Development of a Biodiesel Industry in Rwanda: Processing and Fuel Quality Control

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Workshop on Biodiesel Production And Marketing in Rwanda
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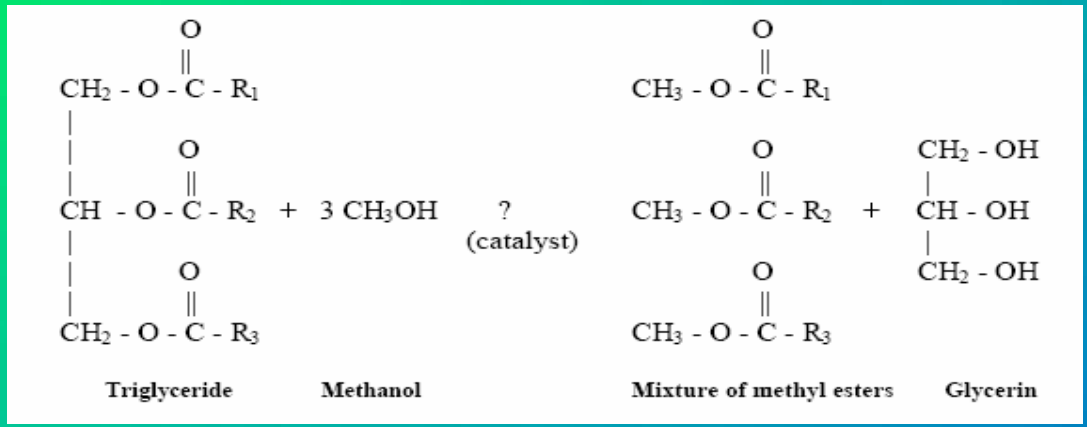
PURPOSES

- Diversification of Rwandan Energy Matrix: Fossil and Renewable
- Reduction of diesel and oil imports
- Generation of jobs and income
- Settling families on the land and expansion of local sustainable agriculture
- Making good use of soils not appropriate for food crops
- Providing an environmentally correct fuel

WHAT IS BIODIESEL ?

- Biodiesel is produced by chemically reacting a fat or oil with an alcohol, in the presence of a catalyst
- The product of the reaction is a mixture of methyl esters, which are known as «***biodiesel***», and «***glycerol***», which is a high value co-product.
- The process is known as «***transesterification***»

ALKALI-CATALYZED TRANSESTERIFICATION

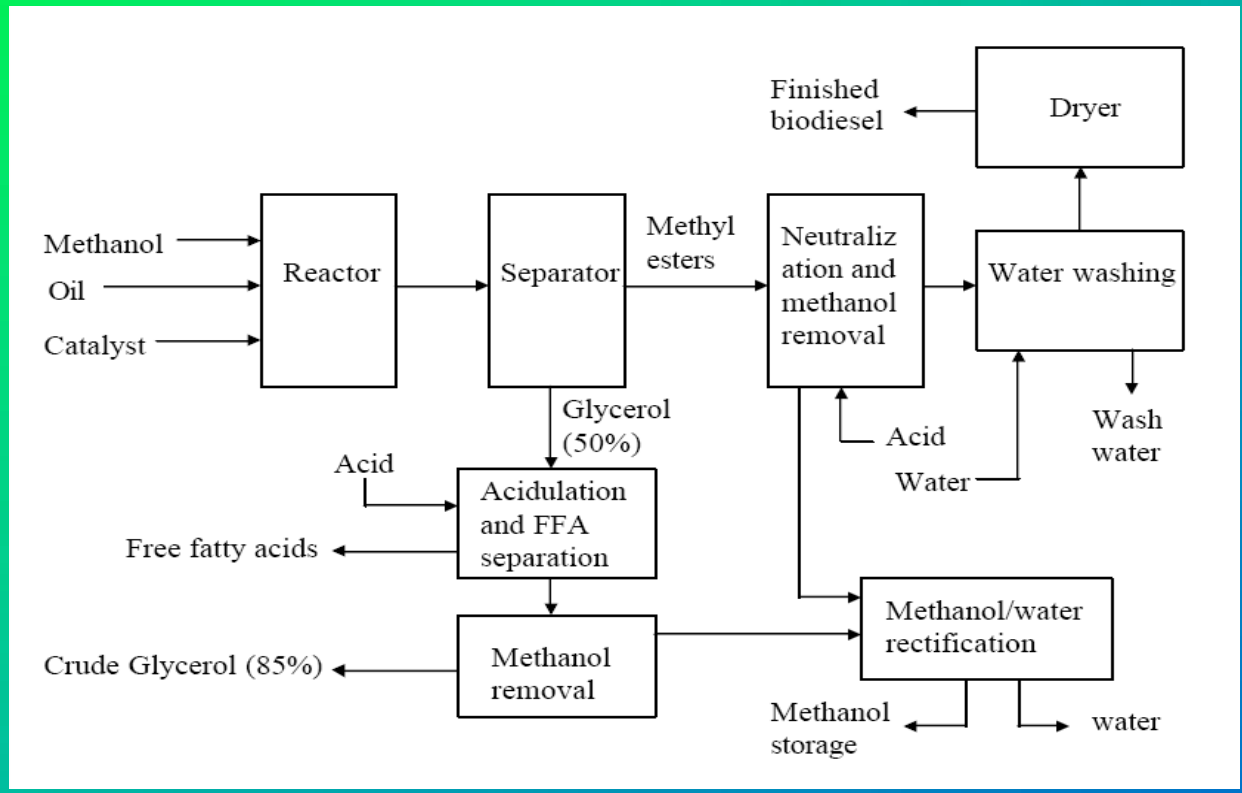


TRANSESTERIFICATION PROCESS TECHNOLOGICAL ARRANGEMENT

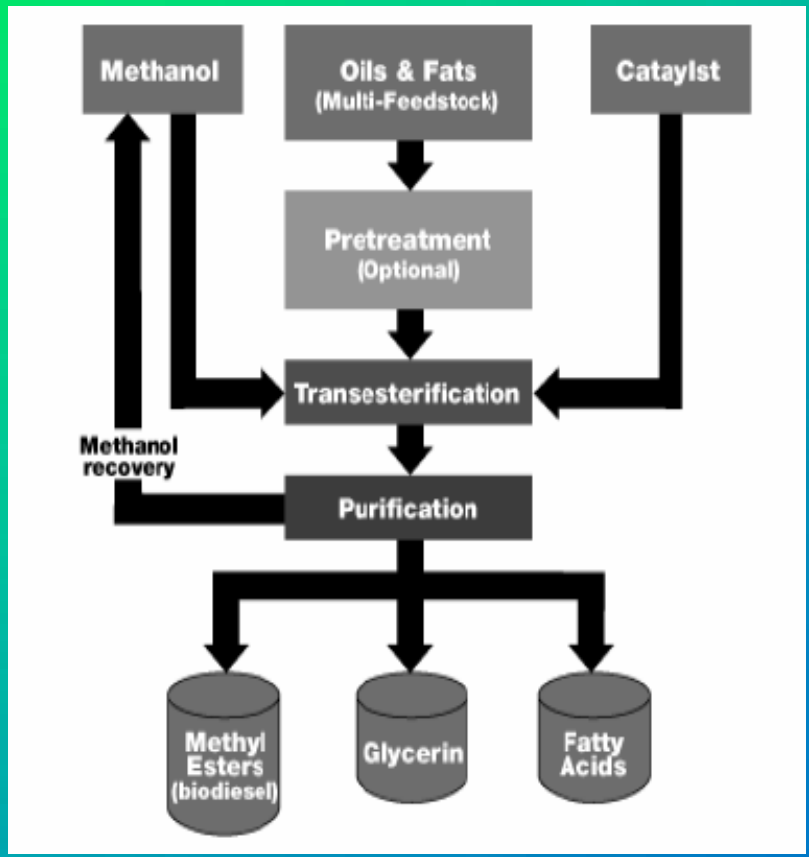
Critical quality parameters of the process are:

- «***Complete reaction***».
- Removal of «***glycerol***».
- Removal of «***catalyst***».
- Removal of «***alcohol***».
- Absence of «***free fatty acids***».
- Low «***sulfur***» content.

PROCESS FLOW SCHEMATIC FOR BIODIESEL PRODUCTION



FLOWCHART OF THE TRANSESTERIFICATION PROCESS



APPLICATIONS OF BIODIESEL

As a **neat** fuel **(B100)**.

As a **medium-level blend (B5-B50)**. Blends can be used to meet Energy Policy Act mandates (B20 essentially = 1/5 vehicle).

As a **low-level blend (1% - 2%).** Small amounts of biodiesel can restore lubricity to low-sulfur fuels.

IRST TEST VEHICLE

TOYOTA HILUX PICK-UP D C

IN COLLABORATION WITH

TOYOTA Akagera Motors S.A.R.L
B. P. 3774 KIGALI
RWANDA
Tél. : 00(250)575220 / 575871
Fax. : 00(250)573018
Represented by: Vinay H. GORAJIA, President – Managing Director
E-mail: **vinaygorajia@toyotarwanda.com**

HOW BIODIESEL WORKS

unmodified diesel engine.
no “engine conversion”
operates on the principle of compression ignition
diesel engines actually use fuel to ignite hot air.
Biodiesel has lower emissions,
is made domestically (which increases national security),
does not affect engine performance
is produced from plants. biodiesel is “liquid solar fuel”.

BIODIESEL BENEFITS

1. runs in any conventional, unmodified diesel engine (except replacing some fuel lines on older engines)
2. Can be stored anywhere
3. reduces carbon dioxide emissions. Climate change neutral
4. can be used alone or mixed
5. is more lubricating than diesel fuel increases the engine life and can be used to replace sulfur, a lubricating agent. High cetane number
6. is safe to handle because it is biodegradable, non-toxic and renewable
7. is safe to transport, has a high flash point, or ignition temperature, of about 300 deg. F compared to petroleum diesel fuel, which has a flash point of 125 deg. F.
8. Autoignition, fuel consumption, power output, and engine torque are relatively unaffected by biodiesel.
9. Biodiesel has a pleasant aroma

DISADVANTAGES OF BIODIESEL

- Biodiesel has 8% less energy per gallon. Max power and miles per gallon will drop by that amount.
- Biodiesel is less oxidatively stable than petroleum diesel fuel. Old fuel can become acidic and form sediments and varnish. Additives can prevent this.
- Biodiesl wil gel (like regular diesel fuel).
  Blending and additives can control this.

  Biodiesel can cause filter plugging (at low temps, due to polymers, fuel tank deposits, other contaminants). Filtering keeps the fuel clean.

FUEL QUALITY

- Of great importance to the **successful commercialization**
- Is a prerequisite for **market acceptance**

Generally, the fuel quality of biodiesel can be influenced by several factors:

The **quality of the feedstock**
The **fatty acid composition** of the parent vegetable oil or animal fat
The **production process** and the **other materials** used in the process (Completion of reaction, Free Glycerol, Residual Alcohol and Residual Catalyst).
Post-production parameters (Water, Sediment and Storage Stability)

PROPERTIES OF BIODIESEL FROM DIFFERENT OILS (BARNWAL, 2005)

Vegetable oil methyl esters (biodiesel)	Kinematic viscosity (mm^2/s)	Cetane no.	Lower heating value (MJ/kg)	Cloud point (°C)	Pour point (°C)	Flash point (°C)	Density (kg/l)
Peanut	4.9	54	33.6	5	–	176	0.883
Soya bean	4.5	45	33.5	1	−7	178	0.885
Babassu	3.6	63	31.8	4	–	127	0.875
Palm	5.7	62	33.5	13	–	164	0.880
Sunflower	4.6	49	33.5	1	–	183	0.860
Tallow	–	–	–	12	9	96	–
Diesel	3.06	50	43.8	–	−16	76	0.855
20% biodiesel blend	3.2	51	43.2	–	−16	128	0.859

FUEL QUALITY (Cont.)

The properties of biodiesel and diesel fuels show **many similarities**, and therefore, biodiesel is rated as a strong candidate as an **alternative** to diesel.

Biodiesel's primary advantages lie in its effect

on emissions,

cetane number,

its flash point,

and its lubricity

CETANE NUMBER AND ENERGY CONTENT FOR BIODIESEL FUELS

(www.me.iastate.edu/biodiesel)

Type of Biodiesel	Heat of Combustion in MJ/Kg	Cetane No.
Methyl Soybean	39.8	46.2
Ethyl Soybean	40.0	48.2
Butyl Soybean	40.7	51.7
Methyl Sunflower	39.8	47.0
Methyl Peanut	-	54.0
Methyl Rapeseed	40.1	-
Ethyl Rapeseed	41.4	-

COMPARISON OF DIESEL/BIODIESEL ENERGY CONTENT AND ENERGY EFFICIENCY

Fuel	Density g/cm^3	Caloric value		Energy efficiency %
		MJ/Kg	MJ/dm^3	
Diesel	0.83	42.90	35.60	38.20
Biodiesel	0.88	37.20	32.90	40.70
Variation		-13 %	-8 %	+ 7%

BIODIESEL QUALITY

The primary criterion for biodiesel quality is adherence to the appropriate standard

The contaminants can lead to severe operational problems when using biodiesel, including

Engine deposits,
filter clogging,
or fuel deterioration.

Therefore, standards such as those in Europe (EN 14214; EN 14213 when using biodiesel for heating oil purposes) and the United States (ASTM D6751) limit the amount of contaminants in biodiesel fuel.

BIODIESL STANDARD ASTM D6751 (United States)

Property	Test method	Limits	Unit
Flash point (closed cup)	D 93	130.0 min	°C
Water and sediment	D 2709	0.050 max	% volume
Kinematic viscosity, 40°C	D 445	1.9–6.0	mm^2/s
Sulfated ash	D 874	0.020 max	% mass
Sulfur	D 5453	0.0015 max or 0.05 max[a]	% mass
Copper strip corrosion	D 130	No. 3 max	
Cetane number	D 613	47 min	
Cloud point	D 2500	Report	°C
Carbon residue (100% sample)	D 4530	0.050 max	% mass
Acid number	D 664	0.80 max	mg KOH/g
Free glycerin	D 6584	0.020 max	% mass
Total glycerin	D 6584	0.240 max	% mass
Phosphorus content	D 4951	0.001 max	% mass
Distillation temperature, atmospheric equivalent temperature, 90% recovered	D 1160	360 max	C

[a]The limits are for Grade S15 and Grade S500 biodiesel, respectively. S15 and S500 refer to maximum sulfur specifications (ppm).

EUROPEAN STANDARD EN 14213 for Biodiesel as Heating Oil

Property	Test method	Limits min	Limits max	Unit
Ester content	EN 14103	96.5		% (m/m)
Density; 15°C	EN ISO 3675 EN ISO 12185	860	900	kg/m^3
Viscosity; 40°C	EN ISO 3104 ISO 3105	3.5	5.0	mm^2/s
Flash point	EN ISO 3679	120		°C
Sulfur content EN ISO 20884	EN ISO 20846		10.0	mg/kg
Carbon residue (10% dist. residue)	EN ISO 10370		0.30	% (m/m)
Sulfated ash	ISO 3987		0.02	% (m/m)
Water content	EN ISO 12937		500	mg/kg
Total contamination	EN 12662		24	mg/kg
Oxidative stability, 110°C	EN 14112	4.0		h
Acid value	EN 14104		0.50	mg KOH/g
Iodine value	EN 14111		130	g iodine/100 g
Content of FAME with ≥4 double bonds			1	% (m/m)
Monoglyceride content	EN 14105		0.80	% (m/m)
Diglyceride content	EN 14105		0.20	% (m/m)
Triglyceride content	EN 14105		0.20	% (m/m)
Free glycerine	EN 14105, EN 14106		0.02	% (m/m)
Cold-filter plugging point	EN 116			°C
Pour point	ISO 3016		0	°C
Heating value	DIN 51900-1 DIN 51900-2 DIN 51900-3	35		MJ/kg

Biodiesel STANDARD EN 14214 (Europe)

Property	Test method	Limits min	Limits max	Unit
Ester content	EN 14103	96.5		% (m/m)
Density; 15°C	EN ISO 3675 EN ISO 12185	860	900	kg/m^3
Viscosity; 40°C	EN ISO 3104 ISO 3105	3.5	5.0	mm^2/s
Flash point	EN ISO 3679	120		°C
Sulfur content EN ISO 20884	EN ISO 20846		10.0	mg/kg
Carbon residue (10% dist. residue)	EN ISO 10370		0.30	% (m/m)
Sulfated ash	ISO 3987		0.02	% (m/m)
Water content	EN ISO 12937		500	mg/kg
Total contamination	EN 12662		24	mg/kg
Oxidative stability, 110°C	EN 14112	4.0		h
Acid value	EN 14104		0.50	mg KOH/g
Iodine value	EN 14111		130	g iodine/100 g
Content of FAME with ≥4 double bonds			1	% (m/m)
Monoglyceride content	EN 14105		0.80	% (m/m)
Diglyceride content	EN 14105		0.20	% (m/m)
Triglyceride content	EN 14105		0.20	% (m/m)
Free glycerine	EN 14105, EN 14106		0.02	% (m/m)
Cold-filter plugging point	EN 116			°C
Pour point	ISO 3016		0	°C
Heating value	DIN 51900-1 DIN 51900-2 DIN 51900-3	35		MJ/kg

QUALITY CONTROL

All biodiesel production facilities should be equipped with a laboratory so that the quality of the final biodiesel product can be monitored

It is also important to monitor the quality of the feedstocks.

WHY BIODIESEL NOW?

Petroleum prices are at all-time highs

Government incentives may provide excellent support:
CCC program
Tax credit
Small producer credit

Price depending on location and how much of the tax credit is passed on to the consumer

OBSTACLES TO THE DEVELOPMENT OF A BIODIESEL INDUSTRY

Risk to capital

Investors are concerned about risk if petroleum prices go down, or incentives go away

Which comes first: Crop or processing plant?

Farmers won't plant crop if there is no processor,
processor won't invest if there is no crop

Some way is need to distribute the risk

CONCLUSIONS

- Insufficiency production of lipids
- Consumption growth of diesel
- Esters of Fatty Acids like biodiesel
- Ethylic Esters more favorable (100% green)

PROSPECTS

- Increase the productivity of lipids
- Develop other vegetable resources (Jatropha Curcas)
- Enhance other sources of lipids (animals, fishes, …)
- Good matching:

Raw materials – Technology - Geoeconomy

WAYS TO FORWARD

- What are the costs of production for different feedstock/fuel pathways at small and large scale in African countries?
- Do we understand the full environmental impacts (e.g. life-cycle GHG emissions) of feedstock and fuel pathways in the African context?
- Do we understand other environmental impacts? Social Impacts Land use change?
- Should production for national use take precedence over production for international trade?

WISHES FOR SUCCESS

- sharing experience on existing biofuel programs

- Identifying policies and tools available for bioenergy planning and management in order to minimize negative social and environmental impacts and maximize benefits

- Identifying capacity building and technology support needs and ways to address these

WISHES FOR SUCCESS (cont.)

- Policy aspects and national strategies

. What are some of the barriers to development of biofuels? How might these be overcome?

. What are some specific criteria you would recommend for ensuring biofuels are produced in an environmentally and socially sustainable manner?

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Partners

International Partners:

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National partners:

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