Desalination and Water Treatment
www.deswater.com

51 (2013) 921–923
January

doi: 10.1080/19443994.2012.700787

A sustainable antiscalant for RO processes

Gerald van Engelen*, Robert Nolles

Cosun Biobased Products, P.O. Box 3411, 4800 MB, Breda, The Netherlands
Email: Gerald.van.Engelen@cosun.com

Received 12 March 2012; Accepted 3 June 2012

ABSTRACT

The fast growing desalination industry is facing two major challenges such as cost reduction and reduction in the environmental impact. The usage of fossil-based chemicals (like most antiscalants) has a negative influence on both challenges. Most often these chemicals are not environmentally friendly and the cost for these chemicals are increasing rapidly due to the rising prices of raw materials (e.g. crude oil and phosphate rock). Most of the currently available environmentally friendly scale inhibitors have some drawbacks related to cost and/or performance. Carboxymethyl inulin is an environmentally friendly antiscalant which has been proven to be cost-effective in RO processes and therefore, could have a positive contribution to both of the above-mentioned challenges.

Keywords: Scale inhibitor; Biofouling; Carboxymethyl inulin; Cosun; Membranes; Reversed osmosis

1. Today's challenges

There is a growing concern and increasing awareness in the society and at government level regarding the environment and sustainability. This concern is related to climate change, the environment in general, future scarcity, and costs of fossil-based raw materials such as crude oil and phosphate rock, and dependency for the supply of these raw materials on political instable regions. Other aspects are the need for rural development in both developed and poor countries and the overall impact of the economic development of upcoming regions like China and India. All these are leading to policy and legislation on regional and global level to stimulate more sustainable sourcing and supply of food products, energy, chemicals, and drinking water.

Drinking water availability and supply is becoming more and more a problem for many people around the globe. Hence, production of drinking water from brackish and seawater is a fast growing industry. The production high quality drinking water against low prices with a minimum of environmental impact is a big challenge. Cost reduction has a high priority and is mainly focused on the reduction of the consumption of energy and chemicals.

The replacement of environmentally unfriendly chemicals by more sustainable alternatives is often not investigated because of the preassumption that it will lead to additional costs. However with the rapid increase in the price level of chemicals-based on crude oil and/or phosphate rock the question is not if, but when bio-based chemicals will outcompete fossil-based chemicals on cost performance. Carboxymethyl inulin could be one of the first environmentally

*Corresponding author.

Presented at the International Conference on Desalination for the Environment, Clean Water and Energy, European Desalination Society, 23–26 April 2012, Barcelona, Spain

Photo 1. Chicory, the source for inulin.

friendly antiscalants for RO processes, which performs excellently without compromising on membrane performance and cost-effectiveness.

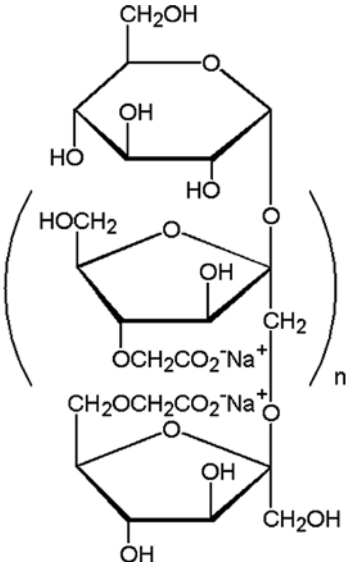

Fig. 1. The structure of CMI.

2. Cosun bio-based products

Cosun bio-based products are part of Royal Cosun, one of the major Dutch agro-food companies. The worldwide business scope of Cosun bio-based products is the development, manufacturing, and marketing of plant derived products for nonfood applications (Photo 1).

Cosun bio-based products are working on a broad port folio of nonfood products. Some examples are carbohydrate-based plasticizers, natural fibers reinforced composite materials, and chemical building blocks for new polymers (furans). Marketed and commercially available products are derivatives based on the polysaccharide inulin extracted from the chicory root, such as carboxymethyl inulin and cationic inulin. Both products are being applied in various products and industries because of their functionality and good fit with the trend of more sustainable and environmentally friendly chemicals and ingredients.

3. Carboxymethyl inulin

The best known inulin derivative being used as threshold scale inhibitor is carboxymethyl inulin branded under the name Carboxy*line*® CMI.

Carboxymethyl inulin (CMI) is a molecule synthesized with various degrees of substitution ranging from 1.5 to 2.5. The structure of CMI is shown in Fig. 1. Generally, the higher the DS the more functional groups, the better the performance of the molecule.

In a nutshell, CMI performs well as a threshold scale inhibitor for various types of scaling due to its three main functionalities: complexing of metal ions, crystal growth inhibition, and dispersancy. The effect of CMI on the growth of $CaCO_3$ crystals is shown in Fig. 2. The presence of CMI has a clear effect on the amount, size, and morphology of the crystals that has being formed.

With CMI, today's and tomorrow's challenges in the drinking water industry can be met. CMI has proven to have an excellent performance against typical seawater scales like $CaCO_3$, $BaSO_4$, $SrSO_4$, and $CaSO_4$. CMI performs well under conditions with high calcium (Ca) and TDS and under high iron (Fe) levels.

Its excellent safety profile, renewable origin, and biodegradability (OECD 306) and the fact that CMI is phosphorous and nitrogen free is a clear advantage in terms of sustainability and will be beneficial to prevent (future) legislative issues.

Most other available biodegradable antiscalants are notorious for their biofouling effect on the membranes in RO processes. Based on this case study, CMI has proven not to contribute to biofouling and therefore,

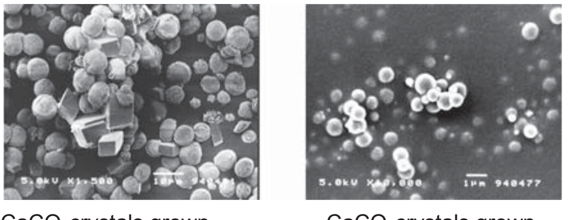

Fig. 2. Crystal growth inhibition with CMI.

to be a cost-effective and green scale inhibitor for RO processes.

4. Case study

In 2006, a joint research project was started in the Netherlands to develop a special grade of CMI for application in RO processes for the production of potable water. Cosun worked closely together with Aquacare Europe BV, a Dutch service company specialized in water treatment (cooling water) and membrane processes. This special CMI grade was first tested on laboratory scale to investigate the biofouling potential, followed by performance testing on pilot scale.

Based on the good results obtained from this R&D work, full-scale testing could start on a groundwater drinking water production plant in the Netherlands. The discharge of the brine of this plant on surface water was restricted for phosphorous. Therefore, the plant was running on an alternative biodegradable antiscalant which led to extra operational costs for cleaning due to biofouling.

This specific production plant uses groundwater for the production of 320 m^3/h of drinking water with RO membranes (four stacks). The operational recovery rate is above 80%. CMI was tested on one stack against the other antiscalant on three stacks. During the sixth month, all operational and technological aspects and costs were closely monitored in good collaboration with all companies involved.

5. Results

CMI proved to be a very effective antiscalant at low dosage levels and with a long induction time. Secondly, the usage of CMI did not lead to biofouling and the cleaning interval could be reduced from every 2–3 months to less than one year. All this resulted in substantially lower cleaning costs, lower energy consumption, and less down time.

After the full-scale trial period, the drinking water company decided to switch to CMI on all four stacks of the production plant and is running on CMI for several years now. During these years, further optimization has been done leading to even further reduced operational costs.

At this moment, CMI is being tested on four other RO plants in the Netherlands running on surface water and groundwater.

Because of the excellent performance of CMI against typical seawater scales there is a clear opportunity for carboxymethyl inulin as antiscalant in desalination processes with RO membranes. The technological roll out has been started for seawater and brackish water.

Acknowledgment

The authors acknowledge Mr. Koos Baas, General Manager, Aquacare Europe BV, P.O box 2147, 5202 CC 's-Hertogenbosch.