

DEVELOPMENT OF DESCRIPTOR TOOLS FOR THE CHARACTERISATION OF AUSTRALIAN SUGAR MILL EVAPORATOR SCALE

By

D.W. RACKEMANN, W.O.S. DOHERTY and C.P. EAST

Sugar Research and Innovation, Queensland University of Technology, Australia
d.rackemann@qut.edu.au

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Abstract

CLEANING of sugar mill evaporators is an expensive exercise. Identifying the scale components assists in determining which chemical cleaning agents would result in effective evaporator cleaning. The current methods (based on x-ray diffraction techniques, ion exchange/high performance liquid chromatography and thermogravimetry/differential thermal analysis) used for scale characterisation are difficult, time consuming and expensive, and cannot be performed in a conventional analytical laboratory or by mill staff. The present study has examined the use of simple descriptor tests for the characterisation of Australian sugar mill evaporator scales. Scale samples were obtained from seven Australian sugar mill evaporators by mechanical means. The appearance, texture and colour of the scale were noted before the samples were characterised using x-ray fluorescence and x-ray powder diffraction to determine the compounds present. A number of commercial analytical test kits were used to determine the phosphate and calcium contents of scale samples. Dissolution experiments were carried out on the scale samples with selected cleaning agents to provide relevant information about the effect the cleaning agents have on different evaporator scales. Results have shown that by simply identifying the colour and the appearance of the scale, the elemental composition and knowing from which effect the scale originates, a prediction of the scale composition can be made. These descriptors and dissolution experiments on scale samples can be used to provide factory staff with an on-site rapid process to predict the most effective chemicals for chemical cleaning of the evaporators.

Introduction

The sugar industry experiences scaling of evaporators; the extent of scaling varies from mill to mill, within a season and from season to season for individual evaporators. These encrustations are formed from the combined effects of several processes involving inorganic and organic molecules or ions.

The type of the scale formed depends on a number of parameters, including the concentrations of scale-forming ions, the amount of dissolved and suspended solids, the pH and flow properties of the solution, the rate of evaporation, and the operating temperature (and pressure) of the system.

Impurities in juice deposit onto heating surface areas because heating surface areas have a higher temperature at their surface than the surrounding juice and provide nucleation sites for scale growth. Scale facilitates the corrosion of surfaces, restricts fluid flow and, because it has low thermal conductivity, its accumulation on metal surfaces impairs heat transfer across the metal-fluid interface.

One of the most important characteristics of any evaporator set is to ensure that it can evaporate water from the juice at an adequate rate to ensure that the set does not become the rate-limiting step in the factory.

After a clean, evaporator sets typically have sufficiently high average heat transfer coefficients to meet the rate of production. However, as the heating surfaces become covered with scale, the heat transfer coefficients (HTC) decline, and if the set is heavily fouled it will not always meet production rates.

This is particularly so in Australian sugar factories where spare evaporators are not available and fouled effects cannot be taken off-line for cleaning without interrupting factory operation. In these circumstances, some limited options are available to reduce the impact on the factory. Options such as the reduction of maceration water on the milling train, lowering of the syrup brix set point and the reduction of filter wash water help to maintain the required evaporator rate. However, these techniques can only sustain the evaporator set for a certain period and ultimately the only option is to stop the factory so that the evaporators can be cleaned.

Cleaning of evaporators is an expensive exercise. The estimated cost associated with scale formation and scale removal for a typical Australian mill is \$400,000 per season. This estimate comprises the costs of: (a) labour due to extended season; (b) factory shutdown causing loss of production, and (c) cleaning chemicals.

The factory stoppage time for cleaning of the evaporator set and the operating time between cleans depends on various factors such as the nature of the scale, type of cleaning chemical and the cleaning procedure adopted (Doherty, 2000). Identifying the compounds present in scale helps in determining which cleaning agents would result in effective cleaning of evaporators and which scale inhibitors will significantly reduce scaling rates (Crees *et al.*, 1993).

Scale consists of many components and its composition can best be determined using a combination of techniques. Applicable techniques include atomic absorption spectrophotometry, x-ray powder diffraction (XRD), x-ray fluorescence (XRF), ion exchange/high performance chromatography, thermogravimetry/differential thermal analysis and electron microscopy (Crees *et al.*, 1992 and 1993). This project aims to characterise scale samples with some of these techniques with the ultimate aim to describe the type of scale in each evaporator by visual and tactile descriptors, simple elemental analysis and dissolution experiments with cleaning chemicals currently used in Australian sugar mills.

Scale formation

Figure 1 illustrates typical distributions of the components in scale (as mass percent), relative to the position in the evaporator set and brix concentration of the juice. The data are based on scale analyses conducted by Sugar Research Institute in Australian sugar mills over the last 15 years.

The distribution trends are similar to those reported by Honig (1963). A large portion of scale formed has calcium as an elemental constituent due to an excess of calcium that is introduced into the process via liming prior to clarification. Any residual calcium that remains in the juice after clarification has the potential to contribute to scale formation in the evaporators, pans and fuggals.

In general, in any evaporator set, the calcium phosphate and hydroxyapatite (a phosphate compound) content in scale decreases from the first to the last vessel, while the amorphous silica, calcium oxalate, calcium sulfate and aconitate content increase from the first to the last vessel. Solubility of amorphous silica and calcium oxalate are known to decrease with increasing sucrose concentration and reducing temperature leading to prevalence of these scales in the latter effects (Crees *et al.*, 1992; Walthew and Turner, 1995; Doherty, 2000). Organic matter is present in all scales, but in decreasing proportions towards the end of the evaporator set.

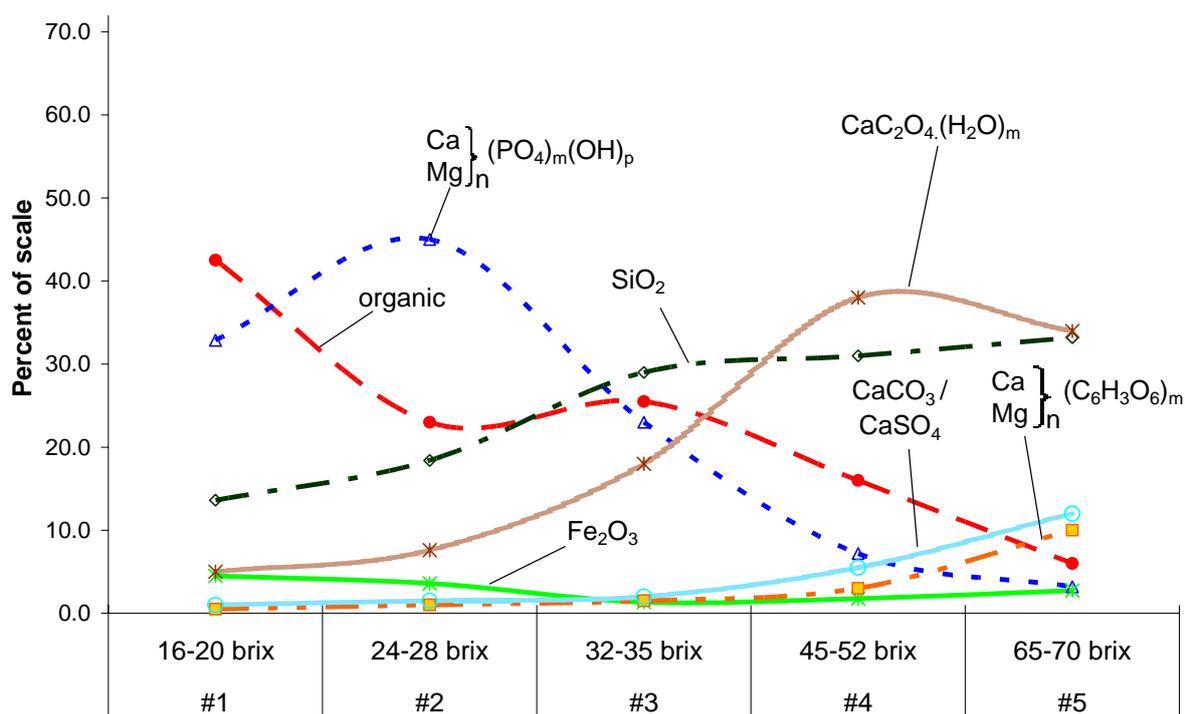


Fig. 1—Percent of various components in scale across a quintuple evaporator set.

Experimental

Scale collection

Samples of scale from calandria tubes were obtained by mechanical means from seven Australian sugar mills during the 2001 crushing season. The samples are further classified with mills A, B and C from the northern growing region, mills D and E from the central growing region and mills F and G from the southern growing region.

These samples were obtained both before and after the calandria tubes had been chemically cleaned, depending on the flexibility of the factory. In most cases though, scale samples were collected with a mechanical device (scale sampler) which allowed samples to be collected prior to cleaning or during maintenance stops without the need for the vessels to cool down considerably. The scale samples were collected from quintuple sets.

Scale characterisation

XRF and XRD analysis

The scale samples were thoroughly washed with distilled water to remove residual sugar and then dried to constant weight under vacuum prior to analysis. They were characterised using XRF and XRD. The elements were analysed using an x-ray fluorescence spectrometer equipped with a Radium tube. The x-ray studies were carried out using a Rigaku camera and a x-ray generator with CuK_α radiation of wavelength 1.5418 Å. X-ray powder diffraction techniques were used as they are the standard methods for the identification of scale components.

Visual and tactile descriptors

The scale samples that were analysed by XRF and XRD were also characterised based on their visual and tactile appearance. The appearances of the scale samples were detailed as powder, granular or flakes. The texture of the scale samples was assessed by rubbing them between the fingers and was described as smooth, coarse, rough or gritty. A visual assessment of the colour of the scale was also made. To obtain the original colour of the scales present in the evaporators, it was

necessary to treat the collected scale samples with water since dehydration during storage might affect their colour.

Scale dissolution

Dissolution experiments using a proprietary Sugar Research Institute procedure were conducted in the laboratory on scale samples with the following chemicals:

- 10% (w/v) caustic soda solution.
- 3% (w/v) sulphamic acid.
- 10% (w/v) ethylene diamine tetra-acetic acid tetra-sodium salt (EDTA).

The dissolution experiments enabled generalised deductions to be made on the effect the cleaning agents have on individual scale components.

Scale characterisation by simple chemical means

The aim of scale characterisation by simple chemical means is to enable factory staff to quickly and cheaply determine the elemental composition of scale samples. The two main inorganic elements (apart from silicon) present in scale are calcium and phosphorus. Standard test kits used for the determination of phosphorus and calcium in boiler feedwater are available in the market and can be used by persons with little background chemistry knowledge. Preliminary assessments were conducted on four analytical tests kits. The Hach test strips and the Nalco orthophosphate octet colour comparator were assessed for phosphate determination, while the Merck calcium analytical test strips and the Nalco hardness test kit for total hardness and calcium hardness (drop titration method) were assessed for calcium determination.

Scale (0.1 g), HCl (5 mL of 10% solution) and distilled water (15 mL) were placed in a 250 mL conical flask and heated to boiling. The solution was further boiled for 30 min with 5 mL water aliquots added from time to time. The solution was filtered through a Whatman No. 91 paper and transferred to a 1 L volumetric flask and made to the mark with distilled water. The scale solution was diluted with distilled water by a factor of five prior to phosphorus and calcium analysis.

Results

Scale characterisation

XRF and XRD analysis

The XRF results gave the elemental composition of the scale samples based on their metal oxides (SiO_2 , Al_2O_3 , Fe_2O_3 , MgO , CaO , Na_2O , P_2O_5 , and SO_3). The XRF data also gives a loss on ignition value due to the volatilisation of organic acids, lipids, proteins, polysaccharides, chemically bound $-\text{OH}$ and H_2O as well as adsorbed water. The results from the XRF showed:

- CaO , P_2O_5 and SiO_2 were the main oxides identified in the scale samples.
- The highest proportion of P_2O_5 was present in the earlier effects (i.e. Nos. 1, 2 and 3).
- There was a reasonable amount of Fe_2O_3 in the scale samples. The presence of large amounts of Fe_2O_3 in some of the scale samples is probably due to corrosion of the tube plates.
- Each scale sample contains a large amount of organic matter as deduced from the loss on ignition.

Interpretation of the XRD patterns of the scale samples identified the following compounds: amorphous silica, hydroxyapatite, iron oxide, calcium carbonate, calcium oxalate (mono- and dihydrate). Table 1 shows data for the seven factories on the approximate proportion of the scale

components determined by simple mass balance calculations and the XRD and XRF data for Nos. 1, 4 and 5 effects.

The results are summarised as follows:

- When SiO₂, P₂O₅, Fe₂O₃ and SO₃ are present in the scale, it has been established that SiO₂ is present as amorphous silica; P₂O₅ is present as hydroxyapatite, Fe₂O₃ is present as iron oxide and SO₃ is present as calcium sulfate di-hydrate.
- High CaO levels in Nos. 4 and 5 effects suggest the presence of calcium oxalate.
- Amorphous silica, hydroxyapatite and organic matter are the main scale components deposited in the No. 1 effect with hydroxyapatite as the largest scale component.
- Amorphous silica, calcium oxalate and organic matter are the main scale components deposited in the later effects with calcium oxalate and silica the largest scale components.

Table 1—Composition of scale in the Nos. 1, 4 and 5 effects of several Australian factories.

Compound (%)	Mill						
	A	B	C	D	E	F	G
No. 1 Effect							
Amorphous silica (hydrated)	10	14	5	27	16	11	35
Hydroxyapatite	57	26	2	50	43	50	30
Iron oxide	2	23	3	1	1	2	5
Calcium carbonate	8	11	6	0	0	0	0
Calcium oxalate (mono- & di-hydrate)	0	0	0	0	0	0	0
Calcium sulfate	2	trace	trace	1	1	2	1
Organic matter	21	26	84	21	39	35	29
No. 4 Effect							
Amorphous silica (hydrated)	8	16	36	trace	35	6	69
Hydroxyapatite	10	1	10	3	11	12	10
Iron oxide	2	5	1	1	1	trace	trace
Calcium carbonate	trace	0	0	0	0	0	0
Calcium oxalate (mono- & di-hydrate)	64	66	40	70 (di)	35	73	9 (di)
Calcium sulfate	trace	trace	0	0	trace	1	1
Organic matter	16	12	13	26	18	8	11
No. 5 Effect							
Amorphous silica (hydrated)	42	24	27	32	78	67	40
Hydroxyapatite	9	1	9	1	2	3	4
Iron oxide	trace	7	trace	trace	3	1	5
Calcium carbonate	1	23	0	16	0	0	0
Calcium oxalate (mono- & di-hydrate)	33 (di)	38	31 (mono)	42	11	2 (di)	34 (di)
Calcium sulfate	1	trace	trace	trace	trace	trace	4
Sodium hydroxide*			22				
Organic matter	14	7	11	9	6	17	13

* The scales were collected after caustic clean.

The results are in agreement with the data in Figure 1. The results also show some variation across the various cane growing regions. Provided similar farming practices are used and similar cane varieties are grown, the scale composition should be reasonably similar over subsequent seasons but the concentrations of the scale components may vary due to changes in phosphate, calcium and organic acid content of the juice.

Visual and tactile descriptors

Some general trends were determined for the visual and tactile descriptors of the scale samples as follows:

- The colour of the scale samples is usually darker in the earlier effects than the later effects of an evaporator set.
- Dark coloured (chocolate brown/black) scale contains mainly hydroxyapatite and organic matter, while creamy coloured scale contains mainly calcium oxalate or is a mixture of calcium oxalate and amorphous silica.
- There was no marked change in colour between the ‘dry’ and wet scales, although the wet scale was darker in some samples.
- Flakes tended to be present in the last effects and were mixtures of calcium oxalate and amorphous silica.
- There was no discernible pattern on the texture of the scales across an evaporator set, other than at some factories the scales in the earlier effects were softer than those in the later effects.

Scale dissolution

The dissolution experiments showed that when the scale contained two main compounds with different chemical properties (e.g. hydroxyapatite and organic matter) a two-step cleaning process was required to completely dissolve the scale sample. The results are presented in Table 2 and confirm the earlier work of Doherty (2000).

Table 2—Reaction between scale components and cleaning agents

Compound	Effect of cleaning agent
Organic matter (proteins, degraded cellulose, polysaccharides etc.)	Readily attacked by caustic soda; not attacked by acid and EDTA
Calcium phosphate (tri-calcium phosphate and hydroxyapatite)	Readily attacked by acid; partially attacked by caustic soda and EDTA
Calcium carbonate	Readily attacked by acid and EDTA; not attacked by caustic soda
Amorphous silica	Slowly attacked by caustic soda; not attacked by acid or EDTA
Calcium oxalate (calcium oxalate mono-hydrate and calcium oxalate di-hydrate)	Readily attacked by EDTA; partially attacked by acid; not attacked by caustic soda
Calcium magnesium aconitate	Readily attacked by EDTA; slowly attacked by acid; very, very slowly attacked by caustic soda

Elemental analysis

Descriptions of the analytical test kits and preliminary testing results are given in Table 3. The kits were first tested on a series of standard solutions (made from sodium orthophosphate and calcium chloride) containing varying amounts of phosphate and calcium ions to determine the ease of use and any practical issues involved with the analytical procedure.

Table 3—Descriptions of analytical test kits.

Element	Type of test kit	Working conc. range (ppm)	Comments on use with standardised solutions
P (as PO ₄)	Hach test strip	0–50	Easy to use, but large concentration increments with small changes in colour reduce accuracy
	Nalco colour comparator	1–100	Produced acceptable values for qualitative determination
Ca	Merck test strip	0–100	Provide approximate concentration. Concentration increments on the colour scale are quite large with no distinction between 10 and 25 ppm calcium
Ca (as CaCO ₃)	Nalco hardness drop titration method	5–600	Produced acceptable values for qualitative determination

The results in Table 3 showed that the Nalco colour comparator can be used to determine the concentration of phosphate in scale, while the Nalco hardness drop titration method can be used to determine the concentration of calcium in scale. Table 4 shows the comparison of the phosphate (expressed as P₂O₅) and calcium (expressed as CaO) results obtained with the Nalco test kits with those obtained from XRF for a number of scale samples.

Table 4—Scale analysis with Nalco test kits.

Scale origin	% P ₂ O ₅		% CaO	
	XRF	Nalco colour	XRF	Nalco hardness
No. 1 effect Mill E	18.1	19	24.0	48
No. 2 effect Mill G	12.5	8	15.9	14
No. 5 effect Mill G	1.5	0.4	14.9	28

The results show differences between the Nalco test methods and the XRF method. The differences of the P₂O₅ results between the Nalco colour method and the XRF method were not very large. As such, the Nalco colour method for phosphate may be used to determine the P₂O₅ content of scale. Marked differences were obtained in the calcium results. These differences may be due to certain components in the scale interfering with the Nalco hardness test method. Also, the colour change (from reddish-purple to bluish purple) for the Nalco hardness test method was broad and hence the end-point was difficult to detect. As a result, the Nalco hardness test, though suitable to analyse calcium in simple solutions, is not recommended for calcium determination in scale.

Development of scale and cleaning tools

The data obtained from the various scale analysis characterisation methods (XRF and XRD analyses, visual and tactile descriptors, scale dissolution and elemental analysis) allow the development of scale descriptor information data sheets for typical scale types present in Australian sugar mill evaporators.

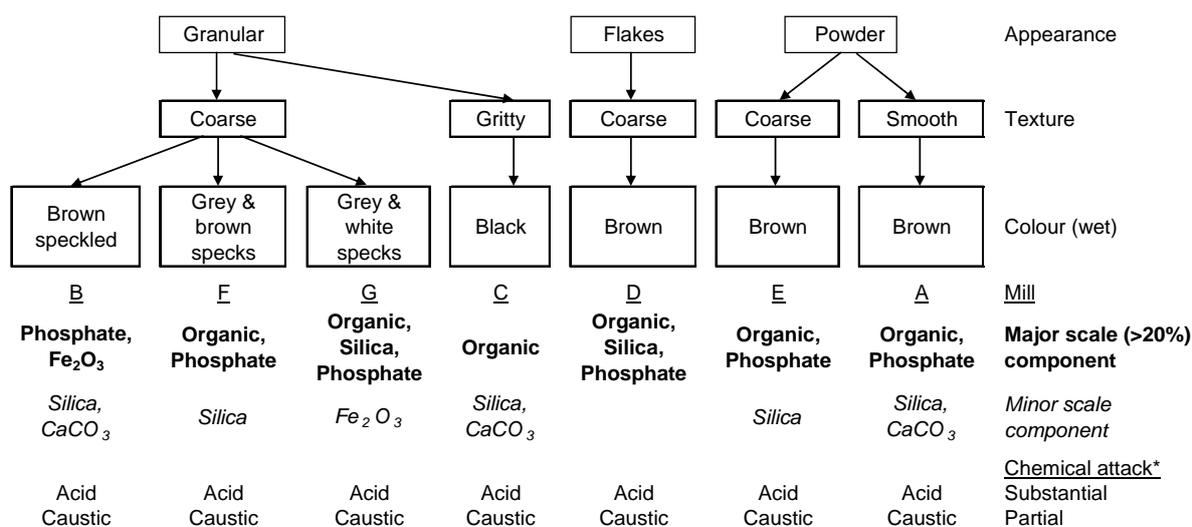
The conclusions from the tactile studies were that it was not an effective method to identify different scale types since the textures of most of the scale types were similar. Nonetheless, the tactile data were included in the data sheets. These data sheets are summarised in Figures 2 to 4 for the scale samples obtained from the Nos. 1, 4 and 5 evaporators.

As chemical analyses of scale samples are expensive and can not be completed in a timely manner, the aim was for the portfolio of data to serve as a reference for factory staff to qualitatively assess the scale composition based on the colour and appearance of the scale. This will assist in the prediction of appropriate and effective chemical cleaning agents to be used in the different effects to remove scale.

The following steps should be undertaken to characterise an unknown scale sample and to propose a cleaning procedure:

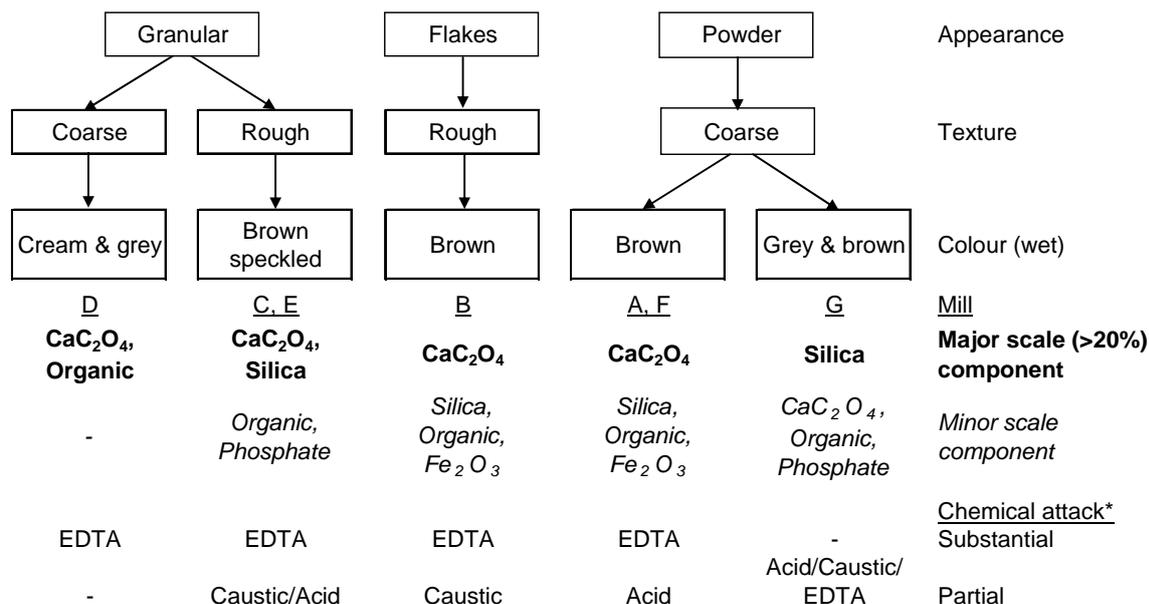
- Step 1.** Identify sample source e.g., No. 1 effect.
- Step 2.** Identify the colour of the sample (note whether the sample is wet or dry).
- Step 3.** Identify the appearance of the sample.
- Step 4.** Based on the results of steps 1, 2 and 3 refer to scale descriptor data sheets containing No.1 scale.
- Step 5.** Based on the results of step 4 propose a cleaning procedure by referring back to the scale descriptor data sheets.
- Step 6** The proportions of the mail scale components may be different from those represented in the data sheets. Therefore, it may be necessary to determine the calcium and phosphorus contents.

It should be noted that the data sheets are not comprehensive as only one set of scale samples was obtained from each mill at varying times through the 2001 crushing season and the composition of scale is known to vary as the crushing season progresses (Doherty, 2000). Certain types of scale may also look the same but have different compositions that will impact on the efficacy of cleaning agents. For example the scale obtained from No. 1 effect at mill G is similar in appearance and texture to the scale obtained from No. 4 effect at mill D; however, one scale is readily attacked by acids and the other by EDTA. Knowing from which effect the scale originates provides an extra parameter that can be used with generalised trends shown in Figure 1 that may allow a more accurate prediction of the scale composition.



*Based on laboratory dissolution experiments: 10% w/v caustic; 10% w/v EDTA; 3% w/v sulphamic acid
 CaCO₃: Calcium carbonate; Phosphate: Tri-calcium phosphate [Ca₃(PO₄)₂] and hydroxyapatite [Ca₅(PO₄)₃OH];
 Fe₂O₃: Iron oxide; Silica: amorphous and crystalline silica

Fig. 2—Descriptors, composition and solubility of the scale from the No. 1 evaporators.



*Based on laboratory dissolution experiments: 10% w/v caustic; 10% w/v EDTA; 3% w/v sulphamic acid
 CaC₂O₄: Calcium oxalate (mono- & di-); CaCO₃: Calcium carbonate; Fe₂O₃: Iron oxide;
 Phosphate: Tri-calcium phosphate [Ca₃(PO₄)₂] and hydroxyapatite [Ca₅(PO₄)₃OH]; Silica: amorphous and crystalline silica

Fig. 3—Descriptors, composition and solubility of the scale from the No. 4 evaporators.

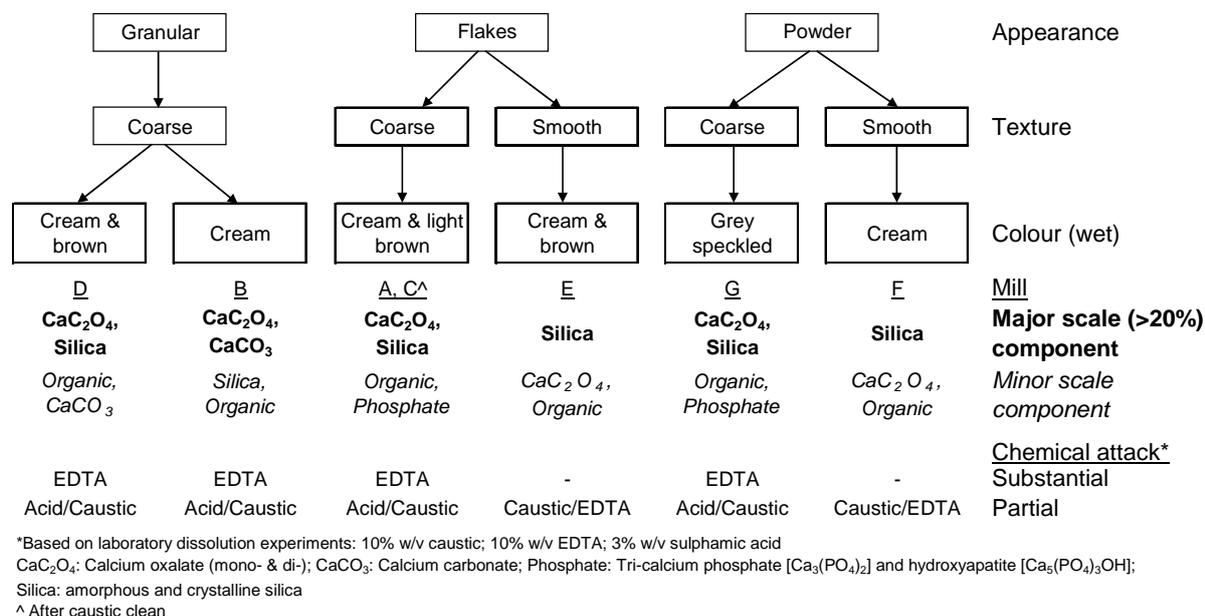


Fig. 4—Descriptors, composition and solubility of the scale from the No. 5 evaporators.

Discussion

The procedures adopted by different mills to control scale in their evaporators vary in the choice and concentration of chemicals, the length of cleaning time and the degree of cleaning obtained. If the evaporator has sufficient monitoring of operating and process parameters, then the HTC can be calculated and used to determine the degree of cleaning obtained and the effectiveness of cleaning chemicals used (Broadfoot and Dunn, 2007).

Alternatively, visual inspection of the heating surfaces enables a similar indication of cleaning effectiveness but requires adequate sight glasses and lighting to observe the evaporator heating surfaces following a clean or that the evaporator is opened for access which takes time and labour. Simple probes could also be developed to allow on-line sampling of scale to overcome these issues.

The cleaning protocol recommended from the present study involves the use of one cleaning chemical at a time. In certain situations, it has been found that this cleaning procedure has yielded unsatisfactory results. This occurs when the composite scale is made up of different layers/regions with different compositions. This has recently been illustrated from scanning electron microscopy and energy dispersive spectroscopy studies on scale in an evaporator tube which showed two different types of morphologies in a composite (East and Doherty, pers. comm., 2009).

Figure 5 shows poorly formed bi-pyramidal calcium oxalate di-hydrate crystals covered by a silica layer with smaller silica ball particles dispersed in the composite matrix. Such a scale matrix can only be effectively removed by the use of a formulation made up of caustic soda and EDTA. EDTA on its own will not dissolve or dislodge calcium oxalate scale that is covered by a layer of silica. However, caustic soda will readily attack the silica layer exposing the oxalate layer to EDTA attack.

Conclusions

Results have shown that, by identifying the chemical elements of scale and knowing from which evaporator vessel the scale originated, a prediction of the scale composition can be made. If the elements silicon, phosphorus, iron and sulfur are detected, then their associated chemical compounds can be predicted. It is not as straight forward with calcium. This is because calcium is

present in a number of chemical compounds and so the use of x-ray powder diffraction becomes necessary. However, in many situations, high calcium levels in Nos. 4 and 5 effects of a quintuple evaporator set suggest the presence of calcium oxalate.

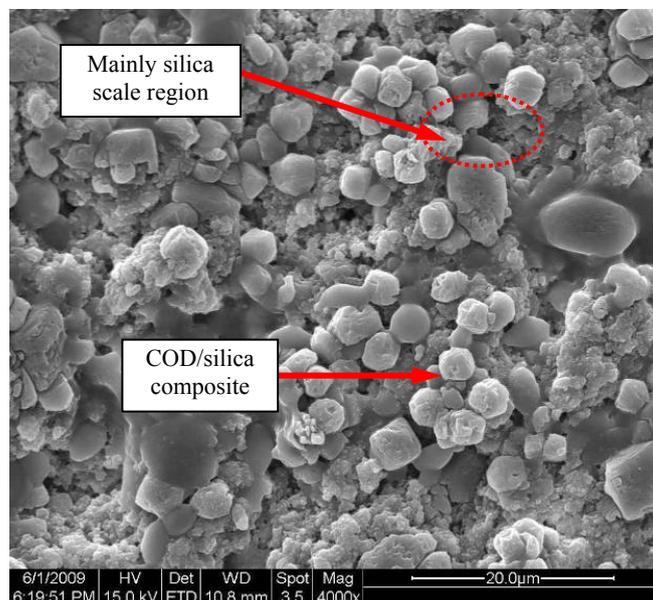


Fig. 5—Scanning electron micrograph of silica/calcium oxalate dihydrate composite in an evaporator tube.

The visual descriptor studies have shown that if the origin of the scale is known, the colour and the appearance of scale can be used to qualitatively assess the scale composition. Dark coloured scale usually contains hydroxyapatite and organic matter, while creamy coloured scale contains calcium oxalate or is a mixture of calcium oxalate and amorphous silica.

When the scale is flake-like in appearance, it is likely to be a mixture of calcium oxalate and amorphous silica. The conclusions from the tactile studies were that it was not an effective method to identify different scale types since the texture of most of the scale types was coarse.

The paper presents a methodology for developing reference information on the scale types present in evaporators for factory staff based on various scale characterisation techniques. The database of information can add to the experience of factory staff that may enable a useful reference to determine effective and appropriate chemicals for cleaning purposes.

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OUTILS DESCRIPTEURS POUR CARACTERISER LES INCRUSTATIONS DANS DES EVAPORATEURS AUSTRALIENS

Par

D.W. RACKEMANN, W.O.S. DOHERTY et C.P. EAST
Sugar Research and Innovation, Queensland University of Technology, Australie
d.rackemann@qut.edu.au

**MOTS CLEFS: Evaporateur,
Composition des Incrustations, Nettoyage Chimique.**

Résumé

LE NETTOYAGE des évaporateurs de sucreries est un exercice onéreux. L'identification des composants des incrustations aide à déterminer les meilleurs produits chimiques pour le nettoyage. Les méthodes actuelles (diffraction des rayons x, chromatographie liquide à échange d'ions/haute performance et l'analyse thermique thermogravimétrie/différentielle) utilisées pour la caractérisation des incrustations sont difficiles, onéreuses et ne peuvent pas être effectuées dans un laboratoire d'analyse conventionnel ou par le personnel du moulin. Cette étude a examiné des descripteurs simples pour la caractérisation des incrustations dans des évaporateurs australiens. Des échantillons d'incrustations provenant de sept évaporateurs australiens ont été obtenus par des moyens mécaniques. L'apparence, la texture et la couleur des incrustations ont été notées; les échantillons ont été caractérisés à l'aide de fluorescence de rayons x et diffraction de poudre de rayons x, pour déterminer les composés présents. Un certain nombre de kits de test analytique commerciaux ont été utilisés pour déterminer le contenu de calcium et phosphate des échantillons. Des expériences pour étudier la dissolution ont été effectuées sur les échantillons avec les agents de nettoyage sélectionnés, pour fournir des informations pertinentes sur l'effet des agents de nettoyage. Les résultats montrent que, en identifiant tout simplement la couleur et l'apparence des incrustations, leur composition élémentaire et de savoir de quel effet l'incrustation est issue, une prévision de la composition de l'incrustation peut être faite. Ces descripteurs et les résultats des expériences de dissolution donnent au personnel d'usine un processus rapide, sur place, pour prédire les substances chimiques les plus efficaces pour le nettoyage chimique des évaporateurs.

**DESARROLLO DE HERRAMIENTAS DE DESCRIPTOR PARA LA
CARACTERIZACIÓN DE INCRUSTACIONES
EN EVAPORADORES EN AUSTRALIA**

Por

D.W. RACKEMANN, W.O.S. DOHERTY y C.P. EAST

Sugar Research and Innovation, Queensland University of Technology, Australia
d.rackemann@qut.edu.au

**PALABRAS CLAVE: Evaporador,
Incrustación, Limpieza Química.**

Resumen

LA LIMPIEZA de evaporadores en un ingenio es una operación costosa. La identificación de los componentes de la incrustación ayuda en la determinación de los agentes químicos eficaces para la limpieza. Los métodos actuales (basados en técnicas de difracción de Rayos X, intercambio iónico/HPLC y termogravimetría/análisis térmico diferencial) usados para la caracterización de incrustaciones, son difíciles, costosos, consumen tiempo y no pueden ser ejecutados en un laboratorio de análisis convencional o por el personal de planta. Este trabajo ha examinado el uso de pruebas simples de descriptor para la caracterización de las incrustaciones en evaporadores australianos. Se obtuvieron muestras de incrustación por medios mecánicos de siete evaporadores. La apariencia, textura y color se registraron antes de caracterizar las muestras usando fluorescencia de Rayos X y difracción de polvos en Rayos X para determinar los compuestos presentes. Se utilizaron varios kits de pruebas analíticos y comerciales para la determinación de fosfatos y calcio en las muestras. Se hicieron experimentos de disolución con agentes de limpieza química para determinar sus efectos sobre diferente tipo de incrustación. Se demostró que simplemente identificando el color y la apariencia de la incrustación, la composición elemental y cual efecto se analizaba, podía hacerse una predicción de la composición de la incrustación. Estos descriptores y experimentos de disolución pueden ser utilizados para suministrar información rápida y formular los químicos para la limpieza de los evaporadores.