Dwindling fossil fuels, rapid growth in transport sector and stringent emission norms are the motivation for this study. The broad objective of this study was to investigate/ find an alternative sustainable fuel for the use in foreseeable future, which is suitable for large-scale implementation in new technology engines such as GDI engines. Test fuels selected for this study were gasohols [15% (v/v) blends of ethanol/ methanol/ butanol with 85% (v/v) gasoline] and baseline gasoline. Experiments were performed to determine important fuel properties using various characterization instruments such as bomb calorimeter, density meter, viscometer, copper corrosion bath etc. Fuel injectors were calibrated for these test fuels at four different FIPs. Thereafter, shadowgraphy was performed at ambient condition to make a comparative analysis of spatial variation among these test fuels. Macroscopic spray investigation was performed to find out spray penetration length and cone angle. A section of this thesis focuses on microscopic spray investigations using phase Doppler interferometry (PDI) technique for measurement of various spray characteristics such as arithmetic mean diameter (AMD), Sauter mean diameter (SMD), spray droplet size distributions and spray droplet velocity distributions etc. After performing spray experiments, same test fuels were experimentally investigated in the engine. The engine could be operated either with a thermal cylinder head or with an optical cylinder head.

In optical engine investigations, phase Doppler interferometry (PDI) was implemented in the engine cylinder to evaluate real time spray droplet velocity distribution and spray droplet diameter distribution under various engine operating conditions. Many questions were answered by these comprehensive experiments, which otherwise remained unanswered in a constant volume spray chamber experiment. The results obtained from these experiments were helpful in optimizing parameters for engine experiments with thermal head. Effect in variation in spark timings (ST), fuel injection pressures (FIP), engine load and engine speed (rpm) on combustion, performance and emission characteristics were investigated experimentally. In engine experiments with thermal head, detailed investigations to evaluate engine performance, combustion and emission characteristics were conducted for the test fuels. Engine exhaust particle sizer (EEPS) was used to obtain particle number-size distribution and mass-size distribution. Total particulate number (TPN) and count mean diameter (CMD) with varying engine load indicated that particles at no load were also harmful. Detailed particulate characterization was done after collecting the soot particles using a partial flow dilution tunnel on to a 47 mm quartz filter paper and then analyzing them using field emission scanning electron microscopy (FE-SEM), high-resolution transmission electron microscopy (HR-TEM), energy-dispersive X-ray spectroscopy (EDS), FTIR and Raman spectroscopy. Inductively coupled plasma-optical emission spectrometer (ICP-OES) was used to determine trace metal emissions from the GDI test engine. Overall, a suitable gasohol blend was proposed to be used in GDI engines, keeping in mind both positive and negative aspects of experimental results obtained for each primary alcohol investigated, which can be implemented on a large scale with lowest environmental impact.