THE ROLE OF ZINC IN PHYSICAL WATER CONDITIONING

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1. Introduction

Physical water treatment (PWT) for the reduction of scale has been actively promoted as an alternative for chemical treatment of water since the first PWT patent was registered in 1945. This patent was for magnetic water treatment (Vermeiren, 1958). Other techniques which gained in popularity, in particular during the last decade, include non-intrusive devices based on varying frequency electric fields induced through wrap-around coils and intrusive "catalytic conversion" devices where water is treated electrochemically by exposure to a metal alloy surface. The potential reward to industry and the environment should physical water treatment prove to produce consistent scale reduction effects, is enormous. This is the reason why research and technical development continues unabated, despite the fact that more than 50 years of intensive research into the effects of electromagnetic fields on scaling processes did not produce a generally accepted theory to explain the mechanisms involved. Although PWT technology has changed substantially in some respects since 1945, the basic claims and effects (Baker and Judd, 1996) remained essentially the same. These include: the formation of a soft scale with weak adhesion properties, reduced kinetics of crystallization, a memory effect of up to 3 days, changes to crystal morphology, reduced or increased particle sizes, descaling and dissolution of existing scale, decreased zeta potential and surface tension.

It was our objective to find a common denominator, which would link the above-mentioned effects and would make possible, a plausible mechanistic explanation. We assumed that scale formation proceeds through the processes of nucleation and crystal growth on exposed surfaces or in the bulk of the liquid phase followed by the attachment of crystalline particles to a surface, forming a layer prone to further growth. It was argued that if PWT was to affect scale formation at all, it should be measurable as an effect on reaction rate, that is on nucleation and crystal growth processes and the characteristics of the precipitate or scale, i.e. its crystal morphology. The next step was to use existing theories of crystallization to predict possible effects of electromagnetic fields on the processes involved and then to design experiments to verify the predictions.

2. Theoretical Background

Two theories were considered to be applicable:

- nucleation and crystal growth theory
- DLVO or electric double layer theory

		Force pN	Sdev n=30
1	CONTROL	1.6	0.1
2	MAGNETISED*	0.6	0.1
3	CONTROL	1.5	0.2
4	CONTROL US**	1.6	0.1
5	MAGNETISED US	[illegible]	0.1
6	CONTROL US	1.6	0.2

* 0.45 tesla field
** 5 min ultrasonic treatment

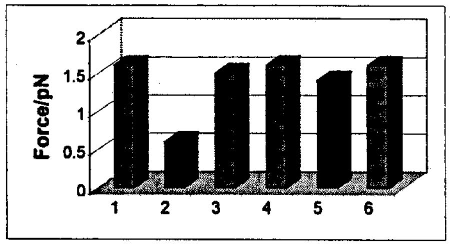

Figure 6: Effect of a 0.45 T magnetic field on the apparent surface charge

Our results also show that the effects, all but disappeared when a treated solution was sonicated for 5 minutes and then reexamined.

It is perhaps to early to formulate a mechanistic explanation for these observations, but they seem to support the distortion of the double layer hypothesis. If these results could be confirmed it would be the first directly measurable effect of small electromagnetic fields on the solid-solution interface on the near molecular level. However, possible artefacts, largely unknown at this stage, but inherent in force-distance measurements with AFM, which could produce the observed results, must in follow-up work first be excluded before these results could be accepted with certainty.

5. Conclusions

1. Free metal ions, in particular Zn^{2+} released by PWT devices or pipes as a result of electrochemical reactions induced by the field, can cause a reduction in nucleation rate and changes in crystal morphology which could lead to a reduction in scale formation.

2. AFM force-distance measurements indicate, but not as yet confirm, a contraction of the electric double layer and a redistribution of surface charge on precipitating particles or a distortion of the hydration sphere around ions caused by the electromagnetic field.

6. References

Baker J S and Judd J (1996), Magnetic amelioration of scale formation. *Water Res*, **30**, 247-260.

Berton R, Beruto D, Bianco B, Chiabrera A and Giordani M (1993), Effect of ELF electromagnetic exposure on precipitation of barium oxalate. *Bioelectrochemistry and Bioenergetics*, **30**, 13-25.

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