

Considering the global quest for environmental sustainability and a dire need for effective energy use, catalytic hydrogenation and hydrotreatment have emerged as a critical process in value-added products, petrochemicals, and environmental industries. The thesis aims to develop efficient green catalytic systems synthesizing fine chemicals for industrial scale and exploring the potential of upgrading model compound methyl oleate and biomass resources such as vegetable oils for large-scale production of diesel-grade hydrocarbons.

The main objectives laid out in this thesis are focused on the synthesis of natural clay or silica-alumina supported metal catalysts. The idea is to use these catalysts for various applications relating to value-added products and the production of biofuels. These catalysts frequently exhibit improved catalytic activity, enhancing reaction rates and better selectivity. The study aims to provide insights into sustainable chemistry and engineering practices, leading to industrial applications, catalyst design, and new sustainable catalysts. The study aims to enhance catalytic efficiency, minimize waste, and find economically viable and environmentally benign materials to ensure its wide usability and production. The studies undertaken in this thesis attempt to address some of these issues.

The use of clay as a cost-effective, environmentally benign, and abundant support is an ideal choice. Clay-supported metal catalysts are compatible with green chemistry principles, leading to increased productivity and a reduced need for potentially hazardous solvents. The study presents a simple wet-impregnation route for a sustainable natural clay-supported palladium catalytic system for the hydrogenation of imine to amines, feedstock for agrochemicals, and pharmaceuticals. The catalytic system was investigated under mild reaction conditions, and its catalytic activity and effect on reaction conditions were analyzed. Catalyst immobilization on clay supports results in reduced costs and waste generation by allowing the recycling of metal catalysts. The mechanistic details of imine hydrogenation are elucidated, structural, chemical, and morphological properties of these catalysts are examined, and reaction conditions are optimized to achieve high conversion rates and selectivity. The study emphasizes the need for greener technology in synthesizing fine chemicals for industrial scale due to rising energy demand and environmental concerns.

Additionally, studies have been done to explore the impact of non-noble metal integration in a  $\text{SiO}_2\text{-Al}_2\text{O}_3$  catalyst on the conversion of methyl oleate into diesel-grade aliphatic hydrocarbons. This study presents the effect of cobalt incorporation into the  $\text{SiO}_2\text{-Al}_2\text{O}_3$  hybrid catalytic system on the conversion, selectivity, and stability of the catalytic conversion of methyl oleate as a model compound for biofuels. The study found that the amount of Co loading, reaction time, temperature, and  $\text{H}_2$  pressures greatly influence the conversion and selectivity. The complete ester conversion rate and substantial yield towards n-heptadecane / n-octadecane are achieved under solvent-free conditions.

Further, iron poisoning on nickel oxide supported on silica-alumina catalysts is investigated. Here, Bimetallic  $\text{Fe}_x\text{Ni}_y/\text{SA}$  catalysts were synthesized using the hydrothermal method followed by chemical deposition strategies. The study also investigated the characterization and tuning of  $\text{Fe}_x\text{Ni}_y/\text{SA}$  catalysts for the low-temperature hydrodeoxygenation (HDO) of methyl oleate and vegetable oils to n-alkanes. Out of all catalysts, The  $\text{Fe}_1\text{Ni}_1/\text{SA}$  catalyst demonstrated outstanding HDO efficiency, conversion, and hydrocarbon selectivity. The  $\text{Fe}^{2+}/\text{Fe}^{3+}$  ratio in  $\text{Fe}_a\text{O}_b$  species on the  $\text{Fe}_x\text{Ni}_y/\text{SA}$  catalyst regulates the carbon number distribution of generated hydrocarbons, suggesting a viable strategy for designing an efficient HDO catalyst.