UNIVERSITI TEKNOLOGI MARA

DIELECTRIC CHARACTERIZATION OF PINEAPPLE LEAF FIBRE (PALF) REINFORCED POLYDIMETHYLSILOXANE (PDMS) COMPOSITES AS A POTENTIAL ANTENNA SUBSTRATE FOR WEARABLE ANTENNA APPLICATION

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Thesis submitted in fulfilment
of the requirements for the degree of
Master of Science
(Electrical Engineering)

Faculty of Electrical Engineering

September 2025

ABSTRACT

The rapid growth of wearable technology has created a demand for antenna substrates that are flexible, lightweight, and high-performance, while maintaining safety for human use, particularly under bending and on-body conditions. Natural fibre–polymer composites have emerged as a sustainable alternative, but their dielectric performance, mechanical robustness under bending, and impact on specific absorption rate (SAR) remain underexplored, leaving a critical gap in wearable antenna research. To address this, Pineapple Leaf Fibre (PALF) reinforced Polydimethylsiloxane (PDMS) composites were fabricated using Hand Lay-Up and Manual Polymer Mixing methods, with fibre loadings ranging from 10 wt.% to 90 wt.% and fibres subjected to alkaline treatment with 1.5M Sodium Hydroxide (NaOH) to enhance fibre–matrix adhesion. Dielectric characterization using a Vector Network Analyzer revealed that pure composites achieved dielectric constants from 1.65 to 2.63, while treated composites improved to 1.58–2.98, with the loss tangent reduced from 0.44 to 0.41 at 2.45 GHz; the Hand Lay-Up method was discontinued due to very low dielectric constant (< 2.0). Antenna prototypes simulated in CST Studio demonstrated enhanced return loss (up to −28dB), radiation efficiency (> 52 %), and stable radiation patterns under bending, with SAR analysis confirming safe levels for wearable use. These findings demonstrate that PALF-PDMS substrates not only provide superior electromagnetic performance and mechanical flexibility but also offer environmental sustainability, positioning them as a promising material for advanced wearable antenna applications.

ACKNOWLEDGEMENT

First, I am profoundly grateful to Allah SWT. for granting me the strength, perseverance, and wisdom to embark on this MSc journey and successfully bring it to completion. This achievement would not have been possible without His endless blessings and guidance.

I extend my deepest gratitude to my supervisor, Ir. Dr. Aslina Abu Bakar, for her invaluable support, insightful guidance, and unwavering encouragement throughout this research. Her expertise and patience have been instrumental in shaping my academic growth.

I am truly thankful to my friends (Athasha, Anis, Irsyad and Qhaishah) for their continuous support, motivation, and assistance throughout this project. Their encouragement and willingness to help have been a source of strength during challenging times.

Finally, this thesis is dedicated to the loving memory of my family, whose vision, sacrifices, and unwavering determination to provide me with an education have shaped the person I am today. This accomplishment is a tribute to them, and I hope it makes them proud. Alhamdulillah.

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CHAPTER 1
INTRODUCTION

The increasing demand for wearable technology has driven the need for efficient, lightweight, and flexible antennas. This research focuses on the dielectric characterization of Pineapple Leaf Fibre (PALF) reinforced Polydimethylsiloxane (PDMS) composites with varying fibre loading and alkaline treatment as a potential antenna substrate for wearable antenna applications. This chapter outlines the overall framework of the study, including the background of the research, problem of current research, research objectives and questions, hypothesis, as well as the significance, limitation and scope of the study.

1.1 Research Background

The increasing demand for sustainable and lightweight materials has led to growing interest in natural fibre-reinforced polymer composites for various engineering applications. Natural fibres such as jute, coir, kenaf, flax, and pineapple leaf fibre (PALF) have emerged as viable alternatives to synthetic fibres due to their biodegradability, renewability, and cost-effectiveness. [1] Among these, PALF stands out for its high tensile strength, low density and availability as an agricultural byproduct making it a promising reinforcement material for composites structures.

Polydimethylsiloxane (PDMS), a widely used synthetic polymer, is renowned for its flexibility, thermal stability, and superior dielectric properties, making it highly suitable for applications requiring reliable electrical insulation [2]. The integration of PALF into PDMS matrices has the potential to enhance mechanical durability and dielectric performance, offering a novel composite material with both structural integrity and reliable electrical properties.