Emerging Glycerol-Derived Additives for Next-Generation Diesel: Synthesis Pathways, Formulation Strategies, and Potential Environmental Benefits

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Abstract

The continuous expansion of the biodiesel sector has resulted in a substantial surplus of crude glycerol, estimated at nearly 10% of total biodiesel output by weight. This surplus has shifted research attention towards converting glycerol into higher-value products, particularly fuel additives with environmental benefits. Among the various derivatives explored, solketal and solketalacetin stand out as renewable oxygenated molecules, noted for their ability to modify fuel density, viscosity, and oxygen content, thereby enhancing combustion efficiency and lowering harmful emissions. This review paper surveys the latest progress on glycerol-derived additives, with specific emphasis on synthesis routes, catalytic developments, and blending methodologies that enable their practical use in diesel formulations. Special focus is placed on how solketal and its acetylated derivatives contribute to raising the cetane number by up to 5–8 points in certain blends, while also lowering particulate matter and greenhouse gas outputs compared to conventional diesel. The discussion also outlines persistent bottlenecks, such as the scalability of catalytic processes, economic feasibility at industrial levels, and integration challenges with modern diesel engines. By compiling recent findings and identifying research gaps, this work highlights the promise of glycerol-derived additives as sustainable enablers for next-generation diesel fuels, while proposing clear research directions to speed up their transition from laboratory studies to commercial applications.

Keywords

Glycerol-derived additives, Solketal and solketalacetin, Oxygenated diesel fuels, Combustion performance, Emission reduction.