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Biodiesel: Environmental Friendly Alternative to Petrodiesel

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Biodiesel is a renewable, efficient, environmentally friendly and biodegradable fuel made from vegetable oil, including waste cooking oil. In the United States, soybean oil is the principal oil being utilized for biodiesel [1]. Animal fats, oils and greases generated in the food industry and restaurants can be recovered by interceptors and traps as a feedstock for biodiesel [2]. Insect fat has also been proposed as a promising resource for biodiesel production [3]. Biodiesel can be blended with conventional petrodiesel in any proportion (even 1% biodiesel will increase engine lubrication by 65%) for use in vehicles with an unmodified diesel engine. Unburned hydrocarbons, carbon monoxide and particulate matter are substantially reduced in the exhaust fumes, up to 75% cleaner than petrodiesel made from fossil fuels. Sulphur dioxide emissions are eliminated as biodiesel contains no sulphur. It has significant potential to reduce greenhouse gas emissions particularly in the trucking industry [4]. In Canada canola oil is produced in massive quantities for domestic marketing. A large amount goes through restaurant deep fryers and must be disposed of after a few days of use [5]. The federal government provides, through the Sustainable Development Technology Canada's NextGen Biofuels Fund, ongoing support in the development of advanced renewable biofuels [6]. Annually, the Canadian Renewable Fuels Association presents the Green Fuels Award to honour pioneers in the development, commercialization and promotion of low carbon renewable fuels. In Ontario, biodiesel is exempted from the provincial tax of 14.3 cents per liter. The largest biodiesel plant, Great Lakes Biodiesel Inc. located in Well and, produces 45 million gallons of ASTM 6751 quality biodiesel made from vegetable oils [7]. It has received BQ-9000 Producer status from the National Biodiesel Accreditation Commission for efficient production of high quality fuel to meet the growing renewable energy demands. Today finding an outlet is getting easier - a new website has started up to catalog locations where drivers can get biodiesel for their cars and trucks [8]. Biodiesel is primarily obtained from the base catalyzed transesterification reaction of oils or fats. An American company, HomeBiodieselKits.com, sells biodiesel processing equipment (for three thousand dollars) that can make the processing of used cooking oil into biodiesel much easier [9]. Some people choose biofuel processors to convert local crops (corn) into renewable fuel (fiber cellulosic ethanol) that can replace gasoline or create electricity, thereby saving money and helping the environment. Biodiesel must meet a cetane number specification of 40 or more (to be higher than petrodiesel) [10], which is a measurement of the fuel combustion quality during compression ignition [11]. Other measurements of diesel quality include cold-flow properties, density, lubricity and sulfur content.

Like ethanol produced from enzymatic digestion of lignocellulosic biomass, biodiesel produced from the lipids of algae was touted as one of the most promising alternative biofuels two years ago [12]. While these alternative fuels offered many potential advantages, significant amounts of research were required to make them economically viable. High throughput screening became a useful tool for the quantitation of neutral lipid production by algae, determination of algal cell growth, and optimization of reaction conditions for the enzymatic digestion of lignocellulosic polymers. Microalgae-based biodiesel has several benefits over other resources, especially faster growth, less land use, potential cultivation in non-fertile locations and a high lipid-to-biodiesel yield. Costa and co-workers assessed thirteen different inputs for biodiesel production from residues to meet all international technical specifications [13]. An efficiency index was built up for data envelopment analysis to enable the integration of sustainable development dimensions. They showed that the higher cost associated with the processing of residual resources were compensated by their smaller procurement costs, immediate availability in the urban centers and larger potential for greenhouse gas emission reduction. Torres and co-workers performed rigorous modeling and multi-criteria evaluation at the pilot scale to achieve optimal topology for third generation biodiesel production [14]. Sensitivity was analyzed over a set of operating variables, including two harvesting pathways and three oil extraction methods. Direct esterification could reduce the energy use but would increase the land use impact. Enzymatic transesterification is becoming a commercially competitive route to biodiesel.

The production of biodiesel by conversion of Waste Cooking Oil (WCO) to fatty acid ethyl esters, catalyzed by immobilized lipase and separated downstream by supercritical CO_2 to recover the biodiesel, were studied in a pilot plant by Lisboa et al. [15]. They used the data generated to design an industrial plant for the conversion of 8000 ton_{WCO} each year. Investment and production costs were considered to estimate biodiesel costs of 1.64 € L^{-1} and 0.75€ L^{-1} for enzyme prices of 800 € kg^{-1} and 8 € kg^{-1}, respectively, assuming a WCO price of 0.25 € kg^{-1}. Ang and co-workers reported that glycerol-free supercritical transesterification using dimethyl carbonate is an economically competitive process with the highest profit margin [16]. Rajaeifar and co-workers studied the energy consumption and CO_2 emissions of biodiesel production from soybean [17]. The life-cycle process of biodiesel was considered as five stages: agricultural soybean production, soybean transportation, soybean crushing, biodiesel conversion, and biodiesel transportation (with co-product allocation). The total fossil energy consumption was 8,617 MJ ha^{-1} and the renewable energy output content was estimated at 16,991 MJ ha^{-1}. Both the net energy gain of 8,374 MJ ha^{-1} and the fossil energy ratio of 1.97 showed that soybean would be a suitable energy crop for biodiesel production. The total greenhouse gas emission was 1,710 kg CO_2 eq ha^{-1}.

Biodiesel compliant with EN 14124 has a flashpoint of over 110°C and other properties which indicate a lower potential hazard. Therefore its handling and storage are not subject to the operational safety rules for hazardous materials, which is a great advantage over petrodiesel.

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Biodiesel analysis tests the acid content, appearance, calorific value, color, ester, odor, sediment, sludge, specific gravity, sulfur, viscosity and water content [18]. Both near- and mid-infrared spectroscopies have played an important role in biodiesel quality analysis which is very important to successful commercialization and market acceptance [19]. Pinto and Lemous applied anodic stripping voltammetry to the determination of cadmium, copper, lead and zinc in biodiesel samples after microwave digestion with dilute acid [20]. Biodiesel analysis was focused on low-level elemental sulfur and nitrogen detection for algae, algal, jatropha, soy and sun flower oils that need on-going validation of structural composition [21]. Standard analyses for carbon, hydrogen, nitrogen, oxygen and sulfur are provided by ICP-AES and ICP-MS. Ultimately, fifty-two different elements can be determined with a limit of detection less than 1 ppm during the biodiesel development cycle. Silveira and co-workers have developed a simple and rapid chromatographic analytical method for the determination of acetate, chloride, formate, phosphate and sulfate anions at mg L^{-1} concentrations in biodiesel prepared from canola, soy and sunflower vegetable oils, or from bovine fat [22]. Extraction of the anions can be performed using a small volume of water with the assistance of ultrasound. Mogollon and co-workers have presented a comprehensive two-dimensional gas chromatography method that can obtain the fatty acid methyl esters profile to determine, by multivariate curve resolution with alternating least squares, the composition of mineral diesel blended with biodiesel regardless of their original sources [23]. Pandiangan and Simanjuntak prepared biodiesels by transesterification of coconut oil with dimethyl carbonate (using TiO_2/SiO_2 as heterogeneous catalyst) and performed GC-MS analysis to reveal the formation of fatty acid methyl esters before verification by ^{1}H-NMR spectroscopic analysis [24].

As biodiesel is redefining the future of renewable fuel, petrodiesel will likely be up-converted for utilization in high-value-added consumer products. Nanotechnology-based processes can both increase the performance of oil refineries and reduce the level of environmental pollutants [25].

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