UNIVERSITI TEKNOLOGI MARA

# PALM OIL MILL EFFLUENT (POME) TREATMENT AND CONVERSION USING NON-CATALYTIC HYDROTHERMAL METHOD

**MOHD ZAHID BIN MARZUKI**

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# ABSTRACT

Palm oil mill effluent (POME) is considered as a major environmental pollution source due to its harmful characteristics and large volume of over 60 million tonnes generated annually. It is characterized by high oils and fats, chemical oxygen demand (COD) and biochemical oxygen demand (BOD) concentrations and therefore subjected to strict discharge parameter standard promulgated under Environmental Quality Act (EQA) 1974. The biochemical oxygen demand (BOD) and chemical oxygen demand (COD) of POME are typically in excess of 30,000 ppm and 50,000 ppm respectively. As such, POME is toxic to environment that requires proper management prior to final discharge to inland water bodies. Current POME management, in most palm oil mills adopted conventional ponding treatment system. However, such practice requires large land area and long hydraulic retention time (>40 days) to achieve COD and BOD removal efficiencies of more than 90%. Complementary anaerobic digestion treatment methods have been proposed to reduce the hydraulic retention time and enhance process performance of the existing POME management scheme, but they are yet to be implemented in large scale. Hydrothermal technology has been widely applied either for complete degradation or conversion of wet biomass to generate hydrochar, bio-oils and gaseous products by utilizing the unique properties of water around its critical temperature and pressure ($T_c$ . 374.4 °C, $P_c$ 219.5 atm). Hence, the aim of this research is to investigate the potential of hydrothermal as complementary treatment method for the POME management. In Part 1, the influence of the hydrothermal process parameters on the POME degradation was assessed at subcritical conditions (200°C, 250 °C, 300 °C and 350 °C) using a slow heating batch reactor, locally fabricated according to ASME BPV (2007) design code. Reaction time was varied between 10 and 60 minutes. In addition, hydrothermal degradation intensification effects were examined by addition of an oxidant (hydrogen peroxide, $H_2O_2$). It was found that in absence of an oxidant, reaction temperature played a significant role over reaction time towards the COD and colour reduction and pH level of the POME derived aqueous phase. Near critical temperature of 350 °C was needed to remove 90% of COD at 60 min reaction time. The final colour (165 ADMI) and pH value (5.2) after hydrothermal treatment was found to be in compliance with the national POME discharge standard (Environmental Quality Industrial Effluent Regulations 2009; BOD less than 100 mg/L, colour less than 200 ADMI and pH between 5 to 9). It was also observed that the addition of $H_2O_2$ oxidant led to reductions in COD (92% removal), colour (99% removal) and pH (6.2) at relatively low temperature of 150 °C and short reaction time of 10 min. The results indicated the potential of hydrothermal oxidation as a potential route for POME treatment. Part 2 of this thesis looked at valorization potential of the POME to bio-oils in a fast heating micro-bomb reactor at subcritical and supercritical water conditions. Bio-oils rich in phenolics and organic acids traceable to lignocellulosic and organic constituents of raw POME were produced at supercritical conditions of 400 °C and 30 min. The extent of conversion suggested that a suite of complex free-radical supported degradation and cracking mechanisms were involved. Likewise, addition of glycerol as co-reactant showed synergistic effect which contributed to higher yields of bio-oils. The yields increased by about three to four-fold from the original 13-14% obtained without glycerol. The phenolics, aromatics and organic acids produced are potential precursors to many industrially important biochemicals. This study showed that hydrothermal is a versatile and tuneable technology to achieve specific target of POME management.

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