THE PERFORMANCE OF THE ELECTRO-COAGULATION IN SILICA, PHOSPHATE REMOVAL USING TITANIUM AND STAINLESS-STEEL AS ANODE AND CATHODE

By

Ahmed Mohamed Nabil Abdel Kader Farahat

A Thesis Submitted to the
Faculty of Engineering at Cairo University
In Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
in
Civil Engineering – Public Works

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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Under the Supervision of

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Title of Thesis:

The Performance of The Electro-Coagulation in Silica, Phosphate Removal Using Titanium and Stainless-Steel as Anode and Cathode

Key Words:
Electrocoagulation; Silica; Phosphate; Titanium; Stainless-Steel.

Summary:

The performance of the electrocoagulation process for Phosphates (PO_4) and Silica (SiO_2) removal from synthetic wastewater using Titanium as anode and Stainless Steel as cathode has been studied under some governing operating variables such as initial pH, applied voltage, electrodes inter-spacing and treatment time and at other fixed variables such as temperature, stirring Rpm, electrodes dimensions and the type and amount of the supporting electrolyte. The results showed that the maximum PO_4 removal efficiency of 99.97% after 90 min. at pH 4.0 and electrodes spacing of 3cm was achieved at applied volts of 12 while the maximum SiO_2 removal efficiency of 31.18% after 90 min. at pH 7.0 and electrodes spacing of 3cm was achieved at applied volts of 12. The results showed also that decreasing the applied voltage drastically dropped the removal efficiency of both PO_4 and SiO_2.

Disclaimer

I hereby declare that this thesis is my own original work and that no part of it has been submitted for a degree qualification at any other university or institute.

I further declare that I have appropriately acknowledged all sources used and have cited them in the references section.

Name: Date: ../../…(it's the date that you handover the thesis)

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Nomenclature

EC: Electrocoagulation

WHO: World Health Organization

EPA: Environmental Protection Agency

RO: Reverse Osmosis

WTP: Water Treatment Plant

CC: Chemical Coagulation

DC: Direct Current

V: Volt

TSS: Total Suspended Solids

TDS: Total Dissolved Solids

BOD: Biochemical Oxygen Demand

COD: Chemical Oxen Demand

Ti: Titanium

Al: Aluminum

SS: Stainless-steel

Rpm: Revolutions per minute

Abstract

Water quality is highly affected by the increased sources of pollution whether point or non-point sources. Third-world countries usually miss the infrastructure as well as the required capital to overcome the water problem. Accordingly, the water science is facing very high challenges to originate and improve the water treatment technologies considering the most determining factors of standard desired water quality, initial and running treatment cost, ease of operation, etc. Electrocoagulation process is an electrochemical treatment technology of wastewater that is facing promoting popularity and extensive technical improvements.

This thesis is studying the performance of the electrocoagulation process for Phosphates (PO_4) and Silica (SiO_2) removal from synthetic wastewater using Titanium as anode and Stainless Steel as cathode. Some governing operating variables such as the effect of initial pH, applied voltage, electrodes inter-spacing and treatment time on the removal efficiency of both (PO_4) and (SiO_2) have been studied at other fixed variables such as temperature, stirring Rpm, electrodes dimensions and the type and amount of the supporting electrolyte. The results show that the maximum PO_4 removal efficiency of 99.97% after 90 min. at a pH value of 4.0 and electrodes spacing of 3cm was achieved at applied volts of 12 however, the maximum SiO_2 removal efficiency of 31.18% after 90 min. at a pH value of 7.0 and electrodes spacing of 3cm was achieved at applied volts of 12. Meanwhile, the PO_4 removal efficiency of 92.30% and 70.60% after 90 min. at pH values of 7.0 and 10.0 and electrodes spacing of 3cm was achieved respectively at applied volts of 12 and the SiO_2 removal efficiency of 30.10% and 28.92% after 90 min. at pH values of 4.0 and 10 and electrodes spacing of 3cm was achieved respectively at applied volts of 12. The results show also that decreasing the applied voltage drastically dropped the removal efficiency of both PO_4 and SiO_2 from 99.97% at 12V to 5.80% at 9V and electrodes spacing of 3cm and from 31.18% at 12V to 5.24% at 9V and electrodes spacing of 3cm respectively.

Keywords: Water Treatment; Electrocoagulation; Silica; Phosphate; Titanium; Stainless-steel.

Chapter 1 Introduction and Objectives

1.1. Introduction and problem statement

Around the world, the most challenging problem that scientists are trying to best solve it is to secure hygienic potable water to the people especially in the developing countries. Rivers, channels and further different waterbodies are being continually contaminated because of the uncontrolled industrial effluents flow besides other anthropogenic activities and natural processes [1]. Conventional water treatment for domestic supply normally includes a coagulation/flocculation stage within the treatment processes. This coagulation stage is a critical process including charge neutralization of colloid resulting of aggregation into flocs which will be ready for solid/liquid separation with subsequent sedimentation and filtration processes. This process usually results in the generation of significant quantities of sludge. Because of the toxic nature of this sludge to aquatic life in addition to the cost burden of dewatering, collection, transport and disposal of this sludge from water treatment plants to landfills, the Electro-coagulation process becomes one of the highly attracting eco-friendly treatment methods that combine the job as well as the benefits of the conventional ways of coagulation and electrochemistry in the water treatment.

The EC reactor is usually made of an electrolytic cell with anode(s) and cathode(s) as shown in Fig. 1.1. When applying the electric current throughout the electrodes, the conductive plate neutral sides will be changed to charged sides, which will have opposite charge compared with the parallel side at the side of it. The ions released will neutralize the particles charges and then initiate coagulation. The released ions may also remove the undesirable pollutants either through chemical reaction then precipitation, or by forcing the colloidal materials to be coalesced and then eliminated by electrolytic flotation.

Accordingly, the EC process could be presented in brief in three sequential stages:

1- Development of coagulants using electrolytically oxidation of the anode
2- Contaminants destabilization
3- Destabilized phase aggregation to form flocs [2].

Accordingly, this process leads the pollutants to be eliminated out of the water and demolished or may be made less solvable. The most important variables that are controlling the EC process efficiency are the materials of electrode, current density, treatment time, chemistry of solution, initial pH value and the chemical configuration of the solution that is being removed, the temperature of the solution, the salt used to elevate conductivity, etc.

The electrodes are commonly made of aluminum as it is considered to be cheap, available and recognized effective, while the most important problem of the aluminum electrode is the residual aluminum remaining in treated water after the electrocoagulation treatment process because of cathodic dissolution, World Health Organization (WHO) advised that under good operating conditions, concentrations of aluminum of 0.1 mg/liter or less are achievable in large water treatment facilities while