Emulsification of biomass pyrolysis oil in diesel

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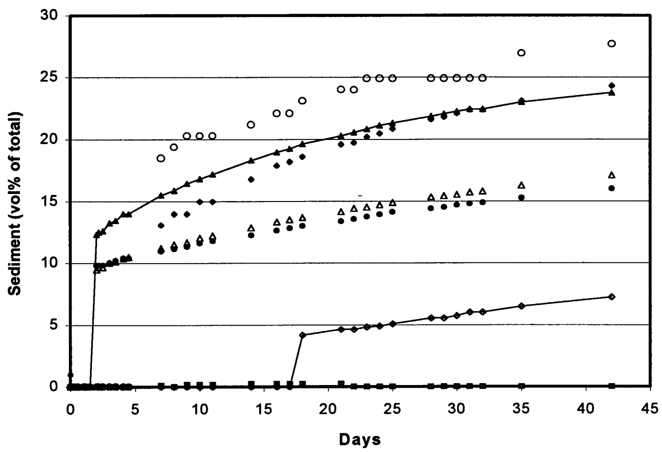
Since the Kyoto accord in 1997, governments around the world have committed to reducing green house gas emissions that are believed to contribute to global warming. The most effective route would be to improve the efficiency of various industrial processes and engines. The selection of fuel types could also help decrease or maintain constant green house gas emissions. Biomass based fuels are CO_2 neutral as biomass absorbs the same amount of CO_2 during its growing period as it releases when combusted as fuel. Bio fuels such as esterifed canola oil and alcohols, albeit a minor role at the moment, have begun to alter energy supply scenes.

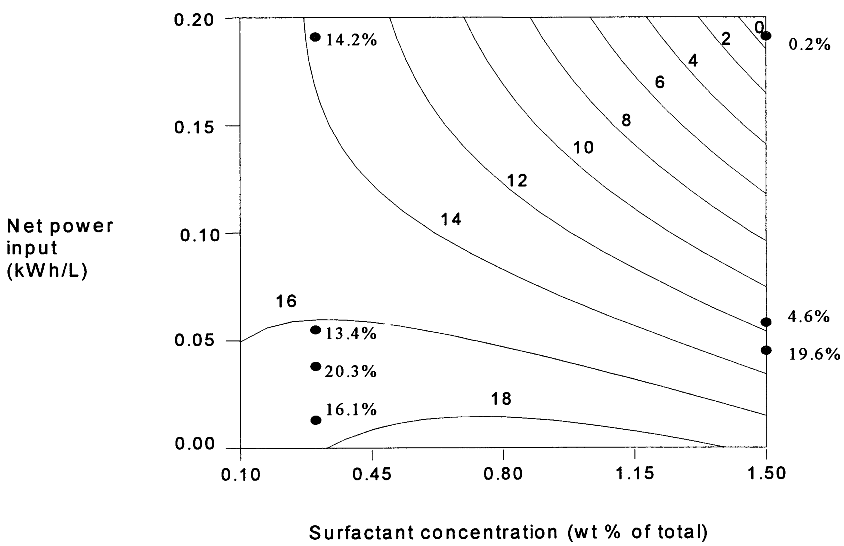
Liquefied biomass fuels can be produced from pyrolysis of wood. Pyrolysis of biomass such as wood and agricultural wastes enables the de-coupling of liquid production from utilization sites. Thus, biomass wastes could be converted to liquid and stored for later use or shipped to other locations as fuel. Various fast pyrolysis technologies for biomass conversion were reviewed recently by Bridgewater [1, 2]. Generally fast pyrolysis results in higher liquid yield than slow pyrolysis in which secondary cracking of primary products contributes to reduced liquid yield. Typical bio-oil contains substantial water, 20-30%, acidic components, ash, char and its viscosity is high: between 35 and 53 cSt at 40°C [3, 4]. Thus, when used in a diesel engine, the as-produced oil would corrode the fuel delivery system. Although modified diesel engines and gas turbines are being developed by some, the entry of bio-oil as a diesel extender would be much easier if the bio-oil could be directly used as fuel in existing diesel engines without modifications [5].

If stable bio-oil in diesel emulsions could be produced some of the above problems would be mitigated. Overall physical characteristics of emulsions would be closer to that of the continuous phase (diesel in this case) than that of bio-oil itself, and the negative effects of ash and char in bio-oil would be less because of dilution by diesel. In addition, low NOx emission could be expected because of low combustion temperature caused by water.

CANMET Energy Technology Centre established that stable emulsions could be prepared from pyrolysis-derived bio-oil and regular diesel fuel using appropriate surfactants [6]. Emulsions so produced are extremely stable depending on surfactant concentrations. Ranges of process conditions required for successful emulsions were established in a batch emulsifier prior to the present work. It was found that product emulsions were prone to form precipitate over time. Although the precipitate is easily redispersed into the emulsion by gentle mixing, its presence is undesirable in fuel. Thus, it became necessary to establish the ranges of lowest surfactant concentration and power input required to produce stable emulsions. A series of runs were conducted to determine the relationship between process conditions and emulsion stability. The stability of the emulsified fuels was analyzed using a statistical model. A quadratic response surface model showed satisfactory agreement with experimental results. It was shown that there are optimal loci that represent the lowest costs of emulsified products for the different levels of bio-oil concentrations.



Stability of 30% pyrolytic bio-oil in No. 2 diesel fuel emulsions



Precipitation contours controlled by power input and surfactant concentrations

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