Making of a microfluidic device in paper using brown coloring pencil for didactic application

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Abstract: *This work describes the making of a microfluidic paper-based device (μPAD) using brown coloring pencil as a cheap and accessible alternative material for the production of hydrophobic barriers with detection by capture of digital images [3] using scanner and the didactic application of this method for determination of iron in medicines. The results were compared with μPAD made with wax printer and spectrophotometric method as reference.*
Key-Words*:* μPAD, Brown coloring pencil, iron, scanometry.

Introduction: The making of microfluidic systems can be driven using different platforms, including paper-based platform. This kind of device was introducted in 2007 by professor's George M. Whitesides Martinez group of research and it's the most widespread due to the advantages of this kind of material [1,2]. The making of the μPAD involves the using of hydrophobic barriers to define the region where the solution will be transported [1].
In this work the use of Brown coloring pencil was studied as an alternative and cheap material for the construction of the hydrophobic barriers in paper-based analytical devices (μPAD) with detection made by digital images and didactic application of determination of iron in medicines. The method is based on the reaction of iron (II) with 1,10-fenanthroline with the formation of a coloured complex with maximum absorbance in 510nm. The results were compared with μPAD made with wax printer and with the spectrophotometric method.

Experimental: 15mm-diameter circles were drawn using Brown coloring pencil in qualitative filtering paper cutted at A4 size, then recieving termical treatment in laboratory oven (100°C for 2 hours). The same procedure was repeated using wax printer, but the thermical treatment was different (100°C for 2 minutes in the kiln). Standard solutions of iron were prepared for the construction of the analytical curve from 0 to 16 mg L^{-1} of iron. The medicine sample containing 40mg of iron each tablet (sample A) was treated this way: 10 pills were individually weighted and macerated, then the average of one single pill was weighted and swelled to 1000mL. 20μL of each one of the standard solutions and the sample were taken and dropped in the circles, and after drying, the spots were scanned. Using an appropriate software (ImageJ), it was possible to separate the intensities of the colors of the RGB system [3], which compound the digital image. An analytical curve was obtained by using the value of the channel "green" (G) and for the sample was determined the quantity of iron in each tablet.The quantity of iron was also determined by spectrophotometric method.
Results and discussion: After the data treatment of Figure 1 by the software ImageJ, the analytical curves of iron had been constructed and are shown in Figures 2, 3 and 4. The interpolation of sample A analyzed (40mg Fe/tablet) provided the values listed in Table 1.

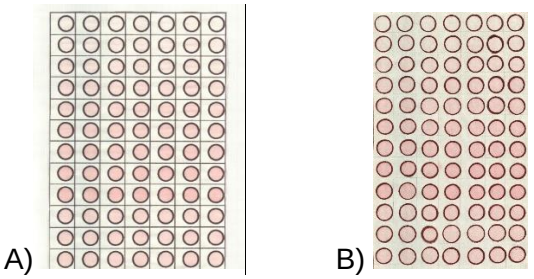

Fig. 1: Image captured by a scanner of the μPAD made with wax printer (A) and brown coloring pencil (B)

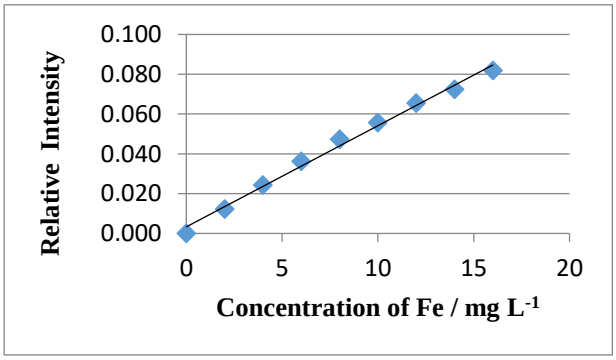

Figura 2: Fig. 2: Analytical curve of Iron in μPAD made with wax printer. Equation Ir = 0.0051.C + 0.0033; R^2 = 0.993.

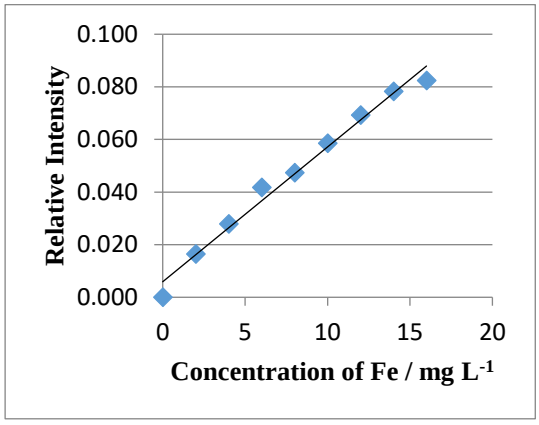

Fig. 3: Analytical curve of Iron in µPAD made with coloring pencil. Equation Ir = 0.0051.C + 0.0059; R^2 = 0.985.

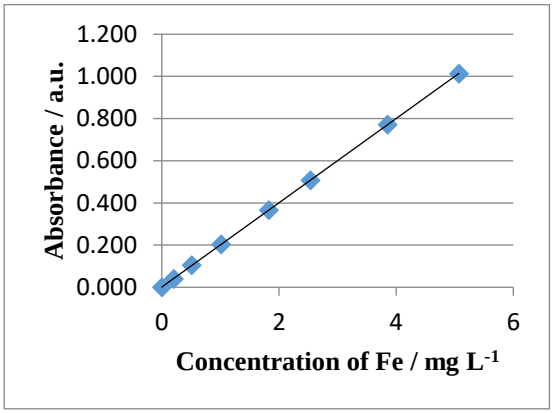

Fig. 4: Analytical curve of Iron in Spectrophotometer at 510nm, used as reference method. Equation Ir = 0.1998.C + 0.0009; R^2 = 1

Table 1: Iron determination in pharmaceutical formulation obtained by the three methods

Method	**Amount of Iron for tablets[a] / mg tablet^{-1}**	**t value (2.365)[b]**
Wax printer	42.2 ± 0.4[c]	1.166
Coloring pencil	39.3 ± 2.0[c]	1.557
Reference method[d]	40.0 ± 0.1[c]	-

(a) Sample A: Label value: 40.0 mgtablet^{-1} (b) Theoretical values of t at 95% confidence level
(c) Average ± standard deviation (SD) of three independent analysis; (d) spectrophotometric

It was possible to conclude, by the Student-t test, that there is no significant difference between the results obtained, once both of the t values calculated are smaller than the tabulated value, showing that the µPAD technique with wax printer and the one with coloring pencil are as reliable as a spectrophotometric method.

Conclusion: The comparison of the results takes us to conclude that the obtained results with µPAD made with wax printer and coloring pencil are statistically similar to the spectrophotometric method, showing that the alternative method (brown coloring pencil at the construction of hydrophobic barriers and detection by digital images) is an accessible and cheap alternative for didactic application with the substitution of the spectrophotometer and the wax printer without losing confiability.

References and acknowledgements:

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