



# Research on Ammonia Fuel Combustion in Automotive Engines

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Ammonia has long been considered a promising clean alternative fuel for transportation, owing to its carbon-free composition, relatively high energy density, and well-established industrial supply chain. Initially adopted in marine internal combustion engines, ammonia later found widespread application in automotive power systems. However, its use in internal combustion engines presents several challenges, including difficult ignition and low flame propagation velocity. To address these issues, a variety of technological strategies have been developed and implemented in ammonia-fueled engines. For instance, introducing a small amount of hydrogen into the intake mixture has been shown to improve ignition stability and accelerate flame propagation. Concurrently, increasing the oxygen concentration can shorten the ignition delay period and enhance combustion intensity, leading to improved indicated thermal efficiency and reduced exhaust emissions. The combined application of oxygen enrichment and hydrogen blending thus offers a promising pathway toward the deep decarbonization of automotive propulsion systems.

Nevertheless, ammonia combustion in internal combustion engines is accompanied by another critical concern: engine knock, particularly under oxygen-enriched conditions and with elevated hydrogen blending ratios. When the hydrogen fraction or oxygen concentration exceeds a certain threshold, the rapid release of heat can generate intense pressure oscillations within the confined combustion chamber. These pressure waves, upon reflection and superposition, may evolve into self-sustaining detonation fronts. Furthermore, the extremely low ignition energy of hydrogen makes the unburned mixture susceptible to auto-ignition before the flame front arrives. Interestingly, the inherently high-octane rating of ammonia counteracts the knock-prone tendency of hydrogen, resulting in a nonlinear threshold behavior in knock onset, which complicates the detection and diagnosis of abnormal combustion events.

To monitor in-cylinder combustion processes, various diagnostic techniques have been developed, including engine block vibration measurements, in-cylinder pressure sensing, and optical diagnostics. However, the large-scale engineering adoption of these methods is constrained by high costs, limited sensor durability, or the need for extensive engine modifications.

The article entitled “Study on Ion Current Characteristics and Reaction Mechanism of Oxygen-Enriched Ammonia Combustion” investigates the pressure and ion current waveform characteristics of an oxygen-enriched ammonia–hydrogen combustion system using a constant volume combustion chamber (CVCC) test platform [1]. In parallel, the underlying formation mechanism of the ion current is elucidated through CHEMKIN-PRO combustion simulations. The findings indicate that ion current detection technology stands out as one of the most promising real-time in-cylinder combustion monitoring techniques, owing to its low cost, fast response, and compatibility with unmodified engine hardware. Notably, the study demonstrates that the peak values and peak timings of the pressure and ion current signals exhibit highly consistent trends with variations in the equivalence ratio. This work provides a valuable reference for researchers and engineers in the automotive field seeking to further explore ammonia combustion in internal combustion engines.



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## Reference

1. Xu, J.; Dong, G.; Zhou, Y.; Li, X.; Li, L. Study on Ion Current Characteristics and Reaction Mechanism of Oxygen-Enriched Ammonia Combustion. *Int. J. Automot. Manuf. Mater.* **2026**. <https://doi.org/10.53941/ijamm.2026.100008>.