulty in breathing and unconsciousness. To avoid the problem, workers should never eat or drink around sodium chlorate, and wash their hands well before eating.
   First aid: In case of ingestion, drink as much water as possible. Do not induce vomiting. Keep breathing passages clear. If the victim is unconscious, do not give anything by mouth. Then get medical attention immediately.

Safety and handling

Fire

A fire involving sodium chlorate can spread rapidly and explosively. Attempts to smother such a fire with a blanket or a chemical fire extinguisher will have no effect because sodium chlorate gives off oxygen during decomposition.
Water, if applied immediately, is the only possible means of controlling a fire involving sodium chlorate.

Safety action

If clothing catches fire, instantly get into a jump tank or under a safety shower and remove all clothing.

Jump tank installed at our Columbus, Mississippi facility

Procedures for safe handling

Observe the following recommendations to prevent both personal injuries and material damage at your facilities:

1. Any sodium chlorate spills or leaks should be contained, or quickly taken care of by workers wearing proper safety attire.
2. Spills should be cleaned up with a non-combustible absorbent and put in containers for disposal. (Consult your local, state and federal regulations for accepted means of disposal.)
3. Never flush sodium chlorate into water sources and public sewers.
4. Never wash sodium chlorate into a sewer where acids have been dumped or may be present. A dangerous reaction could result. For example, certain acids could turn sodium chlorate into chlorine dioxide and or chlorine, which is hazardous and toxic and may become explosive.
5. Make sure sodium chlorate never comes in contact with petroleum based oils, greases and lubricants. In rare instances when this has happened, explosions have resulted.
6. If you use sodium chlorate in super sacs, bags or drums always store directly on concrete floors. Nouryon does not recommend the use of wooden pallets; please use steel or plastic pallets. Any sodium chlorate crystals from a spill or a broken bag should be swept up and put into clean, dry containers. Dispose according to local, state, federal, or government regulations.

Transportation

Please refer to the CURRENT sodium chlorate SDS for the CURRENT regulatory information about the transportation of this product. Your Nouryon Representative will be able to provide you with this document.

Nouryon ships sodium chlorate in many regions of the world, primarily by rail or truck.

Product is usually packaged in super sacs when long distance transportation is required, especially to overseas customers. Alternative packaging in small metal drums is also available.

All vessels for transportation of sodium chlorate are made of compatible materials. The super sacs, utilized for long distance transportation, are made of polypropylene/polyethylene and have an individual capacity of 1000–1250 kg.

Sodium chlorate is classified as hazardous goods – transportation and packaging design must therefore adhere to the international transportation regulations.

Transportation regulations

Sodium chlorate is supplied in crystalline and solution form and must always be packaged in UN-approved packaging. Packaging must always be marked with the required labelling.

Transportation may take place by road, railway, sea or air (sample quantities). Each mode of transport has its own regulations with special requirements regarding packaging, vehicle type and documentation.

Examples of containers/packaging

Hopper truck – crystal product

Tanker truck – solution product

Supersac – crystal product

Drum – crystal product

Rail car – crystal product

Unloading

For questions regarding unloading and/or site specific material recommendations, please consult with your Nouryon Representative.

General unloading of sodium chlorate

All unloading operations must be performed exclusively by dependable, well-trained workers or truck drivers who are fully aware of the proper safety procedures and first aid actions.

The transporting vessel must be properly secured and with warning signs in place. All unloading connections must be securely attached before opening any discharge valves. A dedicated worker or a truck driver must be present at all times to monitor the attachment of connections and the unloading of the vessel.

Be sure to unload incompatible materials, such as strong acids or combustibles, in a separate area isolated from the sodium chlorate facility.

Unloading crystal product

Because of its high solubility in water, sodium chlorate crystals can be easily dissolved and unloaded as a liquid solution. Hot water circulating between the vessel and a mixing tank dissolves the chlorate crystals and forms the desired solution. Since the dissolving action absorbs heat, it is necessary to pre-heat the solution water to 65–80 °C (142–180 °F). During the unloading process, this temperature should not drop below 45 °C (113 °F). A source of additional heat, such as steam coils within the mixing tank or an external heat exchanger in the recirculation line, should be provided to maintain an adequate temperature.

The volume of water needed to unload a delivery will depend on both the amount of sodium chlorate delivered and the concentration required. The information provided in the tables presented on page 13 gives an example of recipes for various sodium chlorate concentrations.

Be sure the storage tank has adequate capacity for the solution to be received, see final volumes detailed in the tables presented on page 13.

Unloading and dissolving crystal product from supersacs

When sodium chlorate is shipped in supersacs, each bag has to be lifted up by a truck or a crane, tipped into a discharging unit and fed to a dissolving tank.

Please contact your Nouryon Representative for specific recommendations on the design of the discharging unit and dissolving tank system.

Sodium chlorate crystal – dilution water requirements and final volume

Metric units

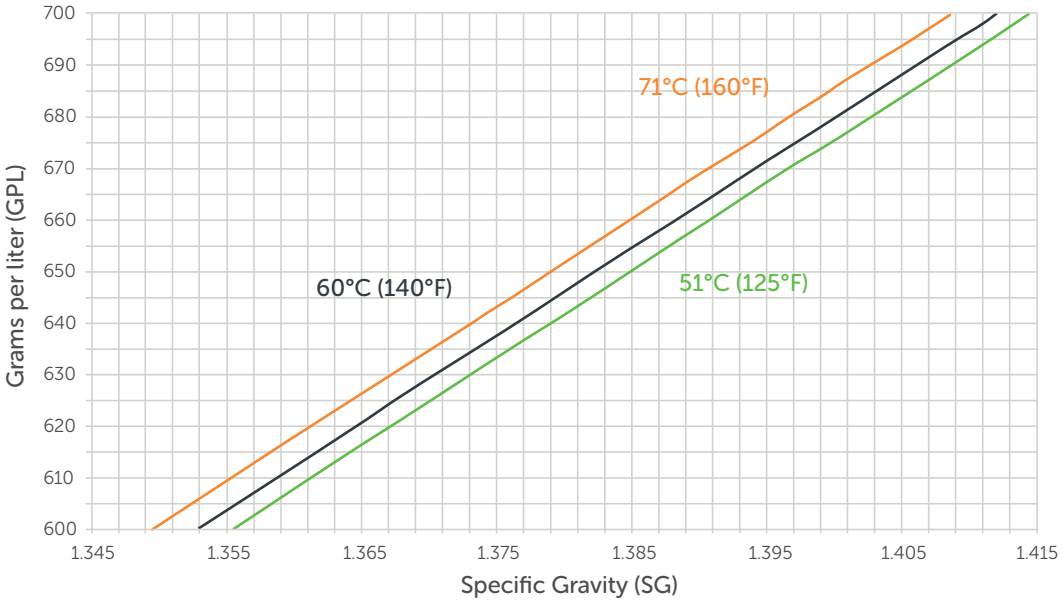
Desired Concentration (g/l)	Dissolving water m^3/metric tonne sodium chlorate @ 65°C	Dissolving water m^3/metric tonne sodium chlorate @ 80°C	Final Volume/metric tonne dissolved sodium chlorate
550	1.39m^3/tonne	1.37m^3/tonne	1.82m^3/tonne
600	1.11m^3/tonne	1.10m^3/tonne	1.54m^3/tonne
650	1.00m^3/tonne	0.99m^3/tonne	1.43m^3/tonne
700	0.96m^3/tonne	0.95m^3/tonne	1.39m^3/tonne

Imperial units

Desired Concentration (g/l)	Dissolving water US Gal/short ton sodium chlorate @ 175°F	Final Volume/short ton dissolved sodium chlorate
550	330 gallons/ton	435 gallons/ton
600	300 gallons/ton	410 gallons/ton
650	265 gallons/ton	370 gallons/ton
700	238 gallons/ton	345 gallons/ton

Specific gravity of sodium chlorate solutions at various temperatures

Sodium Chlorate Solution



Equipment

For site specific material recommendations, please consult with your Nouryon Representative.

Materials in general

Please refer to the information presented in the table on page 15. In general, 316/316L stainless steel and titanium are recommended as the most appropriate design materials for pure sodium chlorate. When using stainless steel, use 316 stainless steel alloy for cast components and use 316L stainless steel alloy for welded or fabricated applications.

Electrical systems must be dust-proof and comply with all applicable code standards. Electrical motors must be Totally Enclosed, Fan-Cooled (TEFC).

For fully dissolved sodium chlorate solutions it is recommended that pipes, valves and connectors be made of 316/316L stainless steel, titanium, Kynar® lined steel or FRP. Pipes, valves and connectors used with partially dissolved sodium chlorate slurries should only be made from 316/316L stainless steel or titanium.

Centrifugal pumps are the best choice for conveying sodium chlorate solutions. The pump must have a double mechanical seal with a minimum differential pressure of 35 kPa. A suitable design material would be titanium or 316 stainless steel.

Heat exchangers should be of Monel® 400 or titanium construction.

Gaskets must be made of inert materials such as Teflon®, Hypalon® or EPDM.

Petroleum-based lubricants should not be used. It is recommended that fluorinated lubricants are utilized on sodium chlorate systems.

Hoses must be made of EPDM, Teflon® or FEP.

Tanks

Storage tanks must be large enough to receive a full delivery. In general, the tank should be one and a half times the normal anticipated delivery volume.

Tanks should be constructed of FRP with added fire retardant or 316L stainless steel. If 316L stainless steel is used, measures to avoid stress corrosion should be employed.

Labeling on tanks

All tanks containing sodium chlorate should be labeled SODIUM CHLORATE SOLUTION and should have the required hazard labels. Follow the regulation given in the local country's safety data sheets, SDS. If you have questions regarding the proper labeling, please contact your Nouryon Representative.

Location of tanks

Tanks are to be surrounded by containment dikes and must be separated from areas containing flammable substances or where strong acids are being handled. Pipelines for other substances (e.g. sulphuric acid) should not be located where any leaks can come into contact with spillages of sodium chlorate.

The discharging area should be located in an easily accessible position. All risk of the sodium chlorate being mixed with other chemicals must be eliminated.

Recommendations on construction materials for sodium chlorate systems

Vessel	Best	Good	Satisfactory
Tanks	FRP	316L Stainless Steel (SS 2353) Alloy	Titanium
Pipes fully dissolved solution	316L Stainless Steel (SS 2353) Alloy	FRP or CPVC wrapped with FRP	Titanium, Teflon or Kynar lined steel
Pipes partially dissolved slurry	316L Stainless Steel (SS 2353) Alloy	Titanium	
Heat Exchanger Plates	Monel 400	Titanium	
Pumps	Titanium	316 Stainless Steel (SS 2343) Alloy	
Valves	316 Stainless Steel (SS 2343) Alloy	Titanium	Teflon or Kynar lined steel, FRP
Gaskets	Teflon	EPDM	
Hoses	EPDM	Teflon	FEP

Analytical procedures

Sodium chlorate concentration in chlorate feed solution

Safety

- Read the Safety Data Sheets for the chemicals before starting.
- Study local regulations for information about handling of hazardous chemicals and waste.
- Clothes contaminated with sodium chlorate can self ignite. Thoroughly wash with plenty of water if clothes are contaminated. However, contaminated leather clothes cannot be laundered and must be disposed immediately.
- Rinse with plenty of water if there is chlorate on the skin.

Summary

Chlorate is reduced with acidic Fe (II) in a known excess. The remainder of the Fe (ll) is then titrated with potassium permanganate to Fe (III). The method is applicable for solutions between 200 and 700 g/l; changing the sample volumes will make it suitable for other concentrations.

$ClO_3^- + 6\ Fe^{2+} + 6\ H^+ \rightarrow Cl^- + 6\ Fe^{3+} + 3\ H_2O$

$5\ Fe^{2+} + MnO_4^- + 8\ H^+ \rightarrow 5\ Fe^{3+} + Mn^{2+} + 4\ H_2O$

Apparatus

- Titrino 756 or similar
- Redox-electrode
- Volumetric pipettes: 20, 10, 2 ml
- Heating plate
- General lab equipment

Chemicals

- Potassium permanganate, $KMnO_4$ 0.050M
- Iron(II)sulphate, $FeSO_4$ 0.45M in 3M H_2SO_4 (see additional instructions)
- Mixed acid, $MnSO_4$+H_3PO_4+H_2SO_4 (see additional instructions)

Procedure

Sample preparation

Dilute 10 ml of the feed solution at process temperature to 100 ml in a measuring cylinder, mix well

Analysis

1. Add 20 ml $FeSO_4$ solution accurately, either by a volumetric pipette, or dosing from a Dosimat or similar equipment to a 200 ml beaker
2. Take 2 ml from the diluted sample to the beaker
3. Add 10 ml Mixed acid
4. Let the sample boil for a minute with glass beads, cool to room temperature
5. Titrate with 0.05M $KMnO_4$ potentiometric or to a faint pink color manually. Note the amount B
6. Prepare at least 2 Blank samples the same way, and titrate. Calculate the average consumption to the blanks and note the amount A

Calculating and reporting

$$NaClO^3(g/dm3) = \frac{(A - B) \times C \times M \times 10}{V \times 6 \times 100}$$

A average ml required for the blank titration
B ml required for the sample titration
C Concentration of $KMnO_4$
M Molecular weight of $NaClO_3$ [106.438]
V Sample volume
5/6 Molar ratio
10/100 Dilution factor
LOQ (limit of quantitation): 25 g/l
Accuracy 2RSD = 1.0 %

Waste disposal

To the sink with plenty of water

References

1. Vogel's textbook of quantitative inorganic analysis
2. Chemical Analysis; Herbert Laitinen
3. Standard Methods of chemical analysis; Wilfred Scott

Additional instructions

$FeSO_4$-solution

Dissolve 125 g $FeSO_4 \cdot 7H_2O$
or 117 g $FeSO_4 \cdot 6\ H_2O$ in deionized water, add 180 ml of concentrated H_2SO_4 and dilute to 1000 ml in a measuring cylinder after cooling.
Note: Always add acid to water – never water to acid.

Mixed acid

Dissolve 350 g $MnSO_4$ in de-ionized water, dilute to approx. 600 ml. Carefully add 150 ml of concentrated H_3PO_4 and 150 ml of H_2SO_4, dilute to 1000 ml after cooling.

Suggestions for titrino setup

The actual setup is dependent on the machine and type and condition of the electrode, so the following can only be considered as an initial suggestion that might have to be modified.

The method

Separated into two – first a blank determination with an average calculation and then the determination, which which automatically uses the average from the blank titration.

Analytical procedures

	Blank	Chlorate determination
Mode	DET	DET
Min.incr	10µl	10µl
Signal drift	50 mV/min	50 mV/min
Equilibr. Time	26 s	26 s
Start v	38ml	OFF
Statistics	On	Off
Mean	n = 2 (3)	-
Res.tab	original	-
EPC	60	60
EP recognition	Greatest	Greatest
Common variables	C30 = MN1	-
RS1	EP1	EP1
Chlorate g/l	-	$\frac{=(C30-EP1)*C01*C02*C03*C04}{C00 * C05}$
C01		0.05 ($KMnO_4$)
C02		106.43 (Mol. wt.)
C03		5 (Molar ratio)
C04		10 (dilution factor)
C05		6 (Molar ratio)

Page intentionally blank

Nouryon
Sales Offices

Bohus
T +46 31 58 70 00

Marietta
T +1 770 578 0858

Jundiaí
T +55 11 4589 4800

Shanghai
T +86 21 2289 1000

email
bleaching_experts@nouryon.com

Nouryon

We are a global specialty chemicals leader. Industries worldwide rely on our essential chemistry in the manufacture of everyday products such as paper, plastics, building materials, food, pharmaceuticals, and personal care items. Building on our nearly 400-year history, the dedication of our 10,000 employees, and our shared commitment to business growth, strong financial performance, safety, sustainability, and innovation, we have established a world-class business and built strong partnerships with our customers. We operate in over 80 countries around the world and our portfolio of industry-leading brands includes Eka, Dissolvine, Trigonox, and Berol.

eka.nouryon.com

00217_190219