Studies on the formation and corrosion resistance of phosphate coatings on steel

A Thesis
Submitted to
Chemistry Department
Faculty of Science-Cairo University

By

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B.Sc., Cairo University, 1999
(**Very good with honour degree**)

In Partial Fulfillment for The Requirements
of
The Degree of Master of Science
(Chemistry)
2009

Acknowledgments

It is a great honor to me to take the chance to express my greatest gratitude and appreciation to **Dr. Said Mashaal,** Minster of Military Production, for his great project and his supporting to all the military production members in all the fields of Science.

I wish to express my sincere thanks and appreciation to **Prof. Dr. Amin Mahmoud Baraka** ,professor of physical Chemistry, Faculty of Science, Cairo University, for all authentic scientific guidance, starting from suggesting this work, his remarkable help , continuous supervision, great support and encouragement in performing this work

I would like to express my thanks to all the staff of military production, especially for all those participating in increasing my knowledge and encouragement in performing this work.

I would like to express my thanks to my teacher in surface chemistry **Ehab El Shabrawy** for his kind advices and his remarkable help**.**

I would like to express my thanks and gratitude for my dear Wife, **Fatma Mohamed Shebel**, for her continuous support, valuable help and encouragement in performing this work.

Finally I would like to thanks the normal support **My Parents.**

Walid Mahmoud Osman
Cairo 2009

Besides the work carried out in this thesis, the candidate "Walid Mahmoud Osman Farg "passed successfully a qualifying examination for partial fulfillment of the M.Sc.Degree (2002) in the following topics:

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2-Catalysis and colloids
3-Electrochemistry of Molten Salts
4-Metallurgy
5-Statistical Thermodynamics
6-Cyclic Voltammetry
7-Electrochemistry
8-Solar Energy
9-Electrode Kinetics
10-Adsorption
11-X-ray Thermal Analysis
12-Thermal Analysis
13-Quantum Chemistry
14-Nuclear Chemistry
15-Molecular Structural Determination
16-Chelatimetry
17-Advanced Analytical Chemistry
18-Ionizing Salt
19-Inorganic Reaction Mechanism
20-Quality Control and Quality Assurance in Chemistry
21-Advanced Inorganic Chemistry
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ABSTRACT

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Titles of thesis: Studies on the formation and corrosion resistance of phosphate coatings on steel.
Degree. (Master) thesis, Faculty of Science, Cairo University, 2009

This work has been carried out to investigate the possibility of use of the fire extinguisher powder which contain at least 88% mono-ammonium phosphate in the iron phosphate process. The obtained results indicated that the fire extinguisher powder can be used in the bath of iron phosphating process. Also the zinc phosphate process was studied and the characterization of zinc phosphating coatings was performed using the different tests. The effect of time and bath temperature on the mass of zinc phosphate coatings was also studied; the result showed that the coating mass increases with increase in time and increase in temperature. The pitting corrosion resistance of zinc phosphated specimens and zinc phosphated then painted specimens at different immersion time in NaCl solution of different concentrations using Potentiodynamic polarization measurements. The obtained results indicate that the optimum immersion time for phosphating process was 20 min. Also, the painting of the phosphated layer greatly decreased the porosity of the coating and increases the corrosion and pitting corrosion resistance.

Key words: Iron phosphate; fire extinguisher powder ; Zinc phosphate ; Zinc phosphate coatings; pitting corrosion resistance ; ammonium phosphate

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CHAPTER ONE

INTRODUCTION AND AIM OF THE PRESENT WORK

Phosphate conversion coatings are employed in many industries either for corrosion protection, preparation of the metal surface for improved paint adhesion, or for decoration. Less commonly, phosphatizing is used to improve the lubrication, or as a base for adhesives in plastic-metal laminations or rubber-to-metal applications [1,2].It serves as a conversion coating in which a dilute solution of phosphoric acid, which is applied via spraying or immersion, chemically reacts with the surface of the part being coated to form a layer of insoluble, crystalline phosphates[1, 2]. This type of coating can be applied on steels [3-7], galvanized steel [6,12] , iron [7,8] , magnesium [10,13,14] , aluminum [11-15] and zinc [16]. There are many types of phosphating baths such as, zinc based [3,16-19], manganese based [6,20-22], iron based [23], A fourth type, lead phosphate, more recently introduced, or even a combination of them. The type of coating used depends on the phosphated material application (Manganese phosphates are used both for corrosion resistance and lubricity and are applied only by immersion. Iron phosphates are typically used as a base for further coatings or painting and are applied by immersion or by spraying. Zinc phosphates are used for rust proofing, lubricity, and as a paint/coating base and can also be applied by immersion or spraying). The chemical compounds that act as accelerators (accelerate the phosphating process) might be oxidant compounds or salts of metals nobler than the metal to be phosphated.

The purposes of these accelerators are:

1-Speed up the rate of coating to oxidize ferrous iron

2- Reduce crystal size.

Various types of chemical accelerators for phosphating can be used such as sodium nitrite [3,9,13,24-26], nitrates [5,9,10,13,14,24,25,27,28], and chlorates [27,29].

Besides the chemical accelerator other additives are used to afford other specific properties.

Various additives are used such as calcium ions [9,29-32],manganese ions [18,20,22,27,32-34], tartaric acid [10,14], fluoride ions [10,13-15,24,26], nickel ions [3,15,18,25,27,29,35], copper ions [36] molybdenum ions [14,34] and, more recently, niobium [36].

Aim of the present work:

1- Investigate the possibility of use the available materials such as fire extinguisher powder which contain at least 88% mono-ammonium phosphate which represent an environmental problem to get rid of it in our factory in the iron phosphate process

2-Study the zinc phosphate process and the characterization of phosphate coatings.

3- Study the effect of time and bath temperature of zinc phosphate process on the zinc phosphate coating mass.

4-Study the corrosion behaviour (pitting corrosion resistance) of zinc phosphated and zinc phosphated then painted steel using Potentiodynamic polarization measurements.

CHAPTER TWO

LITERATURE SURVEY

According to literature [1] and [37] phosphating of metallic substrates occurs through the following reactions:

$$Me_{(s)} + 2H^{+} \rightarrow Me^{2+} + H_{2\,(g)} \quad (1)$$

$$3Zn^{2+} + 2H_2PO_4^{-} + 4H_2O \rightarrow Zn_3(PO_4)_2 4H_2O + 4H^{+} \quad (2)$$

$$Fe^{2+} + 2Zn^{2+} + 2H_2PO_4^{-} + 4H_2O \rightarrow Zn_2Fe(PO_4)_2 4H_2O + 4H^{+} \quad (3)$$

The first reaction corresponds to the metal attack by the acid phosphating solution and the two following reactions lead to phosphate crystals formation and deposition on the metallic surface.

The weight and crystalline structure of the coating and the extent of penetration of the coating into the base metal can be controlled by:

1-Method of cleaning before treatment.

2-Use of activating rinses containing titanium and other metals

3-Method of applying the solution.

4-Temperature, concentration, and duration of treatment.

5-Modification of the chemical composition of phosphating solution.

Phosphate coatings range in thickness from less than 3 to 50 μm. Coating weight (grams per square meter of coated area), rather than coating thickness, has been adopted as the basis for expressing the amount of coating deposited.

Phosphate coatings

Three principal types of phosphate coatings are in general use: Zinc, Iron, and Manganese. A fourth type, Lead phosphate, more recently introduced.

Zinc phosphate coatings

It encompasses a wide range of weights and crystal characteristics, ranging from heavy films with coarse crystals to ultrathin microcrystalline deposits.