UNIVERSITI TEKNOLOGI MARA

QUALIFYING AND QUANTIFYING OF ETHANOL CONCENTRATION USING PLASTIC OPTICAL FIBRE SENSOR AND SPECTROSCOPY TECHNIQUES

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Thesis submitted in fulfilment
of the requirements for the degree of
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CONFIRMATION BY PANEL EXAMINERS

I certify that a Panel of Examiners has met on 18th July 2018 to conduct the final examination of Hasnida Binti Saad on her **Doctor of Philosophy** thesis entitled "Qualifying and Quantifying of Ethanol Concentration Using Plastic Optical Fibre Sensor and Spectroscopy Techniques" in accordance with Universiti Teknologi MARA Act (Akta 1973). The Panel of Examiners recommends that the student be awarded the relevant degree. The Panel of Examiners was as follows:

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AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as reference work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

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ABSTRACT

Ethanol is the main constituent found in alcoholic beverages and other products that undergo fermentation. Ethanol produced from the fermentation process is totally prohibited for Muslims. From the literatures, the effect of intoxication between synthetic and fermented ethanol is the same. Most global halal organizations have clearly stated that, the minimum concentration of ethanol that can be consumed is 0.5 vol%. The problem with previous researches in POF sensors is the inability to detect ethanol concentration in the range of greater than 0.1 vol% and lower than 5.0 vol%. This lower concentration range is important in determining the halal status of consumer products. A reduction in U-shaped POF bending radius to be smaller than 5.0 cm is proposed to solve the problem based on the work done by F. De-Jun *et al.* POF with a smaller bending radius that induced more optical loss and interaction to surrounding medium and thus making it more sensitive. After some modifications made to the proposed POF sensor, it was able to detect ethanol concentrations from 0.5 vol% to 15.0 vol% in ethanol-water mixtures. For ethanol concentration above 15.0 vol%, the sensor is less stable and did not produce repeatable results because the physical dimension of the POF has changed. The outer part of the POF swelled due to the high concentration of ethanol. The POF sensor is unable to identify the identity of ethanol compound in visible wavelength region because ethanol is colorless. POF has higher optical attenuation in the UV, NIR and MIR wavelength regions. With these limitations of POF sensor, spectroscopy technique was proposed. Spectroscopy technique has the advantage of identifying the presence of ethanol as compared to the POF sensor. The proposed spectroscopy technique used in the UV, NIR and MIR wavelength regions showed that ethanol can be successfully identified and quantified. However, for estimation of ethanol content in commercial products, only spectroscopy setup at NIR and MIR were measurable. The estimated amount of ethanol in commercial products measured at NIR region is comparable to the amount measured in MIR region. The variance in these two ranges is between 0.2 vol% to 1.7 vol%. The discrepancy between the estimated and the actual ethanol content in the commercial samples measured from spectroscopy technique is believed to be due to the pH effect and the presence of Propylene Glycol compound in mouthwashes. There are two new findings from this research work. A new range limits for detection of ethanol-water mixtures that was successfully measured between 0.5 vol% to 15.0 vol% using an unclad bare U-shaped POF sensor with bending radius of 1.25 cm. The other new finding is on a comparative analysis of ethanol mixtures measured concurrently across UV, NIR and MIR regions using the spectroscopy technique.

TABLE OF CONTENTS