

MICROWAVE PARAMETERS FOR BITUMEN EMULSION AND ITS
APPLICATION IN HIGHWAY ENGINEERING

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This project report is dedicated to my family
for their endless support and encouragement

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ABSTRACT

Bitumen emulsion is used as a bonding material between two layers and partially acts as a water proofing agent; it gained more importance when there were environmental concerns with cutbacks bitumen. A very few properties of bitumen emulsions are known so far from its physical and chemical prospective. However, a new method to measure its dielectric properties i.e. permittivity by applying electromagnetic waves (microwaves) with open ended coaxial probe (OCP) method was investigated in this study at different temperatures and frequency of 8 to 12 GHz. After examining the physical properties of certain bitumen emulsion a correlation was established on the basis of dielectric constant (permittivity) with the existing conventional property viscosity at temperature of 25, 40, 50 and 60°C. On the basis of these properties different characteristics of the bitumen emulsion were found and hence, a correlation was established to predict its behavior. A good correlation factor was found for the four types of samples used in the study which were 0.98 for SS-1K, 0.99 for MS-1K, 1.00 for RS-1K and 0.99 for K1-40. This study has provided an effective parameter to measure and predict the behavior of bitumen emulsion at different temperature, which can be applied in highway industry.

ABSTRAK

Bitumen emulsi digunakan sebagai bahan ikatan antara dua lapisan dan juga bertindak sebagai ejen kalis air, ianya menjadi lebih penting apabila kebimbangan terhadap penggunaan bitumen cutback yang dikhuatiri boleh menyebabkan pencemaran alam sekitar. Sangat sedikit sifat-sifat fizikal dan kimia bitumen emulsi diketahui setakat ini. Walaubagaimanapun, kaedah baru untuk mengukur sifat-sifat dielektriknya iaitu ketelusan dengan menggunakan kaedah gelombang elektromagnetik (gelombang mikro) dengan prob sepaksi terbuka dihujung (OCP) telah dikaji dalam kajian ini pada suhu yang berbeza dan frekuensi 8 hingga 12 GHz. Setelah menjalankan ujian terhadap sifat-sifat fizikal beberapa bitumen emulsi, satu hubungkait telah dibina berdasarkan pemalar dielektrik (ketelusan) dengan sifat-sifat konvensional kelikatan sedia ada pada suhu 25, 40, 50 dan 60 ° C. Berdasarkan sifat – sifat ini, ciri-ciri lain bitumen emulsi ditemui dan dengan itu, satu hubungkait dibina untuk meramal kelakuannya. Faktor hubungkait yang terbaik telah ditemui untuk empat jenis sampel yang digunakan di dalam kajian ini iaitu 0.98 untuk SS-1K, 0.99 untuk MS-1K, 1.00 untuk RS-1K dan 0.99 untuk K1-40. Kajian ini menyediakan parameter efektif untuk mengukur dan meramal kelakuan bitumen emulsi pada suhu berbeza di mana boleh diaplikasikan dalam industri pembinaan lebuh raya.

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LIST OF ABBREVIATIONS

AASHTO	-	American Association of State Highway and Transportation Officials
ASTM	-	American Society for Testing and Materials
JKR	-	Jabatan Kerja Raya
B.E	-	Bitumen Emulsion
DC	-	Dielectric Constant
LF	-	Loss Factor
cps	-	Centipoise
XRF	-	X-ray fluorescence
RTFOT	-	Rolling Thin Film Oven Test
DSR	-	Dynamic Shear Rheometer
PAV	-	Pressure Aging Vessel
RTD	-	Resistive Thermometric Device
DUT	-	Device under test
ENA	-	Agilent Technologies E series Network Analyser

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Bitumen, as a complex mixture of different molecular weight hydrocarbons and non-metal derivatives, is widely used for road construction to bind with the mineral aggregates together to make up the layers of pavement [1, 2]. Due to its extremely high viscosity, pure bitumen is very difficult to manipulate at normal temperature [3]. Bitumen has to be heated to high temperature usually above 130 °C to get sufficient fluidity. Instead, bitumen emulsions are prepared as a convenient way of converting bitumen into a workable and effective binder for road maintenance products.

The bitumen emulsions are thermodynamically unstable system, which can break down over time through a variety of physicochemical instability mechanisms, such as gravitational separation, coalescence, flocculation, inversion, and Ostwald ripening [4, 5]. Thus, one important requirement of bitumen emulsions is very good stability during storage and long distance transportation. Nevertheless, bitumen emulsions are designed to break quickly after the application to the mineral aggregates for the establishment of the final pavement performance [6, 7].

During the last decades, the technical community of road paving has been looking for new bituminous emulsion specifications based on arguments that they are more rational. The Strategic Highway Research Program in the United States at the beginning of the 1990s [8] and the two generations of European standards issued by

the European Standardization Committee in 1999 and 2005 [9] are examples of institutional standardization of measuring procedures for binder (bitumen emulsion) tests. In this study, it is proposed to evaluate the relationship of the microwave parameters of the bitumen emulsion with the existing physical tests and make a correlation with both the parameters, and hence get a new method to test the emulsion chemical properties to get more understanding of the bitumen emulsion and electromagnetic properties.

1.2 Problem statement

Bitumen emulsion composition is becoming more complex after the addition of several emulsifying agents and modifiers. These additions are directly increasing the complexity to understand the physical behavior of the bitumen emulsion. Till now, there is no adequate knowledge on its chemical composition to predict its behavior during storage and field applications. For the reason physical parameter are used to predict performance following the conventional tests. The physical properties of bitumen emulsion are also not constant and vary substantially with temperature. There is a deem requirement to specify such parameters which can overcome the pertaining issues and provide behavioral prediction of bitumen emulsion which is rational.

1.3 Objectives

The aims of this study are,

- To evaluate the permittivity parameters of the bitumen emulsion.
- To establish a correlation between microwaves parameters of bitumen emulsion with the existing physical parameter i.e. viscosity.
- To develop scenarios for the selection of appropriate bitumen emulsion prolonging designed lifespan of the road.

1.4 Significance of study

From the study, a new parameter will be evaluated to measure different physical characteristic with the microwaves. The previous measuring methods are too slow or are too much time consuming and need to manipulate the temperatures to get the desired result. As there are huge amount of bitumen emulsion prepared in the construction and in the highway industry, a simple and a quick method will save the time and money when introduced. It will revolutionaries the measuring the bitumen emulsion with the changing world in 21th century.

1.5 Scope of study

This study focuses on the microwave parameters of the bitumen emulsion, the parameters such as permittivity and permeability which will be evaluated by correlation with physical properties. Three types of bitumen emulsion will be taken SS1-K, MS-1K, RS-1K and K1-40 and tests will be performed at temperature ranging at 25°C, 40°C, 50°C and 60°C.

The physical test will consist of,

- Saybolt furol viscometer
- Settlement test
- Sieve test
- Sieve Test
- Particle charge test and
- Residue by evaporation test

And Microwave Test

- Open ended Coaxial probe (OCP)

Residue from the “residue by evaporation test”, penetration, short term and long term aging tests will be performed. Aged residue from the RTFOT will be tested on DSR and PAV will be used to get the long term aging of the bitumen emulsion residue. For the microwave tests open-ended coaxial probe (OCP) method will be used.

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