

**CONDUCTIVITY OF CARBON BLACK (CB) AND GRAPHITE (G)
ADDITION IN SILICONE-BASED ELECTRICALLY CONDUCTIVE
ADHESIVES (ECAs)**

NUR ELISSA BINTI AHMAD IZUDDIN

**Final Year Project Report Submitted in
Partial Fulfilment of the Requirements for the
Degree of Bachelor of Science (Hons.) Applied Chemistry
in the Faculty of Applied Sciences
Universiti Teknologi MARA**

FEBRUARY 2024

This Final Year Project Report entitled "Conductivity of Carbon Black (CB) and Graphite (G) Addition in Silicone-based Electrically Conductive Adhesives (ECAs)" was submitted by Nur Elissa binti Ahmad Izuddin in partial fulfilment of the requirements for the Degree of Bachelor of Science (Hons.) Applied Chemistry, in the Faculty of Applied Sciences, and was approved by

Dr. Zuliahani binti Ahmad
Supervisor
B.Sc. (Hons.) Applied Chemistry
Faculty of Applied Sciences
Universiti Teknologi MARA
02600 Arau
Perlis

Dr. Siti Nurlia binti Ali
Project Coordinator
B.Sc. (Hons.) Applied Chemistry
Faculty of Applied Sciences
Universiti Teknologi MARA
02600 Arau
Perlis

Dr. Nur Nasulhah binti Kasim
Head of Programme
B.Sc. (Hons.) Applied Chemistry
Faculty of Applied Sciences
Universiti Teknologi MARA
02600 Arau
Perlis

Date: 09 February 2024

ABSTRACT

CONDUCTIVITY OF CARBON BLACK (CB) AND GRAPHITE (GR) ADDITION IN SILICONE-BASED ELECTRICALLY CONDUCTIVE ADHESIVES (ECAs)

Electrically conductive adhesives (ECAs) have raised a massive interest among researchers to replace traditional Tin-Lead (Sn-Pb) solders especially in electronic manufacturing devices due to its greater attributes than utilizing lead (Pb) which is harmful to human health. In this study, silicone-based ECAs was proposed with the addition of hybrid fillers namely, carbon black (CB) and graphite (G) in which CB and G are both conductive fillers while silicone, specifically polydimethylsiloxane (PDMS) is used as the polymer matrix. By incorporating wet-ball milling method to achieve optimum dispersion of the fillers in the matrix and adopting film casting technique to form thin films beforehand, then the optimum ratio of CB and G (1:2, 2:1, 2:2, 1:3 and 3:1 ratio) on its conductivity properties of CB/G/PDMS composite via multimeter and 4-point probe was identified and the CB/G/PDMS films were characterized via ATR-FTIR and UV-Visible spectroscopy. It was found out that 1:3 ratio had the lowest resistivity of 1.615×10^3 with the optimum conductivity value $6.19 \times 10^{-4} \Omega\cdot\text{cm}^{-1}$ while 3:1 ratio had the second lowest conductivity at $5.49 \times 10^{-4} \Omega\cdot\text{cm}^{-1}$ with a resistivity of $1.82 \times 10^3 \Omega\cdot\text{cm}$ via multimeter testing. From four-point probe analysis, 1:3 ratio had the optimum conductivity value of $4.35 \times 10^{-6} \text{ S/m}$ while the lowest conductivity value belongs to 2:1 at $3.69 \times 10^{-6} \text{ S/m}$. ATR-FTIR was also used to determine the functional groups contained within CB, G and PDMS. CB can be seen having peaks around $2700 - 3000 \text{ cm}^{-1}$, denoting the C-H stretching, PDMS at peaks of $1000 - 1100 \text{ cm}^{-1}$ which corresponds to Si-O-Si stretching, $1250 - 1260 \text{ cm}^{-1}$ of Si-CH₃ stretching and $800 - 850 \text{ cm}^{-1}$ for Si-C stretching. As for graphite, the G band of graphitic carbon could be spotted at around $1580 - 1600 \text{ cm}^{-1}$. UV-Visible spectroscopy spectra depicted the maximum wavelength values for samples ranging from 293 to 302 nm, showing $\pi - \pi^*$ transition. This study is significant to observe the effects of ball milling process and the influences of incorporation of CB and G in improving the electrical conductivity of a silicone-based ECAs.

TABLE OF CONTENTS

	Page
ACKNOWLEDGEMENTS	iv
TABLE OF CONTENTS	v
LIST OF TABLES	vii
LIST OF FIGURES	viii
LIST OF SYMBOLS	ix
LIST OF ABBREVIATIONS	x
ABSTRACT	ii
ABSTRAK	iii
CHAPTER 1 INTRODUCTION	1
1.1 Background of study	1
1.2 Problem statement	7
1.3 Research questions	8
1.4 Objectives of study	9
CHAPTER 2 LITERATURE REVIEW	10
2.1 Electrically Conductive Adhesives (ECAs)	10
2.1.1 Categories of Electrically Conductive Adhesives (ECAs)	13
2.2 Polymeric Materials for Electrically Conductive Adhesives (ECAs)	17
2.3 Silicone-based Electrically Conductive Adhesives	20
2.4 Conductive Fillers for Electrically Conductive Adhesives (ECAs)	22
2.5 Hybridized Form of Carbon Black (CB) and Graphite (G) for ECAs	26
2.6 Mixing Method	30
2.6.1 Ball milling	34
2.7 Casting Technique	37
2.7.1 Film casting method	40
CHAPTER 3 : METHODOLOGY	47
3.1 Materials and Chemicals	47
3.2 Instrument and Equipment	48
3.3 Experimental work	49
3.3.1 Formulation of Silicone-based ECAs with Carbon Black and Graphite	49

3.3.2	Preparation of Carbon Black-Graphite filled Silicone film	50
3.4	Characterization and Testing	52
3.4.1	Characterization study	52
3.4.2	Conductivity properties	54
CHAPTER 4 RESULTS AND DISCUSSION		56
CHAPTER 5 CONCLUSION AND RECOMMENDATIONS		81
CITED REFERENCES		83
APPENDICES		95
CURRICULUM VITAE		96