

Promising yield and characteristics of bio-oil derived from pyrolysis of industrial natural rubber waste for liquid bio-fuel applications

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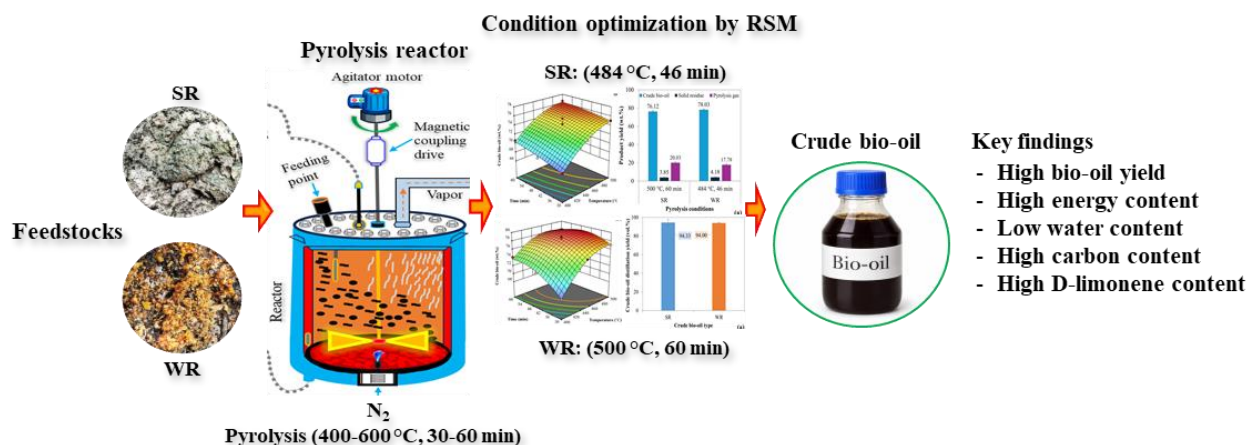
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Abstract

Thailand ranks first in natural rubber (NR) production and exportation. Most of the production is concentrated in the southern region of the country. This leads to the generation of substantial industrial waste streams that require effective management to support the bio-circular-green (BCG) economy [1, 2 and 3]. Thus, this study investigates the conversion of industrial NR wastes, including skim rubber (SR) waste and waste rubber (WR) from block rubber production, into bio-oil via pyrolysis and distillation for applications as liquid biofuels. Pyrolysis experiments were conducted at 400-600 °C with residence times of 30-60 min under an inert atmosphere. Then, the yields and characteristics of crude and distilled bio-oil samples were determined and explored. The results showed that high bio-oil yields of 70-80 wt.% were achieved, attributed to the high volatile matter content (>75 wt.%) of NR wastes and favorable thermal degradation behavior. The optimal pyrolysis conditions for SR and WR predicted by RSM were 500 °C for 60 min and 484 °C for 46 min, yielding 76.27 and 79.28 wt.% bio-oil, respectively. Subsequent distillation (60-340 °C) significantly improved the bio-oil quality, producing fractions with high carbon content (84-87 wt.%) and elevated higher heating values (39-45 MJ/kg). FT-IR and GC-MS analyses confirmed that the bio-oils were dominated by aliphatic and aromatic hydrocarbons with minimal oxygenated compounds, indicating effective deoxygenation during pyrolysis. D-limonene (60-62 %) was identified as the major component in the distilled products, highlighting strong potential for selective chemical recovery. These findings demonstrate that NR waste pyrolysis and upgrading provide an efficient and scalable pathway for producing fuel-grade bio-oil.

Keywords: Biomass pyrolysis, Biofuel, Bio-oil, Natural rubber waste, Pyrolysis

Graphical abstract



References 1) A. Palamanit, et al., *Journal of Material Cycles and Waste Management*, Article In Press (2026). 2) C. Dwivedi, et al., *Composites Part B* 200, 108346 (2020). 3) E. Awosu, et al., *ACS Omega* 10, 8119–8126 (2025).