**UNIVERSITI TEKNOLOGI MARA**

# ULTRASONIC ASSISTED DESULFURIZATION OF ORGANIC SULFUR OF JAMBI COAL USING MIXTURES OF POTASSIUM TERT-BUTOXIDE/TETRAHYDROFURAN AND PEROXYACETIC ACID

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# ABSTRACT

Chemical desulfurization remains an efficient technique for eliminating organic sulfur from coal, but removing organic sulfur is challenging owing to coal's complex macromolecular structures. In this study, peroxyacetic acid (PAA) and potassium tert-butoxide/tetrahydrofuran (KOTBU/THF) were used to desulfurize Jambi high-sulfur coal in the presence of ultrasonics. The parameters that were used to investigate the effect of sulfur removal are the concentration of acetic acid (30,50, and 70) and potassium tert-butoxide (4.75,10,17.5, and 25%), the temperature (30,50, and 70°C), and the sonication time (10,20, and 30 minutes). The optimization of coal desulfurization using PAA and KOTBU/THF was conducted by response surface methodology (RSM) utilizing a central composite design (CCD). The results indicate the highest reduction of 43.54% in organic sulfur for the coal treated by PAA with the conditions of 70:30 (CH3COOH: H2O2), 30°C for 30 minutes, while 66.76% with KOTBU/THF was achieved at optimized conditions of 25% potassium tert-butoxide at 70°C for 30 minutes. The percentage of inorganic, total sulfur, pyrite, and sulfate sulfur of PAA led to ca. 35- 62, 42-74, 43-78, and 15-43%, respectively. Compared to KOTBU/THF with the amount of ca. 43- 73, 50-81, 50-85, and 36-67% using ASTM D2492, with the organic sulfur being determined by difference. The result of absorbance in hydroxyl radical production by PAA and KOTBU/THF was consistent with the regular pattern of the total sulfur removal. From the FESEM-EDX analysis, the sulfur content for both treated coals decreased from 4.2% to 2.4% (PAA) and 1.0% (KOTBU/THF). The FTIR study indicates that the organic sulfur structural characteristics reveal a relative abundance of aliphatic sulfur (thiol, thiophene, and sulfone), whereas the organic matter in these coals decreased after treatment with KOTBU/THF. The treatment resulted in the generation of low molecular weight fragments from aliphatic carbons, which contributed to an increase in mass loss during TGA of 62.05% (KOTBU/THF), followed by PAA at 58.79% of weight loss. By comparing the two different reagents, KOTBU/THF for optimized conditions of 25% potassium tert-butoxide at 70°C for 30 minutes was found to be the best to remove the organic sulfur, as it has the highest percentage of organic sulfur removal (66.76%). In conclusion, this research shows that ultrasonic-assisted desulfurization using KOTBU/THF and PAA effectively reduced the organic sulfur content of Jambi coal. The combination of ultrasonic pre-treatment with KOTBU/THF was most effective in deprotonating sulfur compounds, as confirmed by a characterization study using elemental analyzer (EA), FESEM-EDX, FTIR, and TGA/DTG among all the treatments. These findings highlight the potential of this method as a way for cleaner coal utilization and reduced sulfur emissions, and an efficient approach for coal desulfurization, and are environmentally friendly.

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# CHAPTER 1
# INTRODUCTION

## 1.1 Research Background

Coal is the most important fossil fuel and energy source, playing a significant role in social development and economic growth for decades. According to Jalil et al. (2021), it has emerged as one of the most widely utilized energy sources in several nations, particularly China and other developing Asian countries. Consequently, the global demand for coal continues to rise exponentially, with the increasing rate and the consumption starting to fall and slow in the mid-2020s, except in India. Coal generation in India is expected to increase by over 90% by 2050, driven by the need to meet rapid growth in electricity demand, while Indonesia boosted exports, particularly to Malaysia (Osman et al., 2023).

Figure 1.1 shows that China's coal consumption peaks before 2030 and falls by almost 90% of the reduction in global coal consumption by 2050 from the Current Trajectory, and around 60% in Net Zero. In contrast, the smaller fall in coal consumption from India reflects continued increases by 75% to help meet rising energy demands, with two-thirds of that increase deployed in the power sector (Bp Statistical Review of World Energy, 2024). This happened because the declining use of coal is displaced by rapid growth in wind and solar power. Within this, Zakaria et al. (2021) state that Malaysia has taken a serious approach to coal-based electricity generation, together with significant coal reserves estimated at about 1.9 billion metric tons (MT) in Peninsular Malaysia. However, approximately 98% of the country’s total coal deposits are concentrated in Sarawak and Sabah. Despite this, coal consumption continues to rise, reaching 1 million MT, leading to concerns over supply shortages. Due to limited domestic coal production, Malaysia increasingly relies on coal imports from Indonesia, particularly from Jambi, to meet its growing energy demands.