Electrostatic Coagulation for Separation of Crude Glycerin from Biodiesel

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**ABSTRACT**

Limited energy resources and increasingly strict emission regulations have motivated an intense search for alternative transportation fuels over the last three decades [1]. Biodiesel is an environmentally friendly alternative diesel fuel consisting of the alkyl monoesters of fatty acids from vegetable oils and animal fats. As biodiesel production technology changes, all aspects of the process are being tested and refined for faster, easier, and more efficient production. One such piece of the production process is separating glycerin and biodiesel. The use of gravity method is not a proper solution for production facilities looking to move to a continuous flow setup. Centrifuge systems are expensive as their power consumption is concerned to run and maintain and inefficacy as circumstances change. In this study, to separate glycerin from glycerin-biodiesel mixture a new method was used in which an electrostatic field caused by a high voltage (more than kV) and low amperage AC current (mA) is used. In this method, the process of coagulation particles or drops of glycerin in biodiesel-glycerin mixture from an electrostatic field is done.

**INTRODUCTION**

Limited energy resources and increasingly strict emission regulations have motivated an intense search for alternative transportation fuels over the last three decades [1]. Biodiesel is an alternative diesel fuel consisting of the alkyl monoesters of fatty acids from vegetable oils and animal fats. Biodiesel is defined as the alkyl monoesters of fatty acids from renewable resources, such as vegetable oils, animal fats, and waste restaurant greases [2]. Biodiesel production from abundant bio-sources has drawn the attention of the academic as well as the industrial communities in recent years. However, one of the most serious obstacles for using biodiesel as an alternative fuel is the complicated and costly purification processes involved in its production. The difficulties involved in the separation of glycerin and other un-reacted reactants and by-products necessitate the development of new competent low cost separation processes for this purpose [3]. As biodiesel production technology changes, all aspects of the process are being tested and refined for faster, easier, and more efficient production. One such piece of the production process is separating glycerin and biodiesel. The use of gravity method is not a proper solution for production facilities looking to move to a continuous flow setup. After the reaction, the glycerin is separated by settling or centrifuging and the layer obtained is purified prior to using it for its traditional applications (pharmaceutical, cosmetics and food industries) or for the recently developed applications (animal feed, carbon feedstock in fermentations, polymers, surfactants, intermediates and lubricants) [4]. Removing glycerin from biodiesel is important since the glycerin content is one of the most significant precursors for the biodiesel quality. The traditional means of removing glycerin is mainly by gravity separation or centrifugation [3, 5]. Centrifuge systems are expensive as their power consumption is concerned to run and maintain and inefficacy as circumstances change. In some cases, using centrifuge method leads to transfer part of the biodiesel phase to glycerin phase. Ultimately, other methods need to be found to make separation easy, fast, and less time consuming. The idea of using a high voltage current to separate biodiesel from glycerin came from Graham Laming from UK. Companies also exist who use electrostatic charge to separate insoluble liquids, but that technology is proprietary and made mostly for the oil filtration industry. In this study, to separate glycerin from glycerin-biodiesel mixture, an electrostatic field caused by a high voltage (more than kV) and low amperage AC current (mA) is used. The separation technique was tested on waste cooking oil-based produced biodiesel with KOH as a reaction catalyst.
In this method, the process of coagulation particles or drops of glycerin in biodiesel-glycerin mixture from an electric field is done. The aim of current study, is to determine the effectiveness of a high voltage/low amperage current on glycerin separation in a batch setting. Effect of different parameters including electrode type (point to point, plate, rod and wire type), electrode distance (3, 6 and 9 cm) and voltage and current intensity (3400V-112 mA, 6800V-56 mA, 10200V-38 mA, 13600V-28 mA) on required time for glycerin separation from biodiesel was investigated.

MATERIAL AND METHODS

Materials:
Waste cooking oil was collected from of Tarbiat Modaures University restaurant, Tehran, Iran and 99.9% reagent-grade methanol (Merck, Germany) were used as the reactants throughout this study. The potassium hydroxide (KOH) were purchased from Merck chemicals and used as the catalyst (> 99%).

2.2. Experimental setup and operation:
2.2.1. Biodiesel production:
In order to biodiesel production, Methanol and potassium hydroxide were pre-mixed to prepare potassium methoxide, and then added to waste cooking oil in the reactor with a mixing speed of 600 rpm for 2 h at 50 °C. The molar ratio of waste cooking oil to methanol was 1:6.

2.2.2. Glycerin separation by using electrostatic Coagulation:
At the end of transestrification reaction and methanol recovery, the mixture (200 ml) of biodiesel and glycerin left 24 hr to settle completely. In order to determine the total amount of glycerin-rich phase was separated by using gravity method. The amount of separated glycerin in gravity method as a criterion was considered. In order to evaluate the Concluding electrostatic separation method, effect of different parameters including electrode type (point to point, plate, rod and wire type), electrode distance (3, 6 and 9 cm) and voltage and current intensity (3400V – 112 mA, 6800V – 56 mA, 10200V – 38 mA, 13600V – 28 mA) on required time for glycerin separation from biodiesel was considered. Figure 1 show the type and placement of electrodes inside the container mixture of biodiesel and glycerin.

![Fig. 1: type and placement of electrodes inside the container mixture of biodiesel and glycerin.](image-url)

Results:
Effect of electrode type on glycerin separation:
In this study, the time consumed to separate glycerin from the biodiesel when using four electrodes bar, point to point, plated and wired type in various voltage and current intensity and different electrode distance evaluated. The results showed that conditions a fixed distance between the electrodes, when using the point to
point type electrode in all conditions current and voltage, the time required for separation of glycerin and biodiesel has the lowest range, 19-45 s. Also results showed that the time required for separation of glycerin when using of wired type electrode be maximum. Figure 2 showed the effect of electrode type on glycerin separation.

![Effect of electrode type on glycerin separation](image)

**Fig. 2:** Effect of electrode type on glycerin separation.

**Effect of voltage – current condition on glycerin separation:**

Investigation of voltage and current conditions showed that with increasing voltage from 3400 to 13600 (V) and decreasing of current from 112 to 28 mA, the amount of time required to separation of glycerin and biodiesel has reduced (Fig. 3). This phenomenon can be explained so that increase in voltage leads to a strengthening of electrostatic field and accelerating of the coagulation particles or drops of glycerin in biodiesel-glycerin mixture. Results showed that electrostatic field intensity (higher voltage and lower current) has most effectiveness in reducing the glycerin separation time but observations showed that the higher voltage may cause a negative impact on the biodiesel and And safety considerations should be considered further.

![Effect of voltage – current condition on glycerin separation](image)

**Fig. 3:** Effect of voltage – current condition on glycerin separation.

**Effect of electrode distance on glycerin separation:**

Results of distance between electrodes (3, 6, 9 cm) showed by increasing of electrode distance from 3 to 9 cm, required time for separation process has been increased (Fig. 4). The reason was that increase electrode
distance upto 9 cm (decreasing in electrostatic field) causing the decrease of glycerin particle adhesion (coagulation) So more time is needed to separation get complete.

In relation to the distance between the electrodes should be noted that at lower distances between electrodes they must be immersed in mixture of biodiesel and glycerin and the electrodes should not be exposed to air and methanol vapor. Because this prevent the possibility of an arc occurring in the explosive atmosphere.

**Fig. 4:** Effect of electrode distance on glycerin separation.

**Conclusions:**

The results indicated that electrode type, electrode distance and voltage and current intensity were important factors affecting the time required for separation process. Using electrostatic Coagulation method compared to gravity method due separation process in time less than a minutes. Results of using various electrodes (point to point, plate, rod and wire), various distances between electrodes (3, 6 and 9cm) in various voltage and currents proved that point to point electrode with distance of 3 cm and higher electrostatic field intensity has most effective reducing the glycerin separation time. The problem with this new method is how it used for industrial scale but seems to be an applicable method in the future of crude glycerin separation from biodiesel.

**REFERENCES**