

BIODIESEL FROM PEANUT OIL AND ITS EMISSION AND PERFORMANCE CHARACTERISTICS IN FOUR STROKE IC ENGINE

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Abstract - Biofuel is fuel from recently lifeless or living biological material. And it is different to fossil fuels from long dead biological material. Gasoline and diesel are actually ancient biofuels. Peanut is a potential oil crop as it contains the high amount of oil as compared to only about 15 percentage - 20 percentage for soybean oil. Aside from engine testing, emissions associated with the use of biodiesel also need to be evaluated to assess its cleanliness as a fuel. Hence, this study was conducted to investigate the application of peanut oil biodiesel as an engine fuel. On observing the results of Emission Tests we found out that there was lesser amount of soot formation and absence of black smoke.

Key Words: Biodiesel, peanut oil, emission.

1. INTRODUCTION

Gasoline and diesel are actually ancient biofuels. But they are known as fossil fuels because they are made from decomposed plants and animals that have been buried in the ground for millions of years. Biofuels are similar, except that they're made from plants grown today. Biofuel is fuel from recently lifeless or living biological material. It is different to fossil fuels from long dead biological material. Biofuel can be in forms of solid, liquid or gas. Biofuels are usually used to power cars, heat homes and for cooking. Growing concerns over possible scarcity in petroleum fuel reserves as well as increasing awareness on global environmental issues prompted the development and utilization of non-petroleum based fuels that are clean, sustainable and renewable. Oils from biomass are a potential alternative to petroleum-based fuels; however, their high viscosity limits their application as engine fuel and therefore must be modified prior to utilization. Hence, transesterification of the oils should be done to improve their properties, producing a product termed as biodiesel. Biodiesel is a mixture of mono-alkyl esters of long chain fatty acids derived from a renewable lipid feedstock, such as vegetable oil or animal fat. It can be produced from the transesterification of any triglyceride feedstock, which includes oil-bearing crops, animal fats and algal lipids. The feedstock commonly utilized for biodiesel production depends upon the country's geographical, climatic and economic conditions. Rapeseed and canola oil are mainly used in Europe, palm oil in tropical countries and soybean oil and animal fats in the US. However, the supply of

these feed stocks may not be enough to displace all petroleum-based diesel (petrodiesel) usage. In the US, soybean oil alone cannot satisfy the demand of feedstock quantity for biodiesel production since it accounts for only 13.5 percentage of the total production and only an estimated 6percentage of petrodiesel demand can be replaced if all US soybean production were utilized as biodiesel feedstock. Consequently, alternative feed stocks were identified such as sunflower, moringa, hazelnut and jatropa seed oils among others. Peanut is a potential oil crop as it contains the high amount of oil (40 percentage - 50 percentage of the mass of dried nuts) as compared to only about 15 percentage - 20 percentage for soybean oil. The US Department of agriculture reports an annual peanut yield of 4.70 metric tons per hr., which is almost twice as that for soybean (2.66 metric tons per hr). Thus, oil yield for peanuts can reach as much as 1059 L/hr while it is only 446 L/hr for soybean oil. This product is a peanut oil-diesel blend which was tested for peanut oil viscosity, flash point and fire point, calorific value, ash content all of which met the requirements for bio-diesel fuel. Moser, on the other hand, prepared methyl esters using catalytic potassium hydroxide and obtained 92 percentage yield of peanut methyl esters which exhibited excellent oxidative stability but poor cold flow properties. The obtained biodiesel has a viscosity close to petrodiesel but has calorific value 6 percentage less than that for petrodiesel. Important fuel properties such as density, flash point, cetane number fall within the set standards. Another important aspect in biodiesel research that must be considered is the assessment of its performance as an engine fuel. Studies involving the application of peanut oil biodiesel in an engine are very limited in literature. A number of studies discussed the performance of biodiesel from other feed stocks such as soybean, sun- flower, canola, in an engine which specifically has the effect of using biodiesel blends on engine power and fuel economy. However, engine performance may be affected by the variation in biodiesel quality caused by differences in the esterification process and the raw materials used, among others. Aside from engine testing, emissions associated with the use of biodiesel also need to be evaluated to assess its cleanliness as a fuel. The Environmental Protection Agency reported that non-road diesel engines have a substantial role in contributing to the nation's air pollution and therefore stricter emission standards were imposed with regards to the amounts of particulate matter, nitrogen oxides and sulphur oxides.

Hence, this study was conducted to investigate the application of peanut oil biodiesel as an engine fuel. This study aims to:

- Assess fuel properties of the peanut oil biodiesel in accordance with ASTM standards.
- Determine the effect of blending percentage of biodiesel on the characteristic engine performance (i.e. net brake power, torque and specific consumption).

1.1 BIODIESEL 1

Biodiesel is fuel from recently lifeless or living biological material. It is different to fossil fuels from long dead biological material. Biodiesel can be in forms of solid, liquid or gas. Biodiesel are usually used to power cars, heat homes and for cooking.

1.2 PEANUT 2

A peanut is a plant in the legume family, Fabaceae. It is native to South America, Central America and Mexico.

Binomial Name	: Arachis hypogaea.
Genus	: Arachis
Species	: hypogaea
Family	: Fabaceae

1.3 TYPES OF PEANUT 3

Although peanuts come in many varieties, there are four basic market types: Runner, Virginia, Spanish and Valencia. Each of the peanut types is distinctive in size, flavor, and nutritional composition. Within each four basic types of peanuts, there are several "varieties" for seed and production purposes. Each variety contains distinct characteristics which allows a producer to select the peanut that is best suited for its region and market.

2. LITERATURE REVIEW

Gandhi, A.P., K. Jha, et al. 1992, [7]., Peanut seeds contain 27–29 percentage (w/w) protein and 40–50 percentage (w/w) oil

Bari, S., Yu, C. W., et al. 2002, [2]., Increasingly strict emissions regulations have forced researchers to look for ways to achieve emission reductions through fuel modifications. Biofuels are potential renewable alternative fuels for internal combustion engines.

Bian, Y.-Z, et al. 2003, [3]., Biodiesel is a fuel consisting of the alky-mono-ester of fatty acids from vegetable oils or animal fats

Bari, S., Yu, C. W., et al. 2004, [1]., The world petroleum reserve to production ratio (R/P) stood at about 40 years from the year 2004, but China's R/P is only about 20 years.

Carraretto, et al. 2004, [4]., Biodiesel is similar to diesel fuel in some of its chemical and physical attributes, including its combustion characteristics.

Demirbas A, et al. 2005, [5]., Therefore, biodiesel fuel can be used in diesel engines with little or no modification.

Demirbas A, et al. 2006, [6]., Biodiesel has a higher cetane number than diesel fuel, no aromatics, and no sulphur, and it contains 10–11percentage oxygen. These characteristics of biodiesel reduce some exhaust emissions. Biodiesel has virtually the same miles per gallon rating as petrodiesel. Biodiesel has a very high flash point, making it one of the safest of all alternative fuels. It is the only alternative fuel that can actually extend engine life because of its superior lubricating properties. Peanuts are an important source of lipid and protein in developing as well as developed countries, and peanut oil is one of the major oils in biodiesel production.

3. METHODOLOGY

There are two main process are performed in the production of the peanut oil biodiesel. These were transesterification and washing process. Transesterification is the process of exchanging the alkoxy group of an ester compound by another alcohol. These reactions are often catalyzed by the addition of an acid or base. Washing Biodiesel with water is the oldest and most common method of cleaning biodiesel. About 3 Percentage of raw, unwashed biodiesel is methanol. Methanol is a solvent, it captures soap and other impurities and holds them dissolved in the biodiesel. Water soaks up that methanol, releasing impurities to be washed away with water. And pure biodiesel of peanut oil is collected.

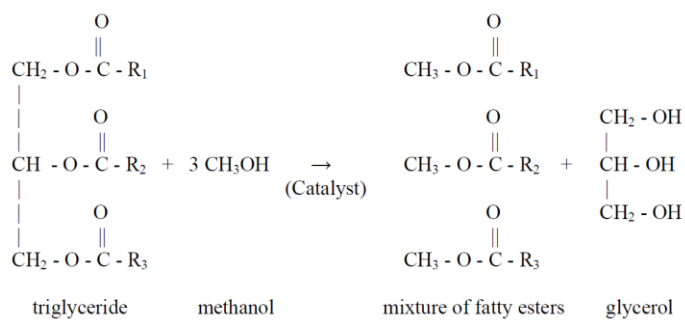
4. METHODS AND PROCEDURES

4.1 WORKING PROCESS

Two operations are performed in the production of the peanut oil ethyl ester. These were transesterification and washing process.

4.1.1 THE TRANSESTERIFICATION PROCESS

The reaction temperature of 60°C was selected as suggested by Alamu et al. (2007). Potassium hydroxide was added to methanol to form potassium methoxide. The methanol-KOH mixture (potassium methoxide) was poured into the groundnut oil in a transesterification reactor, and the following transesterification reaction occurred. The mixture of potassium hydroxide and methanol in the flask was stirred vigorously. The methanol catalyst mixture was poured into the oil in the main reactor and stirred rapidly, settle for 48 hrs. After settling and completion of separation, glycerol which is the heavier liquid collected at the bottom, while the ester product was at the top. The glycerol layer was drained off and the ester layer remained.



4.1.2 WASHING PROCESS

The method used for washing consists of two steps developed by Peterson et al. (1996), is described as follows: The glycerol layer was re-mixed with the ester layer after initial settling has occurred, then 15percentage water was added and the entire mixtures were re-stirred for 10 min and allowed to settle for 48 hrs.

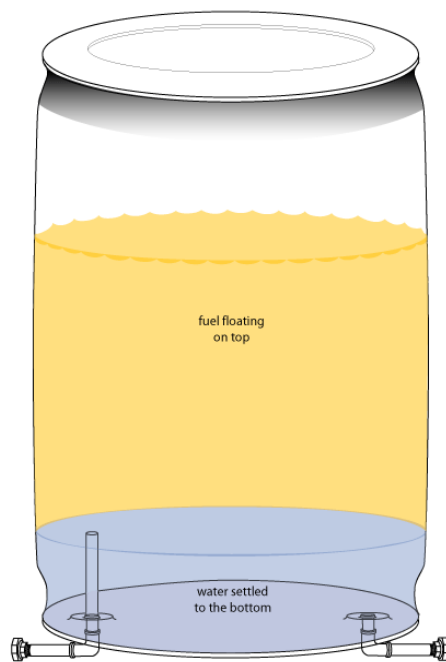


FIG 1 - WASHING PROCESS OF BIOFUEL

The ester product was washed after draining off the glycerol layer. The ester was washed with water at about 30percentage of the ester volume. The water was stirred into the ester with mechanical stirring using a blender. After 10 mins, the stirring was stopped, and the water was allowed to settle out for two days. At this point, the process was complete and the crystal clear product was the groundnut oil ethyl ester. Water soaks up that methanol, releasing impurities to be washed away with water. Most dry wash methods require we evaporate or distill the methanol into a flammable and toxic gas as part of the purification process. Water washing is the most flexible way to purify biodiesel.

4.2 TESTING PROCESS

4.2.1 FLASH AND FIRE POINT TEST

The flash point of a material is the lowest temperature at which the vapour of substance momentarily takes fire in the form of a flash under specified condition of test. The fire point is the lowest temperature at which the material gets ignited and burns under specified condition of test The material is filled in the cup up to a filling mark. The lid is placed to close the cup in a closed system. All accessories including thermometer of the specified range are suitably fixed. The bitumen sample is then heated. The test flame is lit and adjusted in such a way that the size of a bleed is of 4mm diameter. The heating is done at the rate of 5°C to 6°C per minute. The stirring is done at a rate of approximately 60 revolutions per minute. The test flame is applied at intervals depending upon the expected flash and fire points. First application is made at least 17°C below the actual flash point and then at every 1°C to 3°C. The stirring is discontinued during the application of the test flame.

4.2.2 VISCOSITY TEST

Preparation of the Sample - Heat the sample to a temperature not more than 60°C for the tars and pitches and not more than 90°C for bitumens above their respective approximate softening point temperature respectively until it has become sufficiently fluid to pour. Transfer about 20 ml into a suitable container and maintain it to a temperature of 135 ± 5.5°C stirring occasionally to prevent local overheating and allow the entrapped air to escape. Charge the viscometer by pouring the prepared sample to within ± 2 mm of fill line E. Place the charged viscometer in an oven or bath maintained at 135 ± 5.5°C for a period of 10 ± 2 min to allow large air bubbles to escape. Testing - Maintain the bath at the test temperature within ± 0.1°C. Place the charged viscometer vertically in the water bath with the help of a holder so that the uppermost timing mark is at least 2 below the surface of the bath liquid. After the viscometer has remained in the bath for 30 ± 5 min open the valve and allow the asphalt to flow into the viscometer. Measure to within ± 0.5 sec the time required for the leading edge. Upon completion of the test, remove the viscometer from the bath and place it in an inverted position in an oven maintained at 135 ± 5°C until asphalt is drained off thoroughly from the viscometer.

4.2.3 CALORIFIC VALUE TEST

Prepare the sample in the bomb. The sample is put in the crucible together with a piece of cotton wool. A known length of fuse wire is passed through the sample with both ends of the wire being attached to the 2 electrodes of the bomb. Closing the bomb. Care must be taken not to disturb the sample when moving the bomb head to the bomb cylinder. Check the sealing ring to be sure that it is in good condition and moisten it with a bit of water so that it will slide freely into the cylinder; then slide the head into the cylinder and push it down as far as it will go. For easy insertion, push the head straight down without twisting and leave the gas release valve open during this operation. Set

the screw cap on the cylinder and turn it down firmly by hand to a solid stop. When properly closed, no threads on the cylinder should be exposed. Filling the bomb. Connect the oxygen supply to the bomb and close the gas release valve. Open the filling connection control valve slowly and watch the gauge as the bomb pressure rises to the desired filling pressure (usually 30 atm., but never more than 40 atm) then close the control valve. Fill the calorimeter bucket. Put the bomb inside the calorimeter bucket by attaching the lifting handle to the screw cap and lowering the bomb with its feet spanning the circular boss in the bottom of the bucket. Handle the bomb carefully during this operation so that the sample will not be disturbed. Remove the lifting handle and add 1.2 liters of water inside the bucket. Final settings. Connect the power source to the bomb and put the thermometer inside the bucket. Set the cover on the jacket and start the stirrer. Read and record temperatures. Let the stirrer run for 5 minutes to reach equilibrium before starting a measured run. At the end of this period start a timer and read the temperature. Read and record temperatures at one-minute intervals for 5 minutes. Then, at the start of the 5th minute. Recording change in temperature. The bucket temperature will start to rise within 30 seconds after firing. This rise will be rapid during the first few minutes, measuring the energy content of sample using the Bomb Calorimeter then it will become slower as the temperature approaches a stable maximum as shown by the typical temperature rise curve. Record temperatures at one minute intervals until the difference between successive readings have been constant for 3 minutes. Usually the temperature will reach a maximum; then drop very slowly. But this is not always true since a low starting temperature may result in a slow continuous rise without reaching a maximum. As stated above, the difference between successive readings must be noted and the readings continued at one-minute intervals until the rate of the temperature change becomes constant over a period of 3 minutes. Opening the bomb. After the last temperature reading, stop the motor and lift the cover from the calorimeter. Lift the bomb out of the bucket and open the gas release valve on the bomb head to release the gas pressure before attempting to remove the cap. After all pressure has been released, unscrew the cap and lift the head out of the cylinder. Examine the interior of the bomb for soot or other evidence of incomplete combustion. If such evidence is found, the test will have to be discarded. Fuse wire burnt. Remove all unburned pieces of fuse wire from the bomb electrodes; straighten them and measure their combined length in centimeters. Subtract this length from the initial length of fuse wire used and enter this quantity on the data sheet as the net amount of wire burned.

4.2.4 ASH CONTENT TEST

When determining the ash content of asphalt cement, the reference to the dry residue from the determination of residue by evaporation in section 10 are referring to asphalt cement. Incinerate the content of the crucible for 2 hours and remove the crucible from the

furnace to cool to room temperature. Once the crucible is at room temperature, the sample weight shall be determined and recorded to the nearest 1 ml. Return the crucible to the muffle furnace and heat the sample for an additional 30 minutes. After heating, cool the crucible again to room temperature. Once at room temperature, determine and record the sample weight to the nearest 1 ml. If a constant weight has not been achieved, repeat step 3 until a constant weight is reached. Calculate the ash content of a sample as a percent of the asphalt cement or residue by evaporation as applicable. Report the ash content to the nearest 0.1 percentage.

4.2.5 PERFORMANCE TEST

The useful power available at the crank shaft of the engine is called brake power (BP). Torque is a measure of the force that can cause an object to rotate about an axis. Just as force is what causes an object to accelerate in linear kinematics, torque is what causes an object to acquire angular acceleration. Total fuel consumption is the mass of fuel consumed at particular load consumed at particular load per hour. It is expressed in kg / hr. Specific fuel consumption is defined as the mass of the fuel consumed per hour per brake power of the engine. The indicated power actually developed inside the cylinder due to the combustion of fuel are called indicated power (IP) Brake thermal efficiency is defined as the ratio of brake power to heat supplied by the combustion of fuel Indicated thermal efficiency is defined as the ratio of indicated power to heat supplied by the combustion of fuel Mechanical efficiency is defined as the ratio of Brake power to indicated power Calculate the maximum load that can be applied on the given engine. Check the engine for fuel availability, lubricant and cooling water connection. Release the load on the engine and start the engine with no load condition. Allow the engine to run for few minute to attain rated speed. Note the speed of the engine and time taken for consumption of 10 cc of fuel. Increase the load on the engine and note the speed of the engine and time taken for 10cc of fuel consumption Repeat the procedure up to 75 percentage of the maximum load and tabulate the readings.

4.2.6. EMISSION TEST

The first emissions testing was done in California in 1966. Emissions testing determines the level of air pollutants emitted from the exhaust of a motor vehicle. Since then, many states began requiring testing for all registered vehicles. If a vehicle fails the emissions test, repairs must be done and the vehicle retested. An emission test cycle is a protocol contained in an emission standard to allow repeatable and comparable measurement of exhaust emissions for different engines or vehicles. Test cycles specify the specific conditions under which the engine or vehicle is operated during the emission test. There are many different test cycles issued by various national and international governments and working groups. Specified parameters in a test cycle include a range of operating

temperature, speed, and load. Ideally these are specified so as to accurately and realistically represent the range of conditions under which the vehicle or engine will be operated in actual use. Because it is impractical to test an engine or vehicle under every possible combination of speed, load, and temperature, this may not actually be the case.

4.2.6.1. SMOKE TEST

The smoke emitted from all diesel engine heavy goods vehicles and buses is assessed for its density. It is carried out by the use of an approved and calibrated smoke meter. The engine will be accelerated up to governed speed and the density of the smoke measured. After the third acceleration the average reading is recorded. If the reading is below 2.5m1 for non-turbocharged engines or 3.0m1 for turbocharged engines the vehicle will pass. Diesel vehicles first used from 1 July 2008 to 1 January 2014 must have a reading of 1.50, and those vehicles first used on or after 1 January 2014 must have a reading of below 0.7ml. However if the average is higher, a further acceleration is carried out and the average of the last three readings are used, this will continue until a maximum of six accelerations have been carried out. If the average of the fourth, fifth and sixth acceleration is higher than the right level the vehicle will not pass the test. Also, any of the following will result in the vehicle being refused a certificate:

- exhaust emits too much smoke or vapour of any color, to an extent likely to obscure vision
- emissions cannot be measured because a tail pipe is damaged or an accessory is fitted which prevents the insertion of the smoke meter probe
- insufficient oil in the engine or low oil pressure which could cause engine damage if engine is accelerated
- obvious signs of an engine defect such as an unusual noise or emission of smoke
- The emissions of CO increase with increasing load. Higher the load, richer fuel-air mixture is burned, and thus more CO is produced due to lack of oxygen. At lower loads, CO emissions for biodiesel blends are close to mineral diesel.
- At higher load the biodiesel blends show significant reduction in CO emission. All the biodiesel blends exhibit lower HC emissions compared to mineral diesel. This may be due to better combustion of biodiesel blends due to presence of oxygen.
- Increase in the emission of NO was observed in comparison with diesel for the biodiesel fueled engines. The smoke opacity for biodiesel blend fueled engines was lower than diesel at all loads.

5. RESULTS AND DISCUSSIONS

Bio-fuel and Diesel blending ratio - 3:7 [B30]

5.1 FLAS AND FIRE POINT

FLASH POINT OBTAINED - 75°C
FIRE POINT OBTAINED - 84°C

5.2 VISCOSITY TEST

TABLE 1 - VISCOSITY OF THE BIODIESEL

S.NO	TEMPERATURE (°C)	TIME (Sec.)	QUANTITY (ml)
1	40	32	50
2	45	30	50
3	50	28	50
4	55	25	50
5	60	21	50

5.3. CALORIFIC VALUE

Calorific value of Diesel - 45.5 MJ/kg
Calorific value of Bio-Diesel - 39.6 MJ/kg

5.4 ASH CONTENT

Ash content of Diesel - 0.1% to 0.2%
Ash content of Bio-Diesel - 0.2% to 0.5%

5.5 PERFORMANCE TEST

TABLE 2 - PERFORMANCE OF BIODIESEL VS DIESEL

S.NO	PERFORMANMCE CHARECTERISTICS	DIESEL	B30
1	BP (KW)	1.9025	1.9027
3	TFC (Kg/hr)	0.3678	0.3641
4	SFC (Kg/hr)	0.134	0.132
5	Heat supplied (KW)	4.4955	4.2785
6	Induction power (KW)	3.0025	2.5052
7	BTE (percentage)	37.19	45.28
8	IPE (percentage)	62.89	32.71
9	ME (percentage)	50.37	59.47

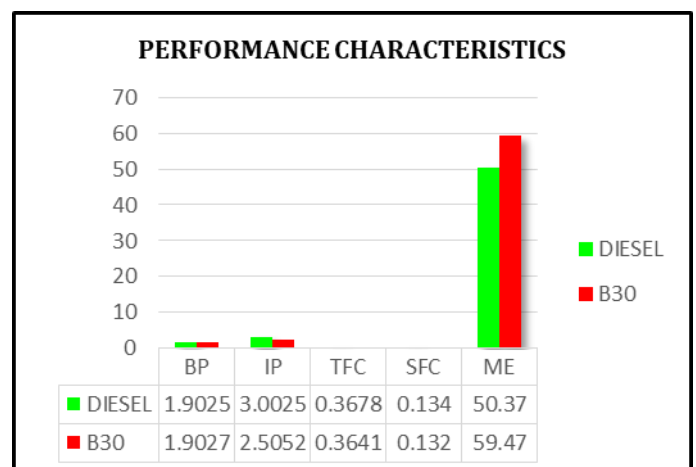


FIG 2 - PERFORMANCE GRAPH OF BIODIESEL VS DIESEL

5.6 EMISSION TEST

TABLE 2 – EMISSION OF BIODIESEL VS DIESEL

S.NO	EMISSION	B100	B30
1	HC	-67 percentage	-20 percentage
2	CO	-48 percentage	-12 percentage
3	NOX	+10 percentage	+2 percentage to -2 percentage
4	PM	-47 percentage	-12 percentage

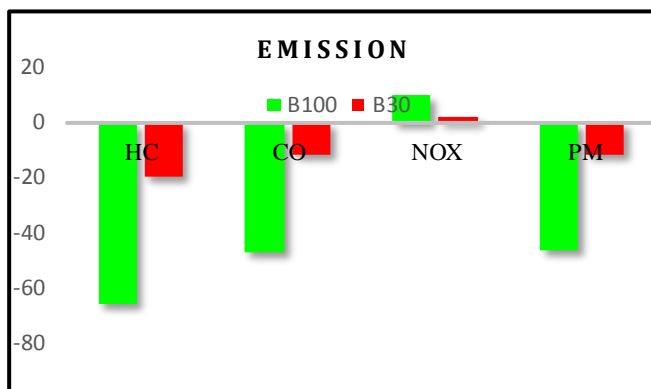


FIG 3 –EMISSION OF BIODIESEL VS DIESEL

5.7 DISCUSSIONS

From the figure 2, comparing normal diesel with biodiesel is obtained very nearest value of various performance test.

From the figure 3 the emission of biodiesel blend is less compared to normal diesel and also due to less soot formation, absence of black smoke occurs during emission test.

6. CONCLUSIONS

It is a simple, eco-friendly, fast and green method to synthesize Biodiesel from peanut oil. In the present study it was found that peanut oil could be a good source for the synthesis of Biodiesel with several advantages. The synthesized Biodiesel was confirmed by Flash and Fire point test. The Emission test of the synthesized Biodiesel showed nearby values of standard emission tests.

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BIOGRAPHIES



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