

UNIVERSITI TEKNOLOGI MARA

**FLEXIBLE ANTENNAS BASED ON
NATURAL RUBBER**

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ABSTRACT

This thesis explores the use of natural rubber as a novel substrate in development of flexible antenna. Reinforcement agent known as filler was added into the rubber matrix to improve its mechanical properties. The type of filler used in this research is carbon black. Different types of rubber were produced by using a standard formulation but with different quantities of carbon black powder. Rubber laminates of different thickness and size were using hot compression technique which enabled it to mould the rubber according to the moulding plate. The study on the dielectric properties of rubbers with different filler loading were carried out. Dielectric measurements were conducted using microwave non-destructive testing and open ended waveguide methods. Results obtained from both techniques were in agreement with theories where it was found the dielectric permittivity and loss tangent increase with increased filler content. Thus the dielectric properties of the rubber were manipulated by only varying the filler content. Using the characterized rubbers from the study conducted, prototypes of simple topology microstrip antenna were fabricated and tested. The simulation and measurement of the antennas return loss and radiation pattern for three different cases were conducted and discussed thoroughly. Additional studies were also conducted regarding the effects of filler content and the effects of rubber thickness on antenna performance. Studies on the bending effects of antenna for three different conditions were also carried out. All results are validated and analysed to prove the feasibility of using natural rubber in development of flexible antenna.

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CHAPTER ONE

INTRODUCTION

1.1 RESEARCH BACKGROUND

Recent advancements in the development of flexible electronic devices or antennas have opened opportunities for new bendable materials such as polydimethylsiloxane (PDMS), conductive fabrics, liquid metal alloys, polymers, and paper [1 - 4]. However, there are complications faced by these devices. Manufacturing complexities and limited outdoor applicability are some of the problems. Meanwhile, natural rubber is seen as a potential alternative for flexible substrate. This is due to its low cost, availability and ease of manufacturing, known flexibility and robustness, elastic and water-proofing. In rubber industry, filler is a type of reinforcement agent added into the rubber matrix to improve its mechanical properties in order to make the rubber more usable dependent on the applications. Hence, this research explores the use of natural rubber as a novel bendable substrate in development of flexible antennas.

There are many types of filler used as reinforcement agent in rubber composite. The type of filler used in this research is carbon black which in powder state and one of the common used reinforcing fillers. High Abrasion Furnace (HAF) N339 is a grade chosen for the carbon black. Since the carbon also influences its dielectric properties, their subsequent effects on the antenna quality factor Q and its overall performances under bending condition are studied. The antenna bending test will facilitate researchers while provide better understanding into the novel use of carbon black-filled natural rubber in flexible antenna design. Implementing rubber as substrate of antenna also offers an added advantage where thickness of the substrate can be varied using customized mold plates and thus the study of its effects on Q is also carried out.