ABSTRACT

The compound 3-monochloropropane-1,2-diol (3-MCPD) is a hazardous contaminant commonly found in vegetable oils as a result of high-temperature processing, particularly during the refining of palm oil. This compound is known to be carcinogenic, genotoxic, and nephrotoxic, so its presence must be strictly monitored. Analysis of 3-MCPD is generally performed using instruments such as GC-MS; however, this method requires complex sample preparation, involves high analytical costs, and takes a relatively long time. Therefore, there is a need to develop alternative methods that are simpler, faster, more sensitive, and more efficient. This study aims to develop a Polymer Inclusion Membrane (PIM)-based ion-selective electrode using polieugenol, D_2EHPA, and TBP as a 3-MCPD sensor in cooking oil via voltammetry. Additionally, this study aims to evaluate the electrode's performance based on electrochemical parameters such as linearity, sensitivity, detection limit, and the potential for using the electrode as an alternative method for MCPD analysis.

The research methodology began with the synthesis of polieugenol via cationic polymerization using 5.8 grams of eugenol and 0.25 mL of BF_3-diethyl ether catalyst, which was added every 30 minutes for a total of 12 times over a period of 15 hours. The reaction was stopped using 1 mL of methanol, then 30 mL of chloroform was added and the mixture was washed with 100 mL of distilled water until the pH reached 6. The synthesized polyeugenol was contacted with 250 mL of a 1000 ppm 3-MCPD solution using 2.5 grams of polyeugenol for 24 hours. PIM synthesis was performed using 60% PVC by mass (0.6 g total), 10% DBE, 20% polieugenol or polieugenol-MCPD, and 5 mL THF as the solvent. The membrane was then cast onto a petri dish and left to stand for 24 hours until an elastic layer formed. Variations of the membrane were also prepared by adding D_2EHPA and TBP as carriers. The resulting membranes were characterized using FTIR, SEM-EDX, hydrophilicity testing, porosity testing, and water uptake testing. Electrodes were fabricated using a mixture of the membrane, paraffin, carbon paste, and Ag wire, and were then tested using cyclic voltammetry with $K_3Fe(CN)_6$ and KCl electrolyte solutions at various 3-MCPD concentrations.

The results of the study indicate that the synthesis of polyeugenol was successful, resulting in the formation of a reddish-brown solid that is soluble in organic solvents such as chloroform and tetrahydrofuran. FTIR characterization results show a decrease in the intensity of the allyl group in the 1630–1640 cm^{-1} region, indicating the successful polymerization of eugenol into polyeugenol. Membrane characterization using FTIR and SEM-EDX revealed interactions between polyeugenol, 3-MCPD, D_2EHPA, and TBP, resulting in a more homogeneous membrane morphology and more open pores following the addition of the carrier. Electrochemical test results showed that the PIM-MCPD D_2EHPA-TBP electrode provided the best performance compared to other membrane variations, with a linearity of $R^2 = 0.9947$, a sensitivity of 1.7975, and a detection limit of 5.75×10^{-5} M. Measurement of cooking oil samples using the electrode yielded an MCPD concentration of 0.327 mg/kg.

Keywords: 3-MCPD; *Polymer Inclusion Membrane*; polieugenol; D_2EHPA–TBP; *cyclic voltammetry*.