Performance, emission and economic assessment of clove stem oil–diesel blended fuels as alternative fuels for diesel engines

The scientists at Tshwane University of Technology, Pretoria, South Africa carried out studies on the performance, emission and economic evaluation of using the clove stem oil (CSO)-diesel blended fuels as alternative fuels for diesel engine. Experiments were performed to evaluate the impact of the CSO-diesel blended fuels on the engine performance and emissions. The societal life cycle cost (LCC) was chosen as an important indicator for comparing alternative fuel operating modes. The LCC using the pure diesel fuel, 25% CSO and 50% CSO-diesel blended fuels in diesel engine were analysed. These costs include the vehicle first cost, fuel cost and exhaust emissions cost. A complete macroeconomic assessment of the effect of introducing the CSO-diesel blended fuels to the diesel engine is not included in the study. Engine tests show that performance parameters of the CSO-diesel blended fuels do not differ greatly from those of the pure diesel fuel. Slight power losses, combined with an increase in fuel consumption, were experienced with the CSO-diesel blended fuels. This is due to the low heating value of the CSO-diesel blended fuels. Emissions of CO and HC are low for the CSO-diesel blended fuels. NO\textsubscript{x} emissions were increased remarkably when the engine was fuelled with the 50% CSO-diesel blended fuel operation mode. A remarkable reduction in the exhaust smoke emissions can be achieved when operating on the CSO-diesel blended fuels. Based on the LCC analysis, the CSO-diesel blended fuels would not be competitive with the pure diesel fuel, even though the environmental impact of emission is valued monetarily. This is due to the high price of the CSO [Mbarawa Makame, Performance, emission and economic assessment of clove stem oil–diesel blended fuels as alternative fuels for diesel engines, Renewable Energy, 2008, 33(5), 871-882].

Biogas production from solid slaughterhouse waste, manure and fruit and vegetable waste

The potential of semi-continuous mesophilic anaerobic digestion for the treatment of solid slaughterhouse waste, fruit-vegetable wastes and manure in a co-digestion process has been experimentally evaluated by the scientists at Plaza del Obelisco, La Paz, Bolivia and Lund University, Lund, Sweden. A study was made at laboratory scale using four 2L reactors working semi-continuously at 35°C. The effect of the organic loading rate (OLR) was initially examined [using equal proportion of the three components on a volatile solids, (VS), basis]. Anaerobic co-digestion with OLRs in the range 0.3-1.3kgVS/m\textsuperscript{3}/day resulted in methane yields of 0.3m\textsuperscript{3}/kgVS added, with methane content in the biogas of 54-56%. However, at a further increased loading, the biogas production decreased and there was a reduction in the methane yield indicating organic overload or insufficient buffering capacity in the digester.

In the second part of the investigation, co-digestion was studied in a mixture experiment using 10 different feed compositions. The digestion of mixed substrates was in all cases better than that of the pure substrates, with the exception of the mixture of equal amounts of (VS/V S) solid cattle-swine slaughterhouse waste with fruit and vegetable waste. For all other mixtures, the steady-state biogas production for the mixture was in the range 1.1-1.6l/day, with a methane content of 50-57% after 60 days of operation. The methane yields were in the range 0.27-0.35m\textsuperscript{3}/kgVS added and VS reductions of more than 50% and up to 67% were obtained [Álvarez René and Lidén Gunnar, Semi-continuous co-digestion of solid slaughterhouse waste, manure, and fruit and vegetable waste, Renewable Energy, 2008, 33(4), 726-734].
Cotton oil soapstock biodiesel

The researchers at Mersin University, Mersin, Gazi University, Ankara and Çukurova University, Adana, Turkey studied usability of cotton oil soapstock biodiesel-diesel fuel blends as an alternative fuel for diesel engines. Biodiesel was produced by reacting cotton oil soapstock with methyl alcohol at determined optimum condition. The cotton oil biodiesel-diesel fuel blends were tested in a single cylinder direct injection diesel engine. Engine performances and smoke value were measured at full load condition. Torque and power output of the engine with cotton oil soapstock biodiesel-diesel fuel blends decreased by 5.8 and 6.2%, respectively. Specific fuel consumption of engine with cotton oil soapstock-diesel fuel blends increased up to 10.5%. At maximum torque speeds, smoke level of engine with blend fuels decreased up to 46.6%, depending on the amount of biodiesel. These results were compared with diesel fuel values [Ali Keskin, Metin Gürü, Duran Altıparmak and Kadir Aydin, Using of cotton oil soapstock biodiesel–diesel fuel blends as an alternative diesel fuel, Renewable Energy, 2008, 33(4), 553-557].

Production of fuel ethanol at high temperature from Sugar cane juice

Researchers at Department of Microbiology, Faculty of Science, Kasetsart University, Bangkok, Thailand isolated Kluyveromyces marxianus DMKU 3-1042, by an enrichment technique in a sugar cane juice medium supplemented with 4% (w/v) ethanol at 35°C and produced high concentrations of ethanol at both 40 and 45°C. Ethanol production by this strain in shaking flask cultivation in sugar cane juice media at 37°C was highest in a medium containing 22% total sugars, 0.05% (NH₄)₂SO₄, 0.05% KH₂PO₄ and 0.15% MgSO₄·7H₂O and having a pH of 5.0; the ethanol concentration reached 8.7% (w/v), productivity 1.45 g/l/h and yield 77.5% of theoretical yield. At 40°C, a maximal ethanol concentration of 6.78% (w/v), a productivity of 1.13 g/l/h and a yield 60.4% of theoretical yield were obtained from the same medium, except that the pH was adjusted to 5.5. In a study on ethanol production in a 5 l jar fermenter with an agitation speed of 300 rpm and an aeration rate of 0.2 vvm throughout the fermentation, K. marxianus DMKU 3-1042 yielded a final ethanol concentration of 6.43% (w/v), a productivity of 1.3 g/l/h and a yield of 57.1% of theoretical yield [Limtong Savitree, Sringiew Chutima and Yongmanitchai Wichien, Production of fuel ethanol at high temperature from sugar cane juice by a newly isolated Kluyveromyces marxianus, Bioresour Technol, 2007, 98(17), 3367-3374].

Catalytic cracking of Palm oil for the production of biofuels

Oil palm is widely grown in Malaysia and palm oil has attracted the attention of researchers to develop an ‘environmentally friendly’ and high quality fuel, free of nitrogen and sulfur. In a study conducted by scientists at Malaysia, the catalytic cracking of palm oil to biofuel was studied over REY catalyst in a transport riser reactor at atmospheric pressure. The effect of reaction temperature (400-500°C), catalyst/palm oil ratio (5-10) and residence time (10-30 s) was studied over the yield of bio-gasoline and gas as fuel. Design of experiments was used to study the effect of operating variables over conversion of palm oil and yield of hydrocarbon fuel. The response surface methodology was used to determine the optimum value of the operating variables for maximum yield of bio-gasoline fraction in the liquid product obtained [Tamunaidu Pramila and Bhatia Subhash, Catalytic cracking of palm oil for the production of biofuels: Optimization studies, Bioresour Technol, 2007, 98(18), 3593-3601].
Jute stick pyrolysis for bio-oil production in fluidized bed reactor

Pyrolysis of jute stick for bio-oil production has been investigated by researchers at Department of Applied Chemistry and Chemical Technology, University of Rajshahi, Rajshahi, Bangladesh in a continuous feeding fluidized bed reactor at different temperatures ranging from 300 to 600°C. At 500°C, the yields of bio-oil, char and non-condensable gas were 66.70, 22.60 and 10.70 wt%, respectively based on jute stick. The carbon based non-condensable gas was the mixture of carbon monoxide, carbon dioxide, methane, ethane, ethene, propane and propene. The density and viscosity of bio-oil were found to be 1.11 g/ml and 2.34 cP, respectively. The lower heating value of bio-oil was found to be 18.25 MJ/kg. Since bio-oil contains some organic acids such as formic acid, acetic acid, etc., the $pH$ and acid value of the bio-oil were found to be around 4 and 135 mg KOH/g, respectively. The water, lignin, solid and ash contents of bio-oil were determined and found to be around 15, 4.90, 0.02 and 0.10 wt%, respectively [Asadullah M, Anisur Rahman M, Mohsin Ali M, Motin M Abdul, Sultan M Borhanus, Alamin M Robiul and Rahman M Sahedur, Jute stick pyrolysis for bio-oil production in fluidized bed reactor, Bioresour Technol, 2008, 99 (1), 44-50].

Biofuels generation from sweet sorghum

A study conducted by scientists at Greece focused on the exploitation of sweet sorghum biomass as a source for hydrogen and methane. Fermentative hydrogen production from the sugars of sweet sorghum extract was investigated at different hydraulic retention times (HRT). The subsequent methane production from the effluent of the hydrogenogenic process and the methane potential of the remaining solids after the extraction process were assessed as well. The highest hydrogen production rate (2550 ml H$_2$/d) was obtained at the HRT of 6 h while the highest yield of hydrogen produced per kg of sorghum biomass was achieved at the HRT of 12 h (10.4 l H$_2$/kg sweet sorghum). It has been proved that the effluent from the hydrogenogenic reactor is an ideal substrate for methane production with approximately 29 l CH$_4$/kg of sweet sorghum. Anaerobic digestion of the solid residues after the extraction process yielded 78 l CH$_4$/kg of sweet sorghum. This work demonstrated that biohydrogen production can be very efficiently coupled with a subsequent step of methane production and that sweet sorghum could be an ideal substrate for a combined gaseous biofuels production [Antonopoulou Georgia, Gavala Hariklia N, Skiadas Ioannis V, Angelopoulos K and Lyberatos Gerasimos, Biofuels generation from sweet sorghum: Fermentative hydrogen production and anaerobic digestion of the remaining biomass, Bioresour Technol, 2008, 99 (1), 110-119].

Steam pretreatment of H$_2$SO$_4$-impregnated Salix for the production of bioethanol

In the bioconversion of lignocellulosic materials to ethanol, pretreatment of the material prior to enzymatic hydrolysis is essential to obtain high overall yields of sugar and ethanol. In a study by researchers at Department of Chemical Engineering, Lund University, Lund, Sweden, steam pretreatment of fast-growing Salix impregnated with sulfuric acid has been investigated by varying the temperature (180-210 °C), the residence time (4, 8 or 12 min), and the acid concentration [0.25% or 0.5% (w/w) H$_2$SO$_4$]. High sugar recoveries were obtained after pretreatment, and the highest yields of glucose and xylose after the subsequent enzymatic hydrolysis step were 92 and 86% of the theoretical, respectively, based on the glucan and xylan contents of the raw material. The most favourable pretreatment conditions
regarding the overall sugar yield were 200°C for either 4 or 8 min using 0.5% sulfuric acid, both resulting in a total of 55.6 g glucose and xylose per 100 g dry raw material. Simultaneous saccharification and fermentation experiments were performed on the pretreated slurries at an initial water-insoluble content of 5%, using ordinary baker’s yeast. An overall theoretical ethanol yield of 79%, based on the glucan and mannan content in the raw material, was obtained [Sassner Per, Mårtensson Carl-Gustav, Galbe Mats and Zacchi Guido, Steam pretreatment of H₂SO₄-impregnated Salix for the production of bioethanol, *Bioresour Technol*, 2008, 99 (1), 137-145].

### Activated carbon from olive kernels

Activated carbons have been prepared by researchers at Greece from olive kernels and their adsorptive characteristics were investigated. A two stage process of pyrolysis-activation has been tested in two scales: (a) laboratory scale pyrolysis and chemical activation with KOH and (b) pilot/bench scale pyrolysis and physical activation with H₂O-CO₂. In the second case, olive kernels were first pyrolysed at 800°C, during 45 min under an inert atmosphere in an industrial pyrolyser with a throughput of 1 t/h. The resulting chars were subsequently activated with steam and carbon dioxide mixtures at 970°C in a batch pilot monohearth reactor at NESA facility, Louvain-la Neuve, Belgium. The active carbons obtained from both scales were characterized by N₂ adsorption at 77 K, methyl-blue adsorption (MB adsorption) at room temperature and SEM analysis. Surface area and MB adsorption were found to increase with the degree of burn-off. The maximum BET surface area was found to be around 1000-1200 m²/g for active carbons produced at industrial scale with physical activation, and 3049 m²/g for active carbons produced at laboratory with KOH activation. The pores of the produced carbons were composed of micropores at the early stages of activation and both micropores and mesopores at the late stages. Methylen blue removal capacity appeared to be comparable to that of commercial carbons and even higher at high degrees of activation [Zabaniotou A, Stavropoulos G and Skoulou V, Activated carbon from olive kernels in a two-stage process: Industrial improvement, *Bioresour Technol*, 2008, 99(2), 320-326].

### Production of activated carbons from coffee endocarp

The use of coffee endocarp as precursor for the production of activated carbons by steam and CO₂ was studied by scientists of Portugal and Spain. Activation by both methods produces activated carbons with small external areas and microporous structures having very similar mean pore width. The activation produces mainly primary micropores and only a small volume of larger micropores. The CO₂ activation leads to samples with higher BET surface areas and pore volumes when compared with samples produced by steam activation and with similar burn-off value. All the activated carbons produced have basic characteristics with point of zero charge between 10 and 12. By FTIR it was possible to identify the formation on the activated carbon’s surface of several functional groups, namely ether, quinones, lactones, ketones, hydroxyls (free and phenol); pyrones and Si–H bonds [Valente Nabais João M, Nunes Pedro, Carroll Peter JM, Carroll M Manuela L Ribeiro, García A Macías and Díaz-Díez MA, Production of activated carbons from coffee endocarp by CO₂ and steam activation, *Fuel Process Technol*, 2008, 89(3), 262-268].

### Increased yields in biodiesel production from used cooking oils by a two step process

Short chain alcohol esters of fatty acids can be used as diesel fuel. In the study conducted at Bogazici University, Department of Chemistry, Bebek, Istanbul, one step and two step base catalyzed room temperature transesterification reaction of used cooking oil was compared. In the two step base catalyzed process, for 1000 g of used cooking oil 4.2 g NaOH and 140 ml MeOH was used in the first step and 1.8 g NaOH and 60 ml MeOH was used in the second step. All reactions were done...
at 25°C; the effects of water content and suspended particles on the yield were studied. The yields were easily determined by Thermo Gravimetric Analysis instead of the usual Gas chromatography and the viscosity of products was measured by Ubbelohde type viscosimeter. It was found that two step processes give a better yield (96%) than the one step process (86%)


Recovery of methane-rich gas from solid-feed anaerobic digestion of Ipomoea

In an attempt to develop commercially viable means of utilizing the otherwise very harmful plant by researchers at India have presented studies on new types of anaerobic digesters in which chopped or dry crushed Ipomoea carnea Jacq. was fed (without any other pretreatment) to obtain methane-rich gas. Two types of solid-feed anaerobic digesters (SFADs) were studied. The first type had a single vessel in which the bottom 35% portion was separated from the top portion by a perforated PVC disk. The weed was charged from the top and inoculated with anaerobically digested cowdung-water slurry. The fermentation of the weed in the reactor led to the formation of volatile fatty acids (VFAs) plus some biogas. The leachate, rich in VFAs, was passed through the perforated PVC sheet and collected in the lower portion of the vessel. The other type of reactors had two vessels, the first one was fully charged with the weed and the second received the VFA leachate. With both types were attached upflow anaerobic filters (UAFs) which converted the leachate into combustible biogas 70% methane. All SFADs developed very consistent performance in terms of biogas yield within 17 weeks of start. The two-compartment reactors yielded significantly more biogas than the single-compartment reactors of corresponding total volume and the reactors with which anaerobic filters (AF) were attached yielded more biogas than the ones without AF. The best performing units generated 2.41 m³ of biogas per m³ of digester volume, as compared to 0.1-0.2 m³ of biogas/m³/d, obtainable with conventional digesters. This indicates the viability of this technology.

The spent weed can be vermicomposted directly to obtain good soil-conditioner cum fertilizer; earthworm Eudrilus eugeniae produced 540 mg vermicast per animal every day, achieving near total conversion of feed to vermicast in 20 days. The proposed systems, thus, makes it possible to accomplish total utilization of Ipomoea [Sankar Ganesh P, Sanjeevi R, Gajalakshmi S, Ramasamy EV and Abbasi SA, Recovery of methane-rich gas from solid-feed anaerobic digestion of Ipomoea (Ipomoea carnea), Bioresour Technol, 2008, 99(4), 812-818].

Effects of biodiesel on emissions of a bus diesel engine

The influence of biodiesel on the injection, spray and engine characteristics with the aim to reduce harmful emissions was discussed by a scientist working at University of Maribor, Faculty of Mechanical Engineering, Smetanova, Maribor, Slovenia. The considered engine is a bus diesel engine with injection M system. The injection, fuel spray and engine characteristics, obtained with biodiesel are compared to those obtained with mineral diesel (D2) under various operating regimes. The considered fuel is neat biodiesel from rapeseed oil. Its density, viscosity, surface tension and sound velocity are determined experimentally and compared to those of D2. The obtained results are used to analyze the most important injection, fuel spray and engine characteristics. The injection characteristics are determined numerically under the operating regimes, corresponding to the 13 mode ESC test. The fuel spray is obtained experimentally under peak torque condition. Engine characteristics are determined experimentally under 13 mode ESC test conditions. The results indicate that, by using biodiesel, harmful emissions (NOₓ, CO, smoke and HC) can be reduced to some extent by adjusting the injection pump timing properly [Kegl Breda, Effects of biodiesel on emissions of a bus diesel engine, Bioresour Technol, 2008, 99(4), 863-873].