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Experimental Study on the Spray Development of Ammonia under High-Pressure Injection through a Single-Hole Injector

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Spray characteristics are fundamental to engine performance and design, as they strongly influence ignition delay and emission formation in internal combustion engines. This study experimentally investigates the spray behavior of ammonia under high-pressure single-hole injection using a constant volume chamber that replicates engine-like conditions. High-speed shadowgraph imaging is employed to capture the spray evolution, and MATLAB-based image processing techniques are applied for quantitative analysis. Key macroscopic parameters, including spray penetration length, cone angle, and spray area, are systematically evaluated. The results show that the distinct physicochemical properties of ammonia—such as its low density, low viscosity, and high latent heat of vaporization—have a significant impact on spray development. Compared to conventional hydrocarbon fuels, ammonia demonstrates shorter spray penetration, wider cone angles, and enhanced atomization processes. Additionally, injection parameters are found to strongly affect the breakup and evaporation of the ammonia spray, underscoring the importance of optimizing injection strategies for its effective utilization as a carbon-free fuel in advanced combustion engines.

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