Available online at www.sciencedirect.com

SciVerse ScienceDirect

Procedia Engineering 47 (2012) 647 – 650

Procedia Engineering

www.elsevier.com/locate/procedia

Proc. Eurosensors XXVI, September 9-12, 2012, Kraków, Poland

Automatic Electronic System to Human Blood Typing

S. Pimenta[a]*, J. M. Nobrega[b], F. M. Duarte[b], G. Minas[a], F. O. Soares[a]

[a]*R&D Centre Algoritmi, University of Minho, Campus de Azurém, 4800-058 Guimarães, Portugal*
[b]*I3N/IPC Institute for Polymers and Composites, University of Minho, Campus de Azurém, 4800-058 Guimarães, Portugal*

Abstract

Blood typing is a crucial test before a blood transfusion and it can be critical, especially in emergency situations, due to the patient condition. Moreover, blood transfusions based on the universal donor (O^-), or on the wrong blood type, may risk the patient's life. For that, in this research the main principles to the development of a miniaturized, low cost, portable and automatic system to human ABO-Rh blood typing and based on a spectrophotometric approach are presented. This system will reduce some limitations of the existing methods to human blood typing.

Keywords: Blood Typing; Electronic System; Spectrophotometric Approach.

1. Introduction

Human blood type is defined by the antigens presented in the red blood cells' surface. The most important blood groups are the ABO and Rh blood systems [1]. The ABO blood system is classified by four blood types: A, B, AB and O. A person with an A blood type has type A antigens in the red blood cells, and type B antibodies in the plasma. Someone with a B blood type has type B antigens and A antibodies [1, 2]. The plasma has always the natural antibody which matches to the antigen that is missing in the red blood cells [1]. Thus, the AB blood type does not have any type of antibodies in the plasma and the O blood type has the types A and B antibodies. The Rh blood system is classified as Rh positive, if type D antigen is present in red blood cells' surface; or Rh negative, if the same antigen is missing [1, 2]. If someone loses a large quantity of blood, he/she needs to be immediately regained with a blood transfusion. Blood typing has a vital contribution to the success of this procedure. However, this test can

* Corresponding author. Tel.: +351 253 510 180; fax: +351 253 510 179.
E-mail address: a52567@alunos.uminho.pt.

doi:10.1016/j.proeng.2012.09.230

be critical, especially in emergency situations because sometimes, due to the patient condition, there is no time to determine the person blood type. In these situations blood is administered under the principle of the universal donor, which offers less, but still a tiny risk of incompatibility to the receptor [1, 2]. Today, there are multiple tests (manual or automatic) to determine the blood type. However, all of them have some limitations as: the subjective of the manual tests and the impossibility in obtaining results in a short time with the automatic systems [3]. For that, the aim of this research is the development of a miniaturized, low cost, portable and automatic system to human blood typing. The system will be able to determine ABO and Rh blood types in a short time and in-situ, which is suitable for emergency situations and allows the blood typing outside a conventional clinical laboratory, i.e., near the patient. In addition, the system decreases human error and the subjectivity of manual tests, due to its automatic procedures.

2. System Design and Implementation

The work developed takes into account the validation of a spectrophotometric protocol to be applied in the system. Moreover, the steps to the miniaturization of the device are presented, in particular the specification of all electronic components that will be used in the prototype. Finally, the implemented system is presented.

2.1. Validation of the test protocol

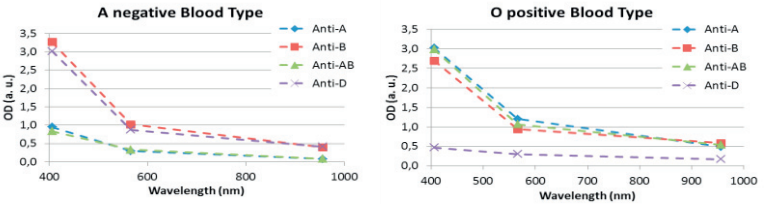
In a previous study [4], the authors validated a simple experimental protocol to be applied in the automatic system, based on a spectrophotometric approach and in the presence of agglutination, i.e., antigen-antibody interaction. The tests were performed in a custom-made system based on a commercial tungsten light source, a monochromator and a photodiode measuring device (S1336-5BQ from *Hamamatsu*). The validated protocol uses blood samples and commercial antibodies as reagents (Anti-A, Anti-B, Anti-AB and Anti-D from HosLab Diagnostic). For each blood sample, four test samples need to be prepared, by mixing blood with a specific antibody. The quantity of blood must be approximately a quarter of the antibody quantity. Table 1 shows the eight possible blood types considering the two situations: agglutinated samples, if there is antigen-antibody interaction; or non-agglutinated samples, if there is no interaction. The optical density (OD) spectra of the test samples were then measured in the range 400 nm to 1000 nm. As the OD spectrum obtained is affected by the type of sample (agglutinated or non-agglutinated), it is possible to determine human blood type.

Table 1. Types of samples obtained by mixing a ABO-Rh blood types with a specific reagent (antibody) – X: agglutinated sample.

Blood type	Reaction with:			
	Anti-A	Anti-B	Anti-AB	Anti-D
A positive	X		X	X
A negative	X		X	
B positive		X	X	X
B negative		X	X	
AB positive	X	X	X	X
AB negative	X	X	X	
O positive				X
O negative				

2.2. Miniaturization and specification of the experimental system

A dedicated light source system, using standard Light Emission Diodes (LEDs) in specific wavelengths, was then studied and designed, avoiding the use of a light source and a monochromator. Thus, it was chosen a group of LEDs with emission peaks in specific wavelengths ranges - 400 nm to 430 nm, 530nm to 575 nm and higher than 750 nm - in order to increase the spectral differences between agglutinated and non-agglutinated samples. For that, it were chosen three standard LEDs with specifics features: peak emission at 406 nm, 566 nm e 956 nm, low consumption, high efficiency, tight band width and emission angle, low cost and small dimensions. Test samples were prepared by the application of the test protocol previously validated [4]. After that, spectrophotometric measurements were performed (ten samples, n=10). The results obtained, Fig. 1 and Table 2, allowed concluding that the proposed system is appropriate to determine ABO and Rh blood types, once it can be seen the spectral differences between non-agglutinated and agglutinated samples, which are in accordance with the theory [5].



(a) (b)

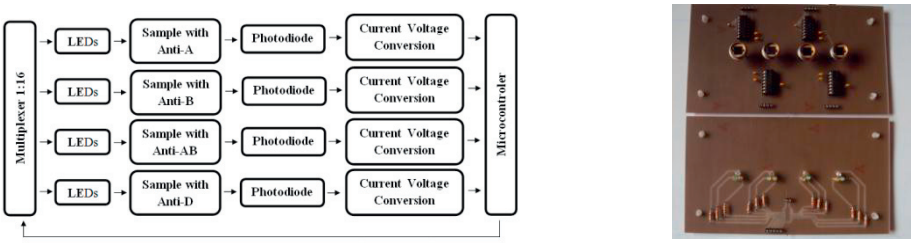
Fig. 1. (a) Discrete values of OD of A negative blood type in the presence of: Anti-A, Anti-B, Anti-AB and Anti-D; (b) discrete values of OD of O positive blood type in the presence of: Anti-A, Anti-B, Anti-AB and Anti-D.

Table 2. Mean Variation of OD values in non-agglutinated and agglutinated samples, for ten samples (n=10).

	Mean Variation of OD (a. u.)	
	406 nm - 566 nm	566 nm - 956 nm
Non-agglutinated samples	2.0136	0.5546
Agglutinated samples	0.4433	0.1167

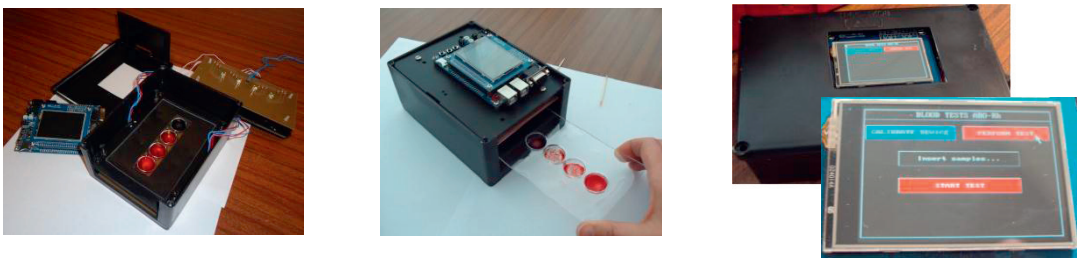
2.3. System Specification and Implementation

Fig. 2 (a) shows a block diagram of the implemented system. The prototype accommodate four test samples (one for each reagent: Anti-A, Anti-B, Anti-AB and Anti-D). Four groups of three LEDs need to be used. A low-voltage 16 channel multiplexer with specific features, ADG706 from *Analog Devices*, is chosen to select which LED is working. A photodiode is selected to be used as a light detector, to produce an output current proportional to the light intensity received. The photodiode spectral response range must include the LEDs emission peaks. Thus, a *Hamamatsu* model is chosen (S2386-8K) with features suitable to analytical instruments. For the conversion of the photodiode current into a voltage that fits the microcontroller analog inputs, the low noise and high precision operational amplifiers (TLC2652CN) from *Texas Instruments*, are chosen. The microcontroller (STM32F103VET6) obtains the voltage values and calculates the discrete OD values, based on the values previously obtained with only the reagents, which set the baseline. After that, the microcontroller interprets the results, and shows, in a display, the blood type. Moreover, the tactile display forms the user interface. Fig. 2 (b) and Fig. 3 show the implemented prototype.



(a) (b)

Fig. 2. (a) Block diagram of the automatic system; (b) System Printed Circuit Boards.



(a) (b) (c)

Fig. 3. (a) Implemented system components; (b) sample insertion mechanism; (c) implemented system (outside dimensions of the device: 150 mm × 120 mm × 70 mm) and zoom of the user friendly interface.

3. Final Comments

All electronic components were assembled and tests were performed, allowing determining ABO-Rh blood types, in laboratorial environment and with standard known samples. The methodology is based on the plate test protocol and on spectrophotometric measurements. In the near future, the prototype will be tested in clinical analysis laboratories with unknown samples.

Acknowledgements

This work is funded by FEDER funds through the "Programa Operacional Factores de Competitividade – COMPETE" and by national funds by FCT- Fundação para a Ciência e a Tecnologia, project reference FCOMP-01-0124-FEDER-022674.

References

[1] Rod S, Tate P, Trent S. *Anatomia & Fisiologia*. 1st ed. Lisboa: Lusodidacta; 2001.

[2] Hoffbrand AV. *Fundamentos em Hematologia*. 4th ed. São Paulo: Artmed, 2004.

[3] Malomgré W, Neumeister B. Recent and future trends in blood group typing. *Anal Bioanal Chem 2009*; **393**: 1443–1451.

[4] S. Pimenta, G. Minas, F. Soares. Spectrophotometric approach for automatic human blood typing. 2nd Portuguese BioEngeneering Meeting, Coimbra, Portugal, 23-25 February 2012.

[5] Nonoyama, Akihisa, et al. Hypochromicity in red blood cells: an experimental and theoretical investigation. *Biomedical Optics Express* 2011; **2:** 2126-2143.