TECHNICAL ASPECTS OF THE PRODUCTION PROCESS OF ALOE VERA GEL BIODIESEL: PRE-TREATMENT AND TRASESTERIFICATION

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Abstract *— The aspiration of the century is to reconcile the economic, energy and social interests with the need to preserve natural resources for future generations, briefly apply the ideal of sustainability. Seeking to address the lack of clean and renewable energy, is an alternative biofuel production on a larger scale. According to this claim, a search began for new oil, biodiesels derived base for vegetable matter and able to fit the transesterification process, which is simple and responsible for reducing the kinematic viscosity method. A viable option was from leaf Aloe Vera, a viscous gel and colorless, it can develop a good adaptation to production processes by pre-treatment.*

Index Terms — Aloe Vera - Biofuels - Clean Energy - oilseed – Pre-treatment - Sustainability - Transesterification.

INTRODUCTION

Today's world scenario presents several problems due to the ever increasing use of hydrocarbons. The steep increase of the green house effect gases emission and the limited amount of reserves are a reason for the global economies to be concerned, considering their total dependency. The demographic growth powered the unbridled use of energy which led to energy supply issues, causing a price increase. This fact led to the need for sustainable policies focusing on the search for other sources of energy that would not harm the environment and fulfill the role of meeting the demand taking economical and social aspects into consideration [1].

The perspective of reaching energetic security considering environmental aspects stimulated the development of a sustainable economy; this idea provided a greater focus on Biodiesel and the upscale production challenges of this biodegradable and sustainable energy source. According to the representative of the MDIC in the Biodiesel interministerial executive commission, Carlos Manuel Pedroso Neves Cristo, as Biodiesel is produced, new concerns arise regarding the search for new species; intensification of the oily plants crops and the ideal amounts to meet the mixture proportion [1]-[2].

In this respect, The Aloe Vera presents itself as a new vegetable raw material possibility for Biodiesel production, considering it can endure tropical and arid climates, Surviving sandy soils without the need of big amounts of water. Its leaves are green and juicy, and are source of a gelatinous extract which is the base for the transesterification process [9]-[10].

The transesterification is the most commonly used method when it comes to Biodiesel production. This process makes viable the creation of a new fuel which is similar to the hydrocarbon diesel. In spite of the investigation of other methods like the micro emulsion, pyrolysis and petroleum derived diesel dilution, The transesterification is the most viable method taking the current market requirements into consideration, due to the fact that it has a low cost, occurs on a single stage under ambient pressure, and according to KNOTHE *et al.* (2006, p.29) this is the only method capable of generating oil and fat alkyl ester, known as [3].

The Biodiesel is obtained through a transesterification reaction of any triglyceride with low molar weight alcohols, methanol or ethanol (PARENTE, 2003). In Brazil, the high demand for ethanol makes it less expensive, besides having advantages for being produced through biomass. However, in most of the countries the transesterification process is done using methyl alcohol. Freedman *et. al*., (1886, p.1377) afirm that methyl alcohol reaction present better aspects than those with ethyl alcohol, considering that the ethanol could only be used on its anhydrous form which would require a high number of complex stages for phase separation. In summary, evaluating the technical aspects and the cost-benewfit relation, methanol was used in this work [4]-[5].

During the researches, the methyl ester presented better results, as previously stated. Another fact of great importance was the catalyst to be used, aiming to control equipment corrosion and to reach better and faster results, it was decided to employ alkaline transesterification in this work. To reach a maximum conversion rate it was indispensable the study of the physicochemical properties of the Aloe Vera Gel and the elimination of substances which

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are not easily removed by simple decantation or filtering, leading to need for a pre-treatment. In Summary, the Aloe Vera Gel was treated by removing the free fatty acids (FFA), the humidity rate and the acid index, so that it could adapt to the transesterification process [10].

DESCRIPTION OF THE ALOE VERA'S BOTANY

"The history of Aloe Vera is ancient and is present among several cultures literature. It`s name is probably originated from the Arabic *word alloeh*, which means bitter shiny substance. The first record of the use of Aloe Vera was made on a Mesopotamian clay tablet dated 2100 b.C. (Atherton, 1997)". The Aloe Vera is popularly known in Portuguese language as Babosa, it is a herbaceous plant from the liliaceaes family, that adapts well to sandy soils and to tropical and arid climates, it is shrubby, has a short stem, long roots and leaves that range between 30 to 60 centimeters long that are green, dense, juicy and spear shaped, presenting short and malleable spikes on its edge. *Aloe Vera* blooms in the beginning of the spring, it`s flowers varies from yellow to red tones, it`s seeds are winged, making the crop easier; it`s small need of water is a favorable factor for an upscale planting [9]-[11].

Properties of the leaf: The Aloe Vera leaf presents countless properties. It is where most of the plant`s nutrients are found. By performing a cut on the leaf it is easy to identify two main components: the aloin and the Aloe Vera's Gel.

The aloin is a yellow resin that is present on a small amount, has a bitter flavor and is found between the skin and the gelatinous pulp. The second component is found in the inner part of the leaf, on a larger amount, colorless and viscous, coming from the parenchymatous tissue of the leaf. It is rich in vitamins, mineral and polysaccharides. Due to this great amount of nutrients, the Aloe Vera's Gel is widely used on the medical and cosmetics industry and now the goal is the study of its use as a possible Biodiesel vegetable raw material [9]-[11].

ALOES VERA GEL EXTRACTION

In order to reduce the big amount of macroscopic waste a medium size press was used to extract the gel. Firstly the extraction was done by hand, using a spatula, but this method failed because it generated a high amount of waste and so it was replaced by the mechanical method using the press which was simple and effective [9].

The extraction process happens the following way: initially the leaves are collected from the plant and cleaned; they are submitted to the pressing process in which all the gelatinous pulp is extracted from the leaf. This process happens slowly to avoid any possible contamination from the yellow resin (aloin) that can blend with the gel. After the extraction, the gel is submitted to a simple filtering process to separate the waste that can be seen by the naked eye such as a piece of the leaf`s skin [9].

The storage process requires few precautions such as avoiding excessive heat and luminosity because this can accelerate the oxidation process. Therefore, after the extraction the gel must be kept in dark containers where there is ventilation. The extracted samples must not be kept for too long, its use in the transesterification process must be done within one hour of the extraction to avoid premature oxidation [9].

Both processes mentioned above contributed with the success of the transesterification process: the lower the ratio of macroscopic waste the higher the quality of the reaction. In the future it is intended to upgrade the extraction method in order to obtain more satisfactory results [9].

General average performance of Aloe Vera gel per leaf mass

While collecting the leaves it is intended to find bigger leaves in order to extract a higher amount of gel, increasing the leaf`s performance. An examination of the volume of gel per mass of leaf was made, with a collected amount of 3 kg of leaf it was possible to produce, on average 650 ml of Aloe Vera's gel (Table I). It is a reasonable amount considering the fact that one plant can have more than 30 leaves.

TABLE I.

AVERAGE PERFORMANCE OF ALOE VERA GEL PER MASS OF LEAF	
Mass of leaves collected	3000g
Volume of gel extracted	650 ml

PHYSICOCHEMICAL ASPECT OF THE ALOE VERA GEL

In this study, focus was given to the comprehension of the peculiarities of the Aloe Vera gel, aiming to forecast the possible reaction problems and match them to the transesterification process. "The specificities of the treatment depend on the nature and conditions of the fatty material used as raw material" (Parente, 2003) [4].

The analysis were conducted through the following methodology: after cutting the Aloe Vera`s leaf, it is possible to observe a gelatinous liquid in it's interior called Aloe Gel. This Gel was submitted to tests such as color

aspect, humidity rate, specific mass at 25 ° C, pH, viscosity and oxidative stability.

- Color aspect: The Aloe Vera gel is colorless. This gel can be distinguished from the aloin due to its yellow color [9]-[11].
- Humidity rate: The Aloe Vera gel has a high water rate, thus a drying process is necessary, because humidity is a factor that inhibits the transesterification [12].
- Specific mass: approximately 0,909 g/ml.
- Viscosity: Slightly gelatinous aspect [9].
- pH: Using the PH measuring tape it was possible to observe an acid PH, that varies from 4,0 to 5,0, thus it is necessary to perform a PH correction with alkaline wash so that there is no saponification during the alkaline transesterification [9].
- Oxidative stability: It is possible to notice an alteration of color, smell, texture and shine when the gel is exposed for 24 hours. This fact led to the conclusion that the gel must be stored in properly closed containers wrapped with aluminum foil. According to YAMOTO (1983), the gel is very unstable in ambient conditions (light, air), modifying its organoleptic properties when in contact with such [6].

PRODUCTION STAGES

Alkaline Wash

Firstly it is necessary to make sure the raw material is free of any waste coming from the extraction process, thus it was necessary to eliminate all the residual waste through a simple filtration using a folded gauze in the inner part of a funnel using paper filter. The draining process with the paper filter is slower due to the high viscosity of the fluid [10].

The pre-treatment processes aim to make minimize the humidity and acidity of the raw material because the alkaline transesterification presents issues regarding the formation of soap while in these conditions. (SCHUCHARDT et al., 1998). Considering that the catalyst used was (NaOH) and that the Aloe Vera's gel presented acid PH, the correction of the PH was only possible through neutralization (alkaline wash with pure sodium hydroxide [3]-[7].

This way, the 200 ml sample was handled the following way: the distilled water was heated, but without crossing its boiling point and along with it the sodium hydroxide was added to the Aloe Vera, removing the free fatty acids (FFA). Subsequently, the gel was submitted to a drying process or dehumidification by heating the mixture above 120°C, not only to remove the water added during the process but also to minimize the high humidity rate present in the gel [10].

The drying process was introduced at the end of the pre-treatment to guarantee the water rate would not inhibit the transesterification reaction, while there was a concern with the gel's properties. It was intended to searching for viable options to preserve the gel and for method that would maintain its characteristics. The use of high temperature for brief periods of time, preferably with the addition of an antioxidant such as the ascorbic acid (Ashley, 1983) is a suggested method [10].

Transesterification: Theory and practice

After the pre-treatment stage the oil is ready to go through alkaline transesterification. "This ways, the pretreated oil, having a low FFA rate, can be transesterified with an alkaline catalyst to convert the triacylglycerols into methyl ester" (Knothe, G.; Krahl, J.; Gerpen, J. V.; Ramos, L.P., 2006, p.38) [3].

The transesterification process, mentioned previously, happens with the reaction of the vegetable oil with an active intermediate formed by the relation of an alcohol (low molar weight alcohols) with a catalyst (acid, basics and enzymatic) that allow the conversion into fatty acid methyl ester (biodiesel) and glycerin (sub product removed by decantation) [3]-[4].

The transesterification process of the Aloe Vera gel occurred the following way: 200ml of gel, that had previously gone through the pretreatment processes (filtering, wash and drying), was heated until 40 °C, 0,4 g of sodium hydroxide and 40 ml of methanol was added. The mixture went through a stirring process for approximately 20 minutes until it became homogenous. After the transesterification, the mixture rested for approximately 24 hours [10].

RESULTS

Due to the pretreatment processes, there was neither soap formation nor traces of leaf fiber, on a way that it was possible to observe a lighter color. After 24 hours of rest, it was possible to observe the phases separation. However, the final product presented issues related to its very basic PH.

Before the stages previously mentioned, it is possible to notice that the Aloe Vera Gel presents peculiarities regarding its physicochemical properties such as the oxidative stability, acid rate and high humidity rate, thus

justifying a more rigid judgment, establishing a slower methodology.

CONCLUSION

With focus on the physicochemical aspects, the procedures were reformulated aiming to provide better performance transesterification reaction. The use of the alkaline wash was very important, because it minimized the free fatty acids and consequently slowed the deterioration process.

As previously mentioned, there are other interesting Aloe Vera Gel's characteristics, that require a correction, just like the PH that ended up too basic, therefore the upgrade of the production processes is essential for a better performance after the reaction.

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