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Microbiological studies on biofilm forming bacteria and their role in enhancing corrosion of iron metals

By

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(M.Sc. in Microbiology, 2009)

A thesis submitted for the degree of PhD in Microbiology
(Microbial Biotechnology)

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2013

Abstract

Many modern investigations have centered on the microbially-influenced corrosion (MIC) of iron metals and alloys and particular microorganisms of interest have been the sulfate-reducing bacteria and biofilm-forming bacteria. It has been estimated that 20-50% of internal corrosion is caused by MIC bacteria growing on the inner pipeline surface. The importance of microbial consortia and the role of extracellular polymeric substances in biocorrosion are emphasized.

Through the current study, fifteen bacterial isolates have been isolated, purified and characterized according to Bergey's Manual of Determinative Bacteriology, 9th edition and 16S rDNA. These isolates represent different groups responsible for microbiologically induced corrosion (MIC) of iron which are Iron Oxidizing Bacteria (IOB), Manganese Oxidizing Bacteria (MOB), Sulfur Oxidizing Bacteria (SOB) and Sulfate-Reducing Bacteria (SRB).

A comparative test has been taken place to select the most promising biofilm forming and sulfate reducing isolates. Accordingly, *Pseudomonas marginalis-SuOA* and *Desulfomonas pigra-SRS* were selected due to their maximum activities for the current study. The growth curves for both organisms have been represented.

The optimum conditions have been investigated and selected for studying biofilm formation and sulfide production by the selected bacterial isolates. Data showed that the optimum conditions for biofilm formation by *P. marginalis-SuOA* were; pH 6 and NaCl concentration (40,000 ppm) at 25^{o}C for 21 days whereas the optimum conditions of sulfate reduction by *D. pigra-SRS* were pH 8 and NaCl concentration (zero ppm) at 35^{o}C for 21 days.

The effect of single and mixed cultures *P. marginalis-SuOA* and *D. pigra-SRS* on the corrosion behavior of mild steel was investigated using scanning electron microscopy (SEM), Fourier transform infrared spectroscopy (FTIR) and Tafel polarization electrochemical measurements. The data showed that both isolates had the ability to form biofilm on the surface of mild steel under investigation and the biofilm formed in the mixed culture was more intensive than in single cultures. The Tafel polarization curve showed that mixed culture induced pitting corrosion compared with control and single cultures.

The quorum sensing signals, Acyl Homoserine Lactone (AHL) was detected during incubation time in axenix, binary and consortia of MIC bacterial cultures. The present results have demonstrated for the first time that quorum sensing signals (AHLs) are involved in coordination language of MIC during biofilm formation and corrosion process.

Twelve pure chemical substances were tested for their biocidal activity against *P. marginalis-SuOA* and *D. pigra-SRS*. The results showed that sodium chlorite, CTAB, Hydrogen peroxide and Crystal violet had the maximum activity against *P. marginalis-SuOA*, while CTAB, sodium chlorite, sodium molybdate and ammonium molybdate had the maximum activity against *D. pigra-SRS*, respectively.

The crude extracts of the agriculture wastes; onion and garlic leaves and date palm seeds showed that the methanolic extract of onion leaves, date palm seeds and water extract of garlic leaves exhibited the maximum biocidal activity against *P. marginalis-SuOA*, while all extracts did not show any biocidal activity against *D. pigra-SRS*.

Acknowledgement

Thank you Allah!

First and foremost I would like to express my utmost gratitude to ***Prof. Mehreshan Taha El Mokadem;*** *professor of microbiology, Botany Dept., Women's College for Arts, Science and Education, Ain Shams University and all supervision committee members:* ***Dr. Eman Ghazy;*** *associated professor of Microbial biotechnology, Microbial Biotechnology Dept., National Research Center (NRC),* ***Dr. Magdy Gadallah;*** *associated professor of Microbial biotechnology, Microbial Biotechnology, Dept., National Research Center (NRC),* ***Dr. Mohammed Nabil;*** *researcher of microbial biotechnology, Microbial Biotechnology Dept., National Research Center (NRC) for their teaching, guidance, and constructive criticism throughout the years.*

I am greatly indebted to ***Prof. Mohammed Safwat;*** *professor of microbial genetics and* ***Prof. Kamal Khalil;*** *professor of molecular biology, Genetic Engineering and Biotechnology Research Division, National Research Center (NRC),* ***Dr. Talaat Elsebai****; Agricultural Research Division, National Research Center (NRC),* ***Dr. Nabil Abdel Ghany;*** *associated researcher of electrochemistry, Electrochemistry dept., National Research Center (NRC) and* ***Dr. Ahmed Khalaf,*** *Botany Dept., Women's College for Arts, Science and Education, Ain Shams University for their valuable assistance in the practical part, statistical analysis and their cooperation throughout this work.*

I would like to acknowledge all members of ***Microbial Biotechnology Dept.****, National Research Center and* ***Botany Dept.,*** *Women's College for Arts, Science and Education, Ain Shams University for their effective role in supporting this work.*

This work was supported and funded by ***National Research Center (NRC)*** *and* ***Academy of Scientific Research and Biotechnology (ASRT).***

Mostafa Abo Elsoud

Contents

List of Tables

List of Figures

List of Abbreviations

AFM	Atomic Force Microscopy
AHL	Acylated Homoserine Lactones
AI	Autoinducer
AMAPETCO	Al-Amal Petroleum Company
APHA	American Public Health Association
APS	Adenosine-5′phosphosulfate
ASTM	American Society for Testing and Materials
ATP	Adenosine Triphosphate
A. tumifaciens	*Agrobacterium tumifaciens*
CLSM	Confocal laser scanning microscopy
CTAB	Cetyl Trimethyl Ammonium Bromide
C. violaceum	*Chromobacterium violaceum*
DPD	4,5-dihydroxy-2,3-pentanedione
D. Pigra	*Desulfomonas pigra*
E. coli	*Escherichia coli*
EIS	Electrochemical Impedance Spectroscopy
EN	Electrochemical Noise
EPS	Exopolysaccharide
Eshpetco	Esh Elmalaha Petroleum Company
FT-IR	Fourier transform infrared spectroscopy
GDP	Gross Domestic Product
GUPCO	Gulf of Suez Petroleum Company
GYM	Glucose-Yeast Extract Medium
ICGEB	International Center for Genetic Engineering and Biotechnology.