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Evaluation of a Blood Extractor for Enhanced Blood Processing

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Abstract: ***Blood component separation plays a critical role in transfusion medicine, ensuring the availability of safe and effective blood products. However, conventional manual methods have limitations in terms of time, accuracy, and reliance on human intervention. To address these challenges, automated blood component separators have emerged as promising solutions, although many existing systems are costly and require frequent recalibration. This research paper introduces a novel blood component separator, the Bio Pressmatic Plus, designed specifically for the Indian market. Unlike traditional systems that utilize load cells, the Bio Pressmatic Plus employs an array of strategically positioned sensors to accurately detect and segregate specific blood components. The results of this study demonstrate the effectiveness of the Bio Pressmatic Plus as an innovative and reliable solution, contributing to the advancement of transfusion medicine in diverse healthcare settings.***

Keywords: Automated blood separation; Blood components; Quality control

1. Introduction

Blood component separation is a vital process in transfusion medicine, ensuring the availability of safe and effective blood products [1]. Traditional manual methods for separating blood components are time-consuming, prone to errors, and lack consistency. The introduction of automated blood component separators has revolutionized this field, offering improved efficiency and reliability [1-4]. However, many of these automated systems are manufactured by foreign companies, making them expensive and inaccessible for many blood banks, especially in India [11-12].

The objective of this study is to develop an affordable and efficient automatic blood component separator specifically designed for the Indian market. The Bio Pressmatic Plus, developed by Bioline India, is a promising solution. Unlike other separators, the Bio Pressmatic Plus accommodates various types of blood bags, including double, triple, and quadruple bags, making it versatile and cost-effective.

The Bio Pressmatic Plus incorporates a specialized sensor assembly consisting of strategically positioned sensors, The pressing mechanism exerts controlled pressure on the blood bag, aiding in the separation of different components. The sensors accurately detect and segregate specific components, ensuring precise identification.

The sensor array utilizes light-emitting diodes (LEDs) to emit specific wavelengths of light. Advanced analog filtering techniques are applied to remove unwanted noise, resulting in a clean and refined signal for analysis. This filtered signal is then converted from analog to digital form for further processing.

Moreover, the Bio Pressmatic Plus includes a plunger mechanism that enhances the separation process within various blood bags. This mechanism applies controlled pressure, aiding in the effective separation of different blood components. The outcomes of this research hold significant implications for transfusion medicine by optimizing blood component separation processes.

2. Background & Related Work

Blood component separation plays a vital role in modern medical practice, offering significant benefits in addressing blood product shortages. This approach enables the utilization of a single unit of whole blood for multiple patients by selectively providing the required components while conserving others. The components include red blood cells (RBCs), platelets, granulocytes, and plasma [5-7]. Conventional blood banks employ centrifugation to separate these components based on their distinct specific gravities, centrifugal forces, duration, and temperature adjustments (table 1). This technique ensures the efficient allocation of blood components according to specific patient needs, maximizing resource utilization and minimizing wastage [8].

Table I: Specific gravity

Sl. No.	Component	Specific Gravity
1	Whole Blood	1.053
2	Plasma	1.08
3	Buffy coat	1.03
4	RBC	1.02

3. Materials and Methods

3.1 Sensor Panel Design

The study aims to design and implement a sensor panel consisting of sensors and photodetectors based on the principle of light transmission. The sensor panel incorporates multiple LEDs specifically for detecting buffy coat, plasma, and red blood cells (RCC). To eliminate noise from the signal, a signal conditioning circuit utilizing a bandpass filter is developed, ensuring a clean and reliable signal.

3.2 Measurement Process

A microcontroller is used to activate leds, initiating the measurement process. The blood bag containing different blood components is exposed to the transmitted light, causing changes in light absorption due to external light interference.

3.3 Flow Control and Separation Process:

The sensor panel also serves to control the speed of the pressing plate, which regulates the flow of blood during the separation process. To prevent mixing of different blood components, a flow control plunger is implemented. Satellite bags are strategically positioned at different locations on the machine: the plasma tray, buffy coat tray, and RCC tray.

3.4 Integration and Monitoring

To facilitate real-time monitoring and control, the system incorporates a liquid crystal display (LCD) and an embedded system. This integration enables continuous monitoring of the separation process, providing essential information and feedback

4. Methodology

The methodology employed in this study focuses on utilizing the Bio Pressmatic Plus system for blood component separation. The experimental setup involves securing the tubing for plasma, red blood cells (RBC), and Buffy coat (BC) in their respective clamps.

The separation process begins by exerting pressure on the pressing plate, initiating the flow of plasma. A photocell, positioned regulating the outflow of plasma. The plasma, with its lower viscosity compared to packed red cells, flows faster, causing the buffy coat layer to move upwards. This process ensures the gradual flattening and optimal positioning of the buffy coat layer in the bag.

Once plasma separation is complete, a dedicated plunger for plasma is clamped along with the flow control plunger. Simultaneously, plunger for RBC is unclamped, enabling the passage of RBC through the plunger into another satellite bag.

The Bio Pressmatic Plus system incorporates a sensor-based control system that ensures precise management of blood component separation. By utilizing photocells and flow control plungers, the system enables accurate regulation of plasma outflow and optimal positioning of the buffy coat layer. This sensor-based automation enhances the efficiency and accuracy of the blood component separation process.

To summarize, the methodology employed in this study utilizes the sensor-based control system of the Bio Pressmatic Plus for efficient blood component separation (FIGURE 1). By employing flow control plungers and photocells, the system achieves precise regulation of plasma outflow and ensures the optimal positioning of the buffy coat layer. This automation advancement enhances the accuracy and effectiveness of blood component separation processes.

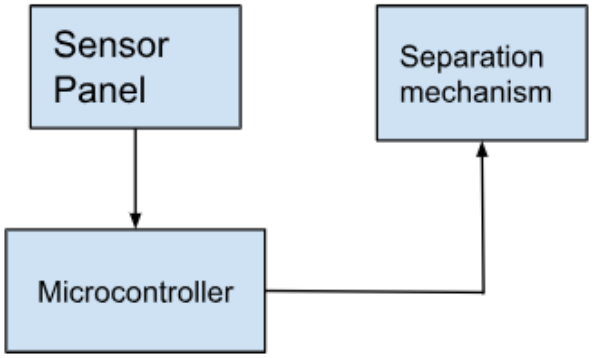

Figure I

5. Absorption Analysis of Led in blood Parameters

In this study, we conducted an analysis to determine the suitability of an LED for detecting blood parameters through absorption. Previous research has indicated that shorter wavelengths have limited penetration into the blood bag, while longer wavelengths.

To quantify the absorption of specific blood components at different wavelengths, we utilized the Beer-Lambert Law. This law states that the absorbance of a substance is directly proportional to its concentration and the path length of the light passing through it. To calculate the absorbance (A) of a blood component at a specific wavelength (λ), we used Equation (1), where C represents the concentration of the absorbent and L represents the optical path length.

$$A = C * L \quad (1)$$

When dealing with a mixture of blood components, we employed Equation (2), which states that the absorbance of the mixture is the sum of the absorbances of its individual components. In this equation, [C1] and [C2] represent the unknown concentrations of component 1 and component 2, respectively, while ελ1 and ελ2 represent the extinction coefficients of component 1 and component 2 at the given wavelength [13].

$$A = C1 * L + C2 * L \quad (2)$$

By applying these principles and equations, we aimed to determine the absorption characteristics of blood components using LED. This analysis is crucial in evaluating the LED's effectiveness for detecting various blood parameters accurately.

6. Conclusion

In this research paper, we introduced the Bio Pressmatic Plus, an automated blood component separator that employs a sensor panel assembly for improved efficiency and accuracy. The sensor panel assembly, consisting of sensors positioned along the blood bag.

Our experimental setup involved the use of LEDs as the light source and a phototransistor to measure changes in transmitted light.

The system's flow control plungers provide precise control over the separation process. Integrated photodetectors regulate the outflow of plasma, ensuring optimal extraction of plasma, buffy coat, and red blood cells. This sensor-based control system, along with automated flow control plungers, significantly improves the efficiency and accuracy of blood component separation.

Overall, the Bio Pressmatic Plus system represents a notable advancement in automating blood component separation, providing a reliable and efficient solution for healthcare professionals. By integrating sensor-based control, precise flow regulation, and absorption analysis, this system offers improved accuracy, enhanced efficiency, and better patient care in the field of blood component separation.

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