UNIVERSITI TEKNOLOGI MARA

SURFACE PROPERTIES AND ANTIMICROBIAL PERFORMANCE OF COPPER COATINGS ELECTRODEPOSITED ON 304 STAINLESS STEEL

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ABSTRACT

Bacterial contamination resulted from frequently-touched surface materials is responsible in the acquisition of infection especially in hospital. The utilization of copper as antimicrobial touch surfaces offers a solution that can serve as an additional line of defense against pathogens. Copper is the first and currently the only one surface metal that has received registration from Environmental Protection Agency (EPA) as antimicrobial material which is capable to inhibit biofilms, retains the antimicrobial activity under typical indoor conditions. In this study, electrodeposition technique was used to coat copper on 304 stainless steel using 0.01 M Cu^{2+} solutions containing either uncomplexed $CuSO_4$ or complexed Cu-EDTA based systems. Effects of applied potential (based on CV analysis) and deposition time were investigated to study the formation, nucleation and growth of copper on the 304 stainless steel. Copper coatings $Cu/SS_{(-0.25\ V,\ CuSO4\ pH\ 1,\ 900\ s)}$ and $Cu/SS_{(-1.1\ V,\ Cu\text{-}EDTA\ pH\ 8,\ 900\ s)}$ prepared at low overpotential from both electrolyte solutions possess good physicochemical and surface properties. In addition, they also have high contact angle,high surface roughness and well-adhered to the substrate. Both copper coatings showed excellent antimicrobial activity towards *E. coli* (100 % reduction within 5min of exposure) and *S. aureus* (100 % reduction within 10 min of exposure), compared to solid copper (100 % of reduction for both bacteria required within 10 min of exposure) whereas stainless steel surface showed no antibacterial activity even after 30 min of exposure. A significant observation is on the reduction of *S. aureus* after 5 min of exposure with $Cu/SS_{(-1.1\ V,\ Cu\text{-}EDTA\ pH\ 8,\ 900\ s)}$ showed outstanding antibacterial activity compared to $Cu/SS_{(-0.25\ V,\ CuSO4\ pH\ 1,\ 900\ s)}$ and solid copper. Even though solid copper has higher dissolution rate (0.1292 mm/yr) than the copper coatings (i.e.: $Cu/SS_{(-0.25\ V,\ CuSO4\ pH\ 1,\ 900\ s)}$ = 0.0531 mm/yr and $Cu/SS_{(-1.1\ V,\ Cu\text{-}EDTA\ pH\ 8,\ 900\ s)}$ = 0.08048 mm/yr) but both copper coatings have faster killing rate of bacteria than solid copper. This indicates that the killing rate does not only depend on dissolution rate but also surface properties. $Cu/SS_{(-1.1\ V,\ Cu\text{-}EDTA\ pH\ 8,\ 900\ s)}$ sample with high surface roughness, hydrophobic, high compositions of copper with uniform distribution of nano-sized grains structure resulted in better and more efficient contact killing of bacteria by allowing copper structure to interact closely with bacterial membranes.

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TABLE OF CONTENTS

		Page
CONFIRMATION BY PANEL OF EXAMINERS		ii
AUTHOR'S DECLARATION		iii
ABSTRACT		iv
ACKNOWLEDGEMENT		v
TABLE OF CONTENTS		vi
LIST OF TABLES		ix
LIST OF FIGURES		x
LIST OF ABBREVIATIONS		xvii
CHAPTER ONE: INTRODUCTION		
1.1	Background of Study	1
1.2	Problem Statements	5
1.3	Objectives of Study	6
1.4	Significance of Study	7
1.5	Scope and Limitations of Study	7
1.6	Thesis Organization	8
1.7	Conceptual Framework	10
CHAPTER TWO: LITERATURE REVIEW		
2.1	Introduction	11
2.2	Hospital-acquired Infections (HAIs)	11
	2.2.1 Bacterial Infections	15
2.3	Conventional Infection Controls	18
2.4	Copper and Copper Alloys	19
2.5	Antimicrobial Copper	21
2.6	Copper as Antimicrobial Touch Surfaces	24
2.7	The Science behind Antimicrobial Copper	34
2.8	Copper Coatings	38

2.9 Electrodeposition of Copper 47
2.9.1 Electrodeposition Techniques 51
2.9.1.1 Cyclic Voltammetry (CV) 51
2.9.1.2 Choronoamperometry (CA) 54
2.9.2 Electrodeposition of Copper from Aqueous System 57
2.10 Electrochemical Studies Related to the Copper Electrodeposition 62
2.10.1 Effect of Adding Additives 64
2.10.2 Metal-Chelate Complexes 69
2.10.3 EDTA as Metal Chelate Complexes 70

CHAPTER THREE: METHODOLOGY

3.1 Introduction 74
3.2 Materials and Chemicals 74
3.3 Instruments and Apparatus 75
3.4 Preparation of Stainless Steel Substrates 75
3.5 Preparation of Electrolyte Solutions 75
3.6 Electrochemical Studies of Copper on Stainless Steel Substrate 76
3.7 Characterization of Copper Coatings 77
3.8 Dissolution Rate Measurement 79
3.9 Antimicrobial Testing 80
3.10 Theoretical Framework 82

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Introduction 83
4.2 Stainless Steel Surface Pre-treatment 83
4.3 Stability of Cu^{2+} Ion at Various pH Values 87
4.4 Electrodeposition using Uncomplexed $CuSO_4$ 92
4.4.1 Cyclic Voltammetry Analysis 92
4.4.1.1 Effect of Adding H_2SO_4 94
4.4.1.2 Effect of pH 97
4.4.1.3 Chronology Events during CV Scan 98
4.4.2 Chronoamperometry Study 100
4.4.2.1 Effect of Applied Potential 101