



## Full Length Article

# Impact of hydrogen-rich-oxygenated ethyl acetate usage as a dual fuel in diesel engines on combustion stability and exhaust emissions under varying EGR rates

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## ABSTRACT

Diesel engines, due to their reliance on petroleum-derived fuels for power generation, not only emit high levels of nitrogen oxides and smoke but also contribute significantly to greenhouse gas emissions that drive climate change. Therefore, the use of alternative fuels has become essential to reduce dependency on petroleum-based fuels in these engines. Oxygenated fuels can be effective in minimizing emissions. In this study, ethyl acetate—which is rich in hydrogen and oxygen and considered a potential hydrogen carrier—is used in dual-fuel mode to improve combustion performance and reduce exhaust emissions. Experimentally, the effects of different exhaust gas recirculation rates and injection durations on the combustion and emission characteristics of a compression-ignition engine operating in a diesel-ethyl acetate dual-fuel mode are investigated. The exhaust gas recirculation rates vary as 0 %, 5 %, 10 %, and 20 %, while the ethyl acetate injection duration changes as 1 ms, 2 ms, and 3 ms. Additionally, experiments are conducted at different engine loads (5 kg, 10 kg, 15 kg, and 20 kg) and a constant engine speed of 1800 rpm. The results indicate that increasing the ethyl acetate injection duration reduces the maximum pressure at low loads but increases it at high loads. Moreover, the use of ethyl acetate increases the ignition delay by approximately 11 % and raises the cycle-to-cycle variation to around 23 %. Regarding emissions, increases in injection duration and exhaust gas recirculation rate reduce nitrogen oxides emissions by an average of approximately 39 % and smoke emissions by an average of around 75 %.

## 1. Introduction

Diesel engines are widely used in transportation and industrial sectors due to their high thermal efficiency and durability. However, they are major contributors to greenhouse gas emissions and local air pollutants such as NO<sub>x</sub> and particulate matter. This contradicts global sustainability objectives such as the United Nations Sustainable Development Goals (SDGs), particularly SDG 7 (Affordable and Clean Energy) and SDG 13 (Climate Action), which emphasize the need for clean and efficient energy systems and urgent action to combat climate change. In this context, alternative fuels with cleaner combustion characteristics, such as oxygenated and hydrogen-rich compounds, are being explored

to reduce the environmental footprint of diesel engines and support the global transition toward net-zero emissions. Growing concerns over air contamination and energy sustainability have spurred extensive research into biofuels and emission control strategies for internal combustion engines (ICEs), particularly diesel engines [1–6]. Although these engines are recognized for their high energy efficiency and durability, they significantly contribute to air pollution by emitting nitrogen oxides (NO<sub>x</sub>) and particulate matter (PM) [7–12]. Furthermore, the frequent utilization of such engines plays a substantial role in the emission of CO<sub>2</sub>, a primary contributor to greenhouse gas accumulation in the atmosphere [13–16]. With the tightening of global emissions regulations, innovative strategies such as dual-fuel combustion and EGR systems are being investigated to enhance combustion efficiency and reduce harmful

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