UNIVERSITI TEKNOLOGI MARA

# SYNTHESIS AND CHARACTERIZATION OF ELECTRODEPOSITED COBALT-IRON NANOPARTICLES ON DIFFERENT SUBSTRATES

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# AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the result of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

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# ABSTRACT

Environmental and health issues from the usage of hard chromium coating as a protective layer for corrosion protection have caused concerns. Research on the use of nanocrystalline Cobalt-Iron as an environmentally friendly and a potential substitute for hard chromium coating on different metals such as Stainless Steel, Copper and Titanium corrosion protection is lacking. The objectives of this research are to synthesize Cobalt-Iron nanoparticles on these three metal substrates in various deposition times and to discuss the characteristics and properties of the nanoparticles. Direct current electrodeposition process is used to prepare the nanoparticles samples using various precursors. Using constant temperatures of $50\pm5^{\circ}C$ and a variety of electrolyte compositions, the synthesis of pure Cobalt gives the optimum electrolyte pH and precursor molarity. These results are then used for the synthesis of Cobalt-Iron nanoparticles in several deposition times on different substrates. In an optimum deposition time, all substrates are fully coated by Cobalt-Iron nanoparticles with decreased crystallite and particle sizes. Corrosion rate decreases while microhardness increases with longer deposition time. Chromium element is unexpectedly found in Cobalt-Iron microstructures on Stainless Steel and believed to have reacted with the electrolyte. However, Chromium content is not found on Copper and Titanium substrates. Interestingly, Cobalt-Iron nanoparticles samples exhibit various surface morphologies. All nanoparticles samples demonstrate active corrosion without passivation and soft ferromagnetic behavior. The findings show that natural elemental composition and properties of metal substrates influence the characteristics and properties of Cobalt-Iron nanoparticles and can be suggested as an alternative for hard chromium coating.

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# CHAPTER ONE

# INTRODUCTION

## 1.1 RESEARCH BACKGROUND

Corrosion is defined as the deterioration of materials properties and occurs to metals and metal alloys. This is due to the chemical reaction between those materials with its environments. Corrosion is known as the common problems in various applications and industries such as oil and gas, automotive, chemical and manufacturing plants, concrete structures and electric power generation plants [1].

The impact of corrosion is of two aspects; economic cost and human safety. The study of the economic cost on corrosion had been conducted in the Unites States of America in the late 1990s and it was found that corrosion alone had cost billions to hundred billion a year [1]. The indirect costs are probably greater than the direct economic cost and very difficult to evaluate. The indirect cost due to the corrosion is influenced by many factors such as plant downtime, loss of product, efficiency reduction and contamination. The impact of corrosion to the human life and safety is seen through the malfunction and damages of certain vital equipment, parts and pipelines in the industries which can lead to the fatal accidents and involve many lives of workers and the nearest neighborhood [1].

Thus, it is important to provide prevention methods to minimize the impact of corrosion. Various efforts have been taken to solve the problems caused by corrosion which include several techniques such as coating, inhibitors usage, cathodic and anodic protection, materials selection and design.

Hard chrome plating has been known mainly for the wear and corrosion resistant coating applications, decorative and functional applications as a result of its excellent characteristics. This plating has hardness between 700 to 1000 Vickers Hardness (HV), bright appearance and resistance to corrosive environments [2]. Hence, in the corrosion resistant coating application, this plating is extensively being applied as the anti-corrosion coating in military aircraft components. It is also being