AAP China Scholarship Council - CSC 2023

PROJET DE RECHERCHE DOCTORALE (PRD)

Titre du PRD : Investigation of water treatment against scaling with a sacrificial anode by using a combined electrochemical sensor

DIRECTION de THESE

Porteuse ou porteur du projet (***doit être titulaire de l'HDR***) :

NOM : PERROT

Prénom : Hubert

Titre : DR ou Autre :

Section CNU : 31

Email : hubert.perrot@sorbonne-universite.fr

Unité de recherche : Code (ex. UMR xxx) et Intitulé : UMR 8235

Ecole doctorale de rattachement : ED388 - Chimie Physique et Chimie Analytique de PC

Nombre de doctorants actuellement encadrés : 3

CO-DIRECTION de THESE (HDR) ou CO-ENCADREMENT (Non HDR) :

NOM : CHEAP-CHARPENTIER

Prénom : Hélène

Titre : Sélectionner ou Autre : enseignant-chercheur

Section CNU : 31

Email : helene.cheap-charpentier@epf.fr

Unité de recherche : Code (ex. UMR xxx) et Intitulé : UMR 8235

Ecole doctorale de rattachement : ED388 - Chimie Physique et Chimie Analytique de PC

Nombre de doctorants actuellement encadrés : 1

CO-TUTELLE INTERNATIONALE envisagée : ☐ OUI ☒ NON

DESCRIPTIF du PRD :

*Ce texte sera affiché en ligne à destination des candidates et candidats chinois : il ne doit pas excéder **2 pages** doit être rédigé en **ANGLAIS***

1) Study context

With the development of the social economy and the population growth, the increasing demand for water resources is highlighted [1]. However, many water resources on earth cannot be used directly. Water treatment has attracted the attention of scientific community. Among water pollutants, heavy metal ions, organic pollutants, and high concentration of mineral salts are the most representative [2]. In this latter case, scaling phenomenon, principally formed by calcium carbonate CaCO3, leads to technical and economic problems in industry. Environmental and health issues lead laboratories to seek new methods of detection to determine and quantify CaCO3 nuclei/crystals in water or on surfaces.

The purposes of this project are the development of a sustainable sensor for water analysis and to propose green solutions against scaling using sacrificial anode of metallic alloys. The sustainable sensor will be based on electrical conductivity and electrochemical measurements. It will be included in an electrochemical cell in order to determine CaCO3 crystals, obtained by homogeneous and heterogeneous precipitation, with a change of electrical conductivity in the former and electrode coverage in the latter. The treatment will be performed by metallic cations delivery and controlled with a selected electrochemical process. The efficiency evaluation will be performed through the new sensor device developped here.

2) Details of the proposal

The project has three main parts:

1/ Development of the sensor combining conductimetric and electrochemical devices

2/ Analysis of the water with classical tools like FCP, EIS, EQCM and SQCM

3/ Find green solution for water treatment against scaling (sacrificial anode)

The sensor will be built at the LISE laboratory, Sorbonne Université. It consists on interdigitated electrodes deposited on a support which allows the conductivity of the electrolyte to be measured. On the same support, a working electrode will be deposited associated to an Ag/AgCl reference electrode and a large Pt counter electrode. The changes in water can assessed by the measurements of the conductivity and the WE to allow the scaling potential to be determined: the homogeneous precipitation will be assessed by the electrical conductivity measurements and the heterogeneous precipitation will be followed by the WE.

To test the efficiency of the sensor, it will be calibrated with synthetic water at different CaCO3 concentrations. The water will be previously analyzed by quartz crystal microbalance coupled with electrochemistry (EQCM) and the fast controlled precipitation (FCP) method. Some green solutions will be proposed to apply a treatment to the polluted water. A sacrificial anode will be used as antiscaling treatment and the efficiency of this treatment will be estimated by the use of this sensor. The laboratory LISE has already good skills in water treatment especially in scale inhibition [3, 4].

At the same time, the inductively coupled plasma (ICP) set-up will be associated at our measurements [5, 6]. The ICP allows the concentration of 40 elements simultaneously in water to be determined and measured . This technique is very sensitive since the detected concentration is in the ppb range.

This project will be developed within the LISE in Paris, which is part of Sorbonne Université. The laboratory is highly qualified in deposits and surface treatments (https://www.lise.upmc.fr/). This work will be carried out in collaboration with the EPF, an engineering school located at Cachan.

3) References

[1] R. Damania, S. Desbureaux, M. Hyland, A. Islam, S. Moore, A.S. Rodella, J. Russ, E. Zaveri, Uncharted Waters: The New Economics of Water Scarcity and Variability. World Bank, Washington, DC (2017) (© World Bank. https://openknowledge.worldbank.org/handle/10986/28096 License: CC BY 3.0 IGO).

[2] E. Jones, M. Qadir, M.T.H. van Vliet, V. Smakhtin, S. Kang, The state of desalination and brine production: a global outlook, Science of the Total Environment 657 (2019) 1343-1356.

[3] M. Gritli, H. Cheap-Charpentier, O. Horner, H. Perrot, Y. Ben Amor, Scale inhibition properties of metallic cations on CaCO3 formation using fast controlled precipitation and a scaling quartz microbalance, Desalination and Water Treatment (2019) 1-9.

[4] M. Gritli, H. Cheap-Charpentier, H. Perrot, O. Horner, Y. Ben Amor, Scaling inhibition by sol-gel phosphosilicate hybrid films: influence of doping Cu2+ and Zn2+ cations, Surface & Coatings Technology 443 (2022) 128597.

[5] H. Cheap-Charpentier, O. Horner, J. Lédion, H. Perrot, Study of the influence of the supersaturation coefficient on scaling rate using the pre-calcified surface of a quartz crystal microbalance, Water Research 142 (2018) 347-353.

[6] J. Han, K. Ogle, Dealloying of MgZn2 intermetallic in slightly alkaline chloride electrolyte and its significance in corrosion resistance, Journal of The Electrochemical Society 164 (2017), C952-C961.

4) Profil of the applicant

The candidate must have a Master's Degree in:

• Materials science or physical chemistry obtained with excellent grades.

• Knowledge in electrochemistry and/or in water analysis is required.

• A good command of English (written and oral) is necessary.

AVIS de l'Ecole Doctorale :

Merci d'enregistrer votre fichier au format PDF sous la forme :
NOM Prénom_Projet CSC 2023.pdf

Fichier à envoyer par mail simultanément
à l'école doctorale de rattachement et à csc-su@listes.upmc.fr