

# CATALYTIC HYDROGENATION OF ACETIC ACID TO ETHANOL IN HOMOGENEOUS AND HETEROGENEOUS PHASES

## ABSTRACT

Increase in the cost of petroleum products and growing concerns of environmental impact of fossil fuel combustion are prompting researchers across the world to investigate alternative routes of fuel production from biomass. Among the many possible routes of conversion of biomass to fuel, ethanol has emerged as one of the major alternatives to fossil fuels along with few other alternatives such as biodiesel, green diesel, DME and Fischer-Tropsch product. Ethanol can be used as a gasoline additive to increase octane number and reduce CO<sub>x</sub>, NO<sub>x</sub>, and SO<sub>x</sub> emissions. World ethanol production is currently around 23 billion gallons per year out of which 85% is consumed as fuel. Presently, ethanol is commercially produced by fermentation of sugars derived from grains of plant crops. Fermentation route of ethanol production is a biological conversion process and hence produces ethanol water mixture as the final product. Production of fuel grade ethanol (moisture free) from fermentation route requires separation of ethanol from water using distillation columns which are energy intensive and hence expensive. Furthermore, fermentation rates are usually much slower compared to any other industrial thermochemical conversion rates. Due to this the sizes of large ethanol fermentation plants are quite big. Apart from this, the commercial fermentation-based ethanol plants can only convert the agricultural grains to ethanol and can't convert the remaining woody biomass. Hence, in a ton of biomass only a fraction of carbonaceous feedstock is converted to ethanol, remaining carbon remains unutilized. In contrast to biological process, thermochemical route uses gasification to convert the entire biomass to synthesis gas (CO + H<sub>2</sub>) thereby significantly increasing the carbon utilization compared to fermentation process. Syngas so produced is further processed to remove contaminants such as H<sub>2</sub>S, NH<sub>3</sub>, COS and tar. Clean syngas is then converted to liquid fuels or chemicals using complex processes involving heterogeneous catalysts. In the case of homogenous catalysts, many organometallic complexes have been reported for conversion of carboxylic acids to corresponding alcohol. However, there is no one to one comparison exists between the reported catalyst. Detailed kinetics of homogenous catalyst are not even reported. Conversion of acetic acid to ethanol over impregnated catalysts have been widely reported but the basis for choosing the active metals are not clearly explained. Some catalyst showed reasonable activity and selectivity towards ethanol synthesis, but no explanation exists why they gave good yields and while others did not. There is no quantitative analysis done on the effect of support and their interaction with active metal on acetic acid conversion. Overall, a holistic view on what characteristics of catalyst and support are suitable for acetic acid hydrogenation is not clearly brought out. Finally, a plausible route to arrive at a robust process towards conversion of acetic acid to ethanol is not clearly brought out. In this work, we attempt to present a reasonable explanation towards these observations and substantiate them by credible evidences.