THE DEVELOPMENT OF MICROWAVE ABSORBER FROM OIL PALM SHELL CARBON

AHMAD ANAS YUSOF

A thesis submitted in fulfillment of
the requirements for the award of the degree of
Master in Mechanical Engineering

Faculty of Mechanical Engineering
Universiti Teknologi Malaysia

SEPTEMBER, 2004

Dedicated to my beloved wife and family…..

For the understanding and moral support

throughout the years………

ACKNOWLEDGEMENT

Firstly, I would like to take this opportunity to express my deepest gratitude to my project supervisor, Professor Ir. Dr. Farid Nasir Hj Ani from the Faculty of Mechanical Engineering, Universiti Teknologi Malaysia (UTM), for his support, confidence and guidance towards completing this thesis.

I would like to express greatest thankfulness to Prof Madya Dr. Wan Khairudin, who has given advice and suggestion that contributed into the aspect of microwave characterization throughout the completion of this project. I would also like to thank Prof. Dr. Tharek Abdul Rahman from Faculty of Electrical Engineering for his support in further evaluation on the microwave reflectivity measurement. Besides, I would like to express my deepest gratitude and appreciation to the Human Resource Development Unit of KUTKM for the sponsors throughout my studies.

In particular, I would like to express my sincere thanks to Mr Adil, research officer at Wireless Communication Research Laboratory for the time spent in supervising the measurement, to Mr Wong and Muhammad for their assistance in analysing the material, to all my friends, to my beloved wife and my family for their moral support in completing this assignment.

ABSTRACT

A method for reducing palm shell residues has been investigated. Using pyrolysis technique, the residues are transformed into carbons, which are later used as a lossy elements in microwave absorber application. The microwave properties of permittivity,(ε), loss tangent, (tan δ) and absorption performance of microwave absorber utilizing palm shell carbon mixed with unsaturated polyester resin were studied in the microwave region of 8 to 12 GHz (X-band). The measurement of (ε) and (tan δ) emphasize on the influence of carbon concentration (mass %) and pyrolysis temperature in the production of the carbon. It was found out that by increasing carbon pyrolysis temperature, an increase in (ε) and (tan δ) had been observed. The increase of carbon concentration inside each measured sample also influenced the increase of (ε) and (tan δ) condition. The optimum (tan δ) was found by using 30% carbon pyrolysed at 800^{o}C temperature, suggesting significant contribution in dielectric loss properties of the material. The preparation of microwave absorber by utilizing 30% mass concentration of palm shell carbon mixed with unsaturated polyester resin had been tested for microwave absorption. The amplitude of the absorption was relatively measured to a metal plate reference, which resulted in a various microwave absorption with respect to the thickness of the absorber. Moderate microwave absorption around - 10 dB was achieved for most samples within the same frequency band, with maximum absorption of - 30 dB for a thickness up to 75 mm. All the data indicates the possibility of using pyrolysed carbon derived from palm shell residues in providing an affordable solution for microwave technology as well as an alternative in managing the increase of the residues throughout the country.

ABSTRAK

Satu kaedah untuk mengurangkan sisa kelapa sawit kepada bahan berguna telah dikaji. Melalui proses pirolisis, sisa buangan tersebut diubah kepada karbon, yang kemudiannya digunakan sebagai elemen kehilangan dalam aplikasi penyerap gelombang mikro. Sifat gelombang mikro seperti kebertelusan, (ε), tangen kehilangan, (tan δ) dan prestasi penyerapan penyerap gelombang mikro menggunakan campuran karbon kelapa sawit dan resin polyester telah dikaji pada frekuensi 8 hingga 12 GHz. (X-band). Pengukuran nilai (ε) dan (tan δ) menekankan kepada pengaruh kandungan karbon (jisim %) dan suhu pirolisis kepada penghasilan karbon. Pemerhatian mendapati dengan penambahan suhu pirolisis, satu peningkatan dalam nilai (ε) dan (tan δ) telah didapati. Peningkatan kepada kandungan karbon di dalam setiap sampel juga mempengaruhi peningkatan (ε) dan (tan δ). Nilai optimum (tan δ) telah didapati pada kandungan 30% karbon yang dihasilkan pada suhu 800^{o}C, yang memberi sumbangan besar terhadap sifat kehilangan dielektrik bahan. Penyediaan penyerap gelombang mikro dengan mengunakan 30% kandungan karbon kelapa sawit dicampur dengan resin polyester telah diuji untuk penyerapan gelombang mikro. Amplitud penyerapan diukur secara relatif kepada plat logam rujukan, yang menghasilkan pelbagai kesan penyerapan gelombang dari aspek ketebalan penyerap. Penyerapan gelombang mikro yang sederhana sekitar - 10dB diperolehi untuk semua sampel pada jalur frekuensi yang sama, dengan penyerapan maksimum -30dB pada ketebalan menjangkau 75 mm. Semua data menunjukkan potensi penggunaan karbon yang dihasilkan dari sisa kelapa sawit dalam menyediakan penyelesaian mudah kepada teknologi gelombang mikro selain daripada menjadi alternatif dalam menguruskan peningkatan sisa tersebut di seluruh negara.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

$\boldsymbol{E}$	Vector electric field
$\boldsymbol{J}$	Vector current density
I	Electric current
A	Cross-sectional area
ρ_v	Volume resistivity
R	Resistance
V	Voltage
σ	Conductivity
ε	Permittivity
ε_0	Permittivity of free-space
ε_r	Relative permittivity
ε'_r	Relative real permittivity
ε''_r	Relative imaginary permittivity
$tan\delta$	Loss tangent
μ_0	Permeability of free-space
μ_r	Relative permeability
μ'_r	Relative real permeability
μ''_r	Relative imaginary permeability
ω	Angular frequency
f	Frequency
k	Wave numbers
n	Index of refraction
Z_o	Free-space impedance
Z	Intrinsic impedance
ρ	Reflection coefficient

Γ	Power reflection coefficient
d	Sample thickness
l	Sample length
λ	Wavelength
λ_0	Free-space wavelength
V_{min}	Minimum voltage standing wave
V_{max}	Maximum voltage standing wave.
x_o	The distance of first minimum position from the dielectric material.
L_{sm}	The location of the sliding probe during second minimum of standing wave pattern recorded without the sample inside the waveguide.
L_{fm}	The location of the sliding probe during first minimum of standing wave pattern recorded without the sample inside the waveguide.
L_{nsm}	The location of the sliding probe during second minimum of standing wave pattern recorded with the sample inside the waveguide.
VSWR	Voltage standing wave ratio
λ_1	Wavelength in medium 1 (waveguide)
λ_2	Wavelength in medium 2 (sample)
γ	Complex propagation factor
β	Phase constant
α	Attenuation constant
S	Surface area
A_m	Area of occupied by single adsorbed gas molecule
V_m	The quantity of gas adsorbed, either using Langmuir or BET Theories. area of occupied by single adsorbed gas molecule.
N_A	Avogadro constant (6.023 x 10^{23} molecules/mole).
V_o	Molar volume of the gas (22414 cm^3).
m	Mass of the adsorbing sample.

LIST OF ABBREVIATIONS

EFB	Empty Fruit Bunch
POME	Palm Oil Mill Effluent
CBP	Cement-Bonded Particleboard
GBP	Gypsum-Bonded Particleboard
NRL	Naval Research Laboratory
PAC	Pacific Activated Carbon
MEKP	Methyl Ethyl Ketone Peroxide

LIST OF APPENDICES