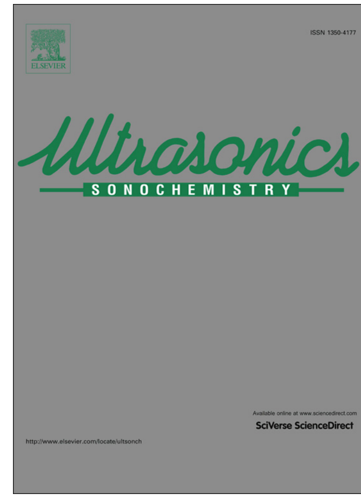

Ultrasonic modification of carbonate scale electrochemically deposited in tap water

G. Vasyliev, S. Vasylieva, A. Novosad, Y. Gerasymenko

PII: S1350-4177(18)30091-9
DOI: https://doi.org/10.1016/j.ultsonch.2018.05.026
Reference: ULTSON 4184

To appear in: *Ultrasonics Sonochemistry*

Received Date: 22 January 2018
Revised Date: 17 May 2018
Accepted Date: 18 May 2018

Please cite this article as: G. Vasyliev, S. Vasylieva, A. Novosad, Y. Gerasymenko, Ultrasonic modification of carbonate scale electrochemically deposited in tap water, *Ultrasonics Sonochemistry* (2018), doi: https://doi.org/10.1016/j.ultsonch.2018.05.026

Ultrasonic modification of carbonate scale electrochemically deposited in tap water

Vasyliev G., Vasylieva S., Novosad A., Gerasymenko Y.

National technical university of Ukraine “Igor Sikorsky Kyiv Polytechnic Institute”, 37, Prospect Peremohy, 03056, Kyiv-056, Ukraine

Corresponding author

Georgii S. Vasyliev

Tel.: +380969249888

Fax.: +380442369774

E-mail address: g.vasyliev@kpi.ua

Postal address: National technical university of Ukraine “Igor Sikorsky Kyiv Polytechnic Institute”, 37, Prospect Peremohy, 03056, Kyiv-056, Ukraine

Keywords: Chronoamperometry, Calcium carbonate, Nucleation-growth process, Ultrasonic cavitation

Abstract

Influence of the ultrasound intensity (28 kHz, 1.1–7.5 W/cm^2) on $CaCO_3$ nucleation-growth on the surface of a cylinder mild steel electrode rotating at 500 rpm was studied in tap water. The deposition kinetics was analyzed by chronoamperometry; the calcareous layer was characterized by gravimmetry, scanning electron microscopy and XRD. Application of ultrasound to calcium carbonate crystallization affects nucleation sites density, mass-transport rate and cavitation erosion of the deposits. Lower intensity ultrasound reduces scale porosity and area density by increasing nucleation site density and accelerating the mass transport. Higher intensity ultrasound promotes cavitation erosion of the formed layer, thus cleaning the surface from the scale. A scale layer with the highest blocking properties formed under applied ultrasound intensity of 1.9 W/cm^2. The ultrasound doubled crystallization rate, reduced the scale porosity 5 times and halved its area density comparing to non-sonicated conditions. Ultrasound of controllable intensity can solve both scale and corrosion problems of industrial heat-exchange equipment by forming a protective scale layer and removing excessive deposits.

Introduction

Calcium carbonate precipitation is a major concern of energy production in industry. The scaling phenomenon causes technical problems such as reduction of heat transfer efficiency and obstruction of pipes. The non-productive expenses related to scaling were estimated at 1.5 billion Euros per year in France, about 0.8 billion $US in Great Britain, 3 billion $US in Japan and 9 billion $ in the USA [1,2]. Another problem of industrial heat-exchanging equipment is internal corrosion. Corrosion causes deterioration of materials and leads to economic losses since repairs and equipment replacements are required more often [3].

Three crystalline forms of $CaCO_3$ exist: calcite, which has a cubic shape; vaterite, with a sperulite, hemispherical flowers, or lenses morphology; and aragonite, which is recognised as needles.[4] The type of deposited phases was found to depend on the substrate nature (copper or stainless steel) [5] and the initial state of the substrate surface (clean or damaged) [6]. The presence of a passivating layer on non-noble metals reduces the density of nucleation sites and thus promotes formation of vaterite nuclei [4]. The calcium^{2+} concentration