Salt Partners Ltd.
Carl Spitteler Str. 102
CH-8053 Zurich
Tel.: +41 (44) 422 26 82
Fax: +41 (44) 422 26 83
www.salt-partners.com

# Abstract

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## The "Missing Link" between saltworks biology and solar salt quality

***Vladimir M. Sedivy***
*MSc (Hons) Chem Eng, IMD*
*President, Salt Partners Ltd, Zurich, Switzerland*
*Email: vladimir.m.sedivy@salt-partners.com*

It has been widely recognised in the salt community that healthy biological systems in solar saltworks lead to higher salt production and better salt quality. However, a comprehensive explanation of the biological, chemical and physical mechanisms that cause sodium chloride to crystallise as monocrystals from "healthy" brine or as agglomerates from "organics containing" bitterns, has not yet been developed.

Salt Partners embarked on a research program targeting the discovery of this "Missing Link". Organic compounds, such as 1,2,3-trihydroxypropane (glycerol) biosynthesised by *Dunaliella salina* for survival by osmoregulation in hypersaline environments, have been identified as inhibitors that unfavourably modify sodium chloride crystallisation habit. Under laboratory conditions, pure saturated sodium chloride solution has been left to freely evaporate from Petri dishes at room temperature. Organic compounds, such as glycerol, were added in concentrations ranging from few ppm up to 10'000 ppm (1%). High concentrations of such organic compounds can occur in solar crystallisers operating with brine rich in nutrients, such as nitrogen and phosphorous. When bitterns in such solar crystallisers reach concentrations so high that *Dunaliella salina* no longer successfully survives, the organic compounds are released to the brine. As can be seen on the picture above, the NaCl crystallisation habit is visibly influenced already by small (500 ppm) addition of glycerol to the brine in the Petri dish in the middle of the picture. The NaCl crystallisation habit is distinctly modified by addition of 5'000 ppm of glycerol to the brine in the Petri dish on the right. It can be also observed that addition of glycerol slows down the rate of evaporation and NaCl crystallisation from brine.

In solar crystallisers operating with "healthy" brine, salt grows as large monocrystals (see picture below, crystal on the left). They are hard, transparent and very pure (up to 99.99% NaCl). In the crystallisers of solar saltworks operating with "organics containing" bitterns, salt forms agglomerates of tiny sodium chloride crystals (see picture below, agglomerate on the right). These tiny crystals are closely attached to each other. The voids between them contain magnesium rich mother liquor (15 - 50 g/l $Mg^{++}$) and enclose embedded gypsum ($CaSO4 . 2H_2O$). Chemical industry consumes some 60% of the world salt production. In chloralkali manufacture salt purity is crucial to save brine purification chemicals and prevent formation of contaminated effluents.

Salt Partners seek the cooperation of scientists and solar salt producers to complement the "Missing Link" program with field research.

Salt Partners is an independent firm of consultants and engineers, active in the field of salt production, processing and hypersaline biotechnology. Salt Partners' reputation is based on more than 30 years of experience gained in salt and chloralkali projects implemented world-wide.