copenhagen atomics

Chloride Salts

Produced by
Copenhagen Atomics

Chloride Salts
Highlights

- Highly purified salt quality (~100 ppm oxides)
- Ships in 1 m^3 tanks for safe and convenient use
- Pre-mixed and pre-melted
- Very low level of impurities from moisture, oxides and metal traces
- 10 times less moisture update compared to powder
- Significantly less corrosion

The molten salts
Introduction

Optimized for High-Temperature Applications

Traditionally commercially available Chloride salt comes in powder form and needs to be mixed to the eutectic composition, while often containing a large and variable amount of moisture, oxide and metal contaminants.

Therefore, Copenhagen Atomics has developed high purity grade of Chloride salt commercially available. The control of these impurities and pre-mixed product enable research groups and companies using molten salt to obtain more reliable and consistent data and less corrosion in processes employing molten salts.

Purified salt

Chloride salt undergoes a time consuming purification process to remove moisture, oxides and metal impurities from the salt. Purified salt is available in large quantities, intended for large testing requirements or molten salt processes in operation.

Reference	Oxides level	Metals level
High purified	< 100 ppm	< 250 ppm

Specifications

Chloride Salt Specifications

Reference	Chloride salt Eutectic mixture of NaCl, KCl and $MgCl_2$
Constituents	Sodium chloride (NaCl): CAS No. 7647-14-5 Potassium chloride (KCl): 7447-40-7 Magnesium chloride ($MgCl_2$): 7786-30-3
Formula	$MgCl_2$–KCl–NaCl eutectic*: 45.4 : 40.7 : 13.9 wt%
Appearance	Solid white
Melting/boiling point	400-405 °C / n.a.
Density (melt)	ρ(T in °C) = 1974.0-0.5878T (kg·m^{-3}) [1]
Viscosity (melt)	μ(T in K) = 0.689 · 10^{-4}exp(1224.7 / T) (Pa · s) [1]
Heat Capacity (melt)	c□(T in °C) = 1.3E-6 * T^2 -1.8E-3*T + 1.661(J·kg^{-1}·K^{-1}) [1]
Identified use	Lab/industry chemical
Storage	Store in an inert atmosphere or vacuum
H.S. Code	2827.20.00

*: Composition subject to customer requirements

Corrosion and Impurities

Copenhagen Atomics has significantly increased the accuracy of measuring impurity in Chloride salt. Metal impurity is measured through ICP OES and oxide impurity through electrochemical techniques.

See the oxide and metal contaminant level in different grade salts in the figure on the right.

Increased accuracy of impurity measurement, leads to increased accuracy of measuring corrosion, as corrosion scales with increased moisture, oxide and metal content.

Corrosion rate decreases substantially with Chloride salt produced by Copenhagen Atomics.

Corrosion rate induced by Copenhagen Atomics' purified salt is less than 0.01 mm/y*.

Corrosion rate induced by commercially available Chloride salt powder is more than 1 mm/year*.

Table of typical impurities

Z	Element	Impurities (ppm)
8	Oxygen (O)	<100
13	Aluminium (Al)	1-10
14	Silicon (Si)	1-5
24	Chrome (Cr)	5-50
25	Manganese (Mn)	1-5
26	Iron (Fe)	1-5
27	Cobalt (Co)	0-1
28	Nickel (Ni)	1-5
29	Copper (Cu)	0-1
30	Zinc (Zn)	0-1
39	Yttrium (Y)	0-1
40	Zirconium (Zr)	2-20
41	Niobium (Nb)	0-1
42	Molybdenum (Mo)	1-5
	others	2-20
=	Total	50-200

*Corrosion rate in stainless steel 316L at 550 ˚C in static experiments without galvanic effects.

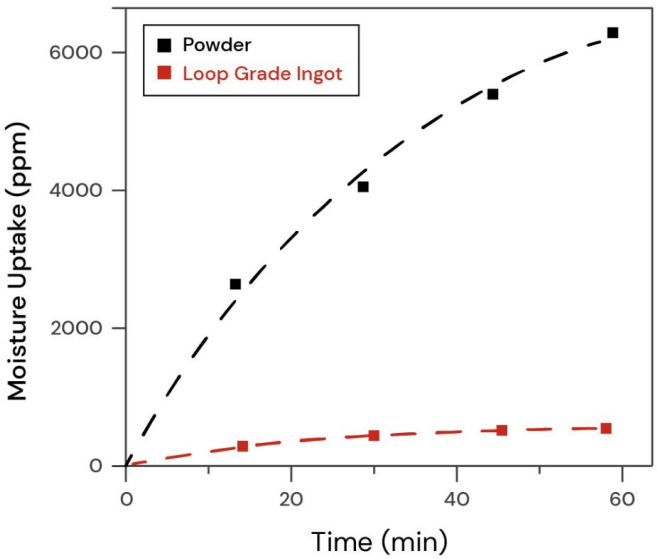
Advantages

Copenhagen Atomics purified salts ships in ingots and canisters.

There is around 10 times the amount of moisture uptake in the powdered salt compared to the ingot at each time interval, when exposing the Chloride salt to air measuring the increase in the mass.

It is challenging to ship and handle salts in powder form without introducing moisture. The handling alone will introduce a large amount of moisture that will potentially result in 5 - 10 times more corrosion of steel.

As the use of Copenhagen Atomics' Chloride salts will result in significantly less corrosion if handled correctly*, it would be more cost effective to use purified salts from Copenhagen Atomics and stainless steel 316 instead of powder-based salts and more expensive steels, such as Hastelloy N.



Unrefined Chloride powder	Copenhagen Atomics Salt
Mixing: Time and labour-demanding	Already pre-mixed
Powder form: Dust, loss of material, contamination and electrostatic phenomena	Tanks/ingot/pellet form: Minimum loss of material, minimum dust formation
Hygroscopicity: High specific surface area	Hygroscopicity: Reduced specific surface area
Impurities: Uncontrolled amounts of oxides, moisture and metal traces	Impurities: Minimum moisture, oxides and metal traces

*Copenhagen Atomics will provide guidelines on how to handle the salt in order to minimize the oxygen content in your system during loading and operation.

References

1. Youyang Zhao (2020). "Molten Chloride Thermophysical Properties, Chemical Optimization, and Purification" National Renewable Energy Laboratory Report NREL/TP- 5500-78047.

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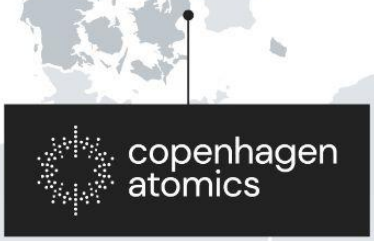

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