# STABILITY AND COLD FLOW PROPERTIES OF PONGAMIA BIODIESEL

**Ph.D. THESIS**

*by*

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# ABSTRACT

In view of the fast depletion of fossil fuel and rise in prices of crude oil, the search for alternative fuels has become inevitable. The petroleum biodiesel is considered as substitute of diesel all over the world. The non-edible oils are the potential feed stock resources for biodiesel production. The non-edible oil plants like *Jatropha, Pongamia, Neem, sal* etc are considered as the future source for biodiesel production in India.

Due to high oil viscosity, it cannot be used directly as engine fuel as it poses serious engine problems leading to frequent wear, tear and engine over hauling. These problems are due to more susceptibly of vegetable oil and biodiesels to oxidation. That is why, a need to carryout studies related to stabilisation of biodiesel in term of oxidation, thermal and storage stability as well as cold flow properties (CFP) of biodiesel and its blends to ensure the long term quality acceptance.

CFP like cloud point and pour point also leads to the solidification of fuel and causes the blockage of fuel lines filters and ultimately the fuel starvation in engine operation during operation. The improvement in oxidation stability as well as CFP of biodiesel is, therefore, the need of the hour from the point of biodiesel quality. Since the *Pongamia* is grown in the country on massive scale and therefore, it can be used as future feed stocks for the biodiesel production.

Therefore, the present thesis is devoted to study the CFP and oxidation stability (OS) of Pongamia biodiesel (PB). The following are the main objectives of the thesis are: classification of oil for biodiesel production on the basis of OS and CFP. To optimize the biodiesel production, estimation and improvement in OS and CFP of PB and study the impact of PB on engine performance. The result of analytical study shows that on the basis of CFP and OS, *Castor* oil can be recommended for biodiesel production, but it is edible in nature but *Pongamia* which is non-edible in nature identified as source for biodiesel production due to its wide availability in Indian subcontinent but it has poor CFP and Poor OS. The experimental investigation reveals that optimum biodiesel yield of 98.4% has been achieved with optimum methanol/oil molar ratio (11.06:1) using KOH as catalyst (1.43 % w/w) in 81.4 min time at 56.6$^{o}$C temperature based on experimental work and was verified using response surface methodology (RSM). The $PB_{100}$ suffers with poor OS and inferior CFP. The OS of $PB_{100}$ was evaluated using Rancimat apparatus was found very poor (1.83 hours) compared to EN14214 standard i.e. 8 hours. So its OS has been improved by adding optimum antioxidants concentration of 300 ppm for achieving

maximum stability in term of OS (8.35 hours). $PB_{100}$ also suffers with poor cloud point (CP) and pour point (PP) i.e. 20 and 19°C respectively which were also improved by 5°C using the winterization technique but there is loss of biodiesel yield of 15.6%. So binary blending of PB is done with diesel and kerosene.

The result of blending of PB with diesel showed an improvement in CP and PP by 9 and 11°C respectively, while blending with kerosene improved CP and PP by 11.5 and 12.5°C which is much higher as compared to diesel. To further improve the CFP, the bioethanol was used as cold flow improver (CFI). The addition of ethanol ($PBE_{25}$) is found to improve CP and PP for PB from 20 and 19°C to 6 and 5°C which are comparable to that of diesel.

The engine performance in term of BSFC, BTE and exhaust emission using biodiesel with improved stability and CFP has also been done. Engine operation using PBE25 blend has shown that though the brake specific fuel consumption (BSFC), brake thermal efficiency (BTE) and exhaust emission were better than PB100. When this performance is compared with diesel, it is observed that due to low energy content of ethanol in PBE25 blend, the BSFC has increased and BTE decreased.

The above study also concludes that PB20 blend can be used as engine fuel, but PB100 not due to its poor stability and poor CFP. By adding PY in 300ppm the stability, improved significantly with improvement in its thermal stability. Further, the addition of PY (500ppm) and Aluminium (0.85ppm) has made the PB100 quality comparable to the biodiesel specification under long term storage. This has resulted in lower CFP of PB100 which was improved by adding ethanol in 25% (v/v), kerosene, diesel but improvement in CFP was significant with ethanol. Therefore, from stability point of view, the PBE25 has been recommended for engine operation with few limitations.