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Completely Lab-Build flow injection System supplied with Combined Fluorometer and Photometer

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Abstract

A dull detectors, Fluorometer and photometer, were constructed from simple available components. This lab build detector was supplied with two microcontrollers and joined with flow injection system. The proposed system was successfully used to determine fluorescein and methylene blue by changing the angle from 90 to 180 respectively. The obtained results clearly indicated that system is simple, inexpensive, easy to use and can be used in educational laboratory.

Keywords: Lab-made fluorimeters, photometer, 3Dprinter, Flow injection, Fluorescein, Arduino.

1. Introduction

This work relates to a method for using an open-source, with aid of a 3-D printer and affordable separated parts available in local markets to fabricate analytical instruments and systems [1-6]. It is a unique approach to design and build up dual Fluorometer and photometer detectors and joined with a flow injection system [7-10]. Michelle et .al. was reviewed in detail the recent student-built spectroscopy instrumentation projects which clearly indicated that intensive work was done in this field[11]. Due to Increasing in student numbers in the chemistry department and the shortage of new sophisticated instrumentation in the laboratories which unfortunately cannot be offered[12-14]. Recently many papers were published from our laboratory dealing with design and build-up different instruments and systems[15- 19].
Al-Balaawi[20] had been designing a special homemade filed photometer unit to measure some nutrients in Basrah water. Namea and Al-Sowdani[21], also design a homemade Fluorometer detector for the flow injection system. So thought, it can be simply designed and built up a Fluorometer and photometer as dual detectors for the flow injection system. This approach is a good alternative to be used in education institute laboratories with low income in developing countries.

2. Experimental

2.1 Chemicals

During analytical application with proposed system deionized distilled water was used throughout and all reagents employed were analytical grade unless otherwise stated .Value of measurements as peak height was the average of three successive measurements. A stock fluorescein dye ($C_{20}H_{12}O_5$,M.Wt 332.31 g.moL^{-1}) solution of 0.01 M was prepared by dissolving 3.321 g of fluorescein in 1000 ml of distilled water, then a series of concentrations were prepared through serial dilution[22]. Where 0.01 M of methylene blue was prepared by dissolving (3.199 g) of methylene blue (FLUKA) in (1000 ml) of distilled water, then a series of concentrations were prepared through serial dilution[23].

2.2 Instrumentation

The figures (1-3) show the fully lab-build flow injection system supplied with Combined Fluorometer and Photometer detector which consist the following components;-

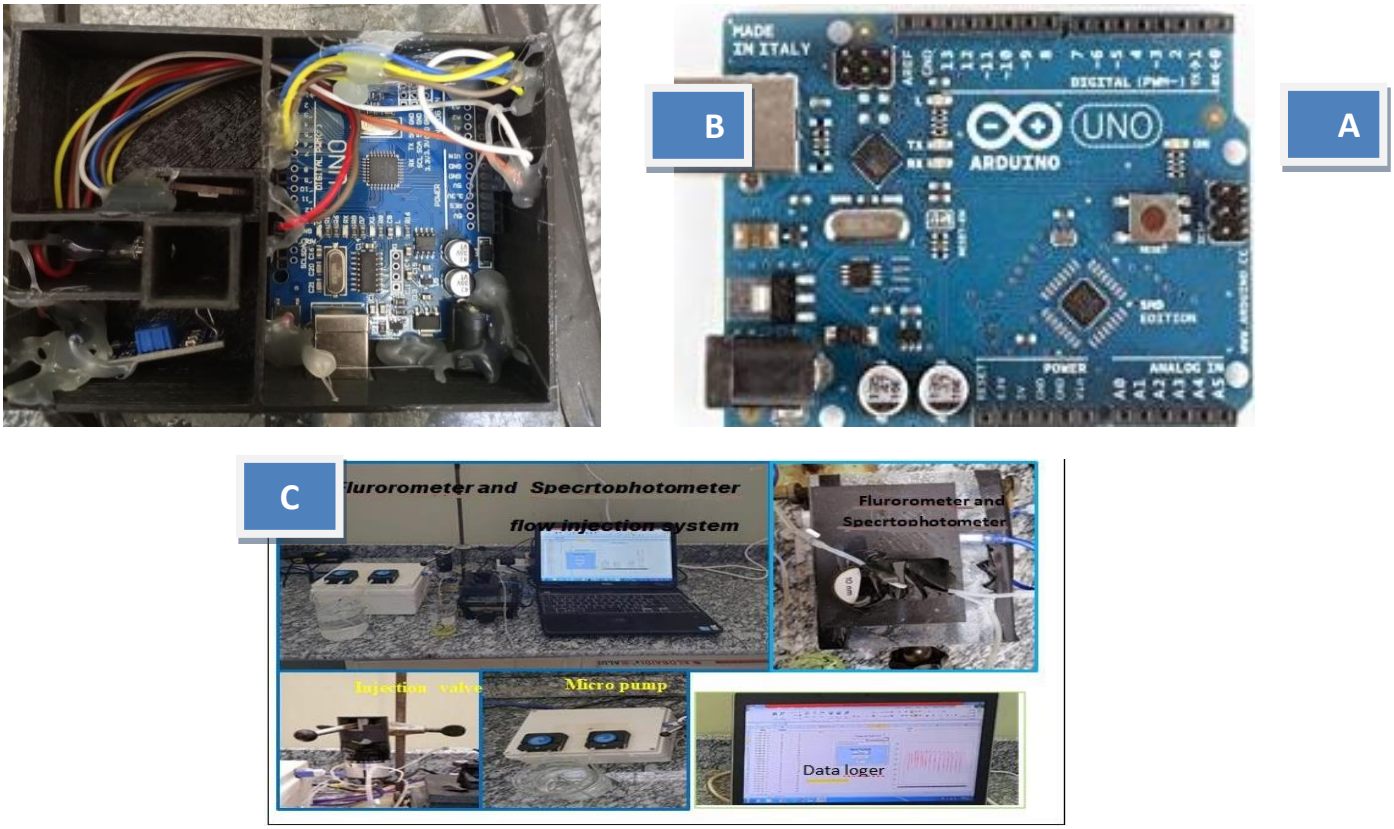

Fig.1. A. The components of the Lab build system, B. The Arduino Mega microcontroller (Data logger) and C. The lab build system.

a. Mini lab made peristaltic pump, which was manufactured from the parts shown in figure (2). It is provide a flow rate in the range 2.0 – 12 mL. This mini pump was controlled by Uno microcontroller, which interface with PC through a homemade software (20) through the face of the program (Fig. 3) which line up locally.

Fig. 2. The comonnents of mini lab made peristaltic pump.

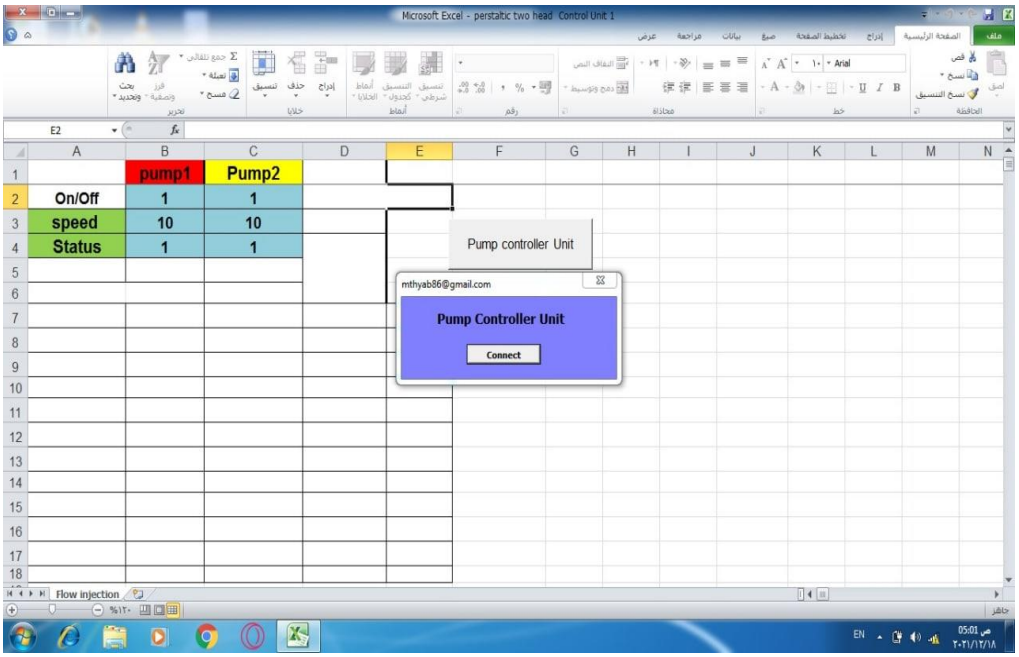

Fig. 3. Front view of the home made program view.

b. Injection valve (RHEODYNE, Catati California) supplied with home- made variable loops (15-35 µl) was used to inject 25 µL from the fluorescein or methylene blue.

c. The dual detectors **(**Fluorometer and Photometer)was built from the following parts :

i. Ultra violet and RGB sources were used for Fluorometer and Photometer respectively.

ii. The sample container was 450 µL volumes flow cell (Hellma GmbH & Co.) with four faces to easily arrange the correct angle. 90 ° or 180° for measuring the florescence or absorption respectively.

iii. LED emitting detector (20) was utilized to measure each of florescence or absorption. The signals, which were processing to PC throughout Arduino Mega microcontroller (Italy). This microcontroller is work as a data logger to convert the analog signal to digital one. Also, the PC supplied with a homemade software (single to peak) to convert the signal to peak (Arduino-MegaItaly). The peak height is corresponding to the concentration of fluorescein or methylene blue. The PC was supplied with Excel 2010 to record these peaks.

iv. The constructed system also, consist other simple accessories, which are very important to join the different components of this system. In order to minimize the size of the manifold, (figure4) the rest of the manifold and the mixing coils were made from a 0.2 mm i.d. tube[21-23].

v. All these parts were housed in one compact a small plastic box which fabricated by aid of 3D printer .The internal and external covers for this plastic pox were made from black plastic which thought to prevent the unwanted light from reaching the detector. The device is very lightweight (165.5 g) and box dimensions were 11cm in length, 8cm in width, and 3cm in height.

3. Methodology

Figure 4.A shows the manifold, which is used to measured thefluorescein or methylene blue. A25µLfrom the sample was injected in deionized distilled water, which was used as a carrier stream. The fluorescence or absorbance was measured when the sample zone pass through the flow cell by choosing the right angle for measurement from the face of the program (Fig.4. B).The measured signal was recorded as a peak height which corresponding to the concentration of the injected sample.

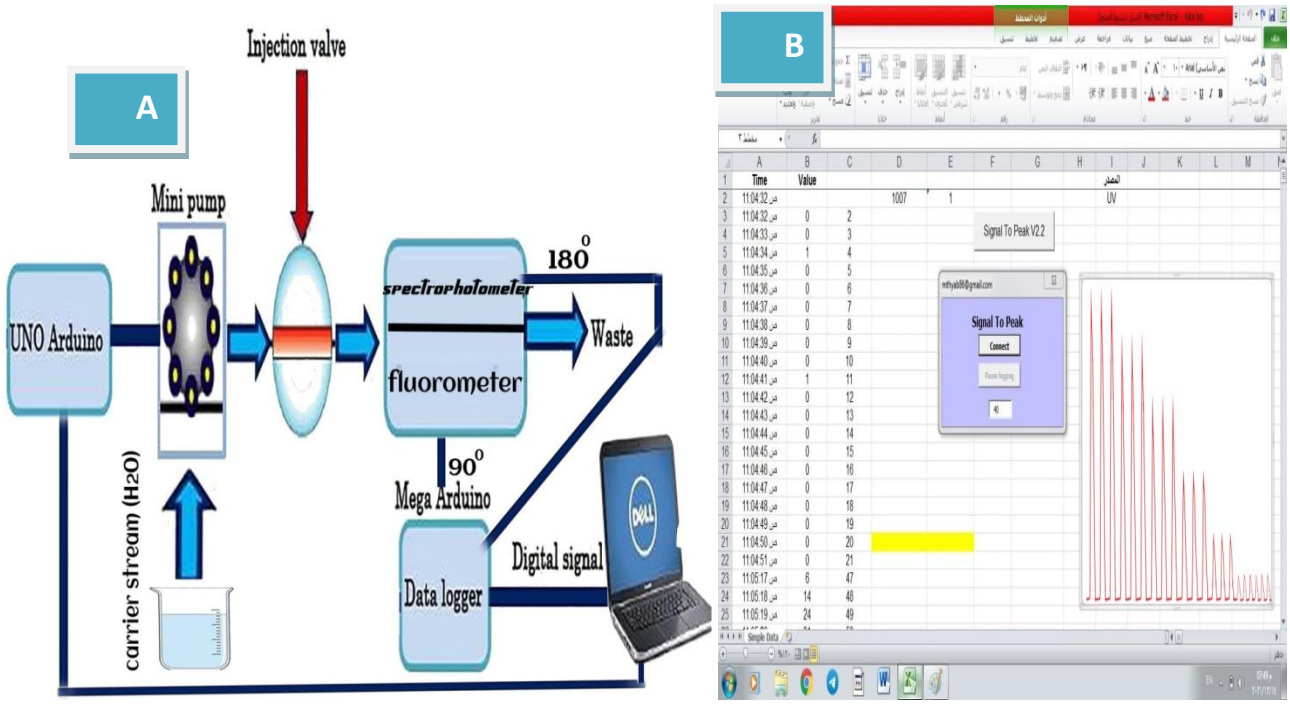

Fig.4. A.The manifold B.The obtained data and peaks.

4. **Results and Discussion**

4.1 Optimum conditions

By using the manifold shown in figure (4.A) the optimum conditions for determination of fluorescein and methylene blue by the lab made Fluorometer and photometer respectively were established. Table1 lists these results.

Table (1): The optimum conditions for determination of fluorescein and methylene blue by the lab made Fluorometer and photometer respectively.

Parameter	Values for	
	Fluorescein[1]	methylene blue[2]
Flow rate (mL/ min)	3.2	3.2
Sample volume(µL)	27	18
Mixing coil length (Cm)	10	10

1 and 2 the concentrations of Fluorescein and methylene blue which are $3x10^{-5}$ mol/L and $1X\ 10^{-4}$mol/l respectively.

3.2 **Calibration curves for fluorescein and methylene blue.**

Under the established conditions a corresponding calibration graph for fluorescein determination was obtained(Table 1) . Linearity was found in the range (1-8)x10^{-5}mol/L) and the regression coefficient was 0.9987 as shown in Table(2) and Fig 5.A and B . The repeatability was studied via measurements r.s.d% for the eight replicates was ± 0.88% as shown in Fig 5(c).and detection limit was 8×10^{-6} mol/L.The sample throughput was 180 samples per hour. The dispersion coefficient of the manifold (Fig. 4A) was 1.1as shown in Fig (6).

Table (2) Concentration values and peak heights (mm) for fluorescein

Peak height (mm)	Conic (mole/L)
10	$1x10^{-5}$
19	$2x10^{-5}$
41	$4x10^{-5}$
60	$6x10^{-5}$
78	$8x10^{-5}$

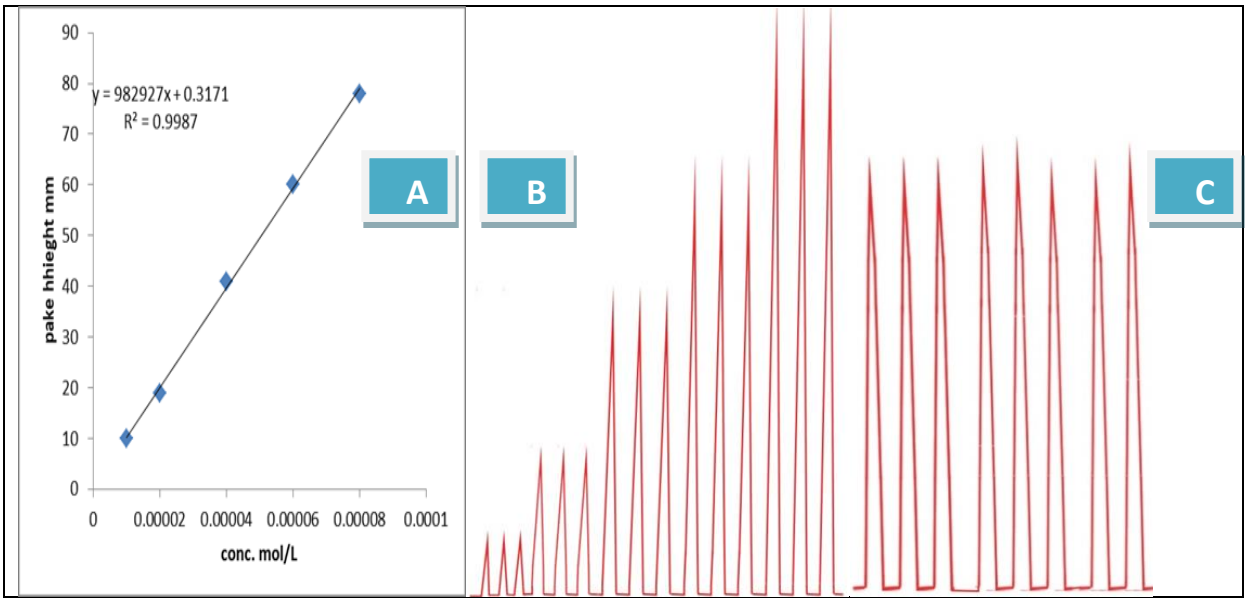

Fig.5A.The calibration graph B. The corresponding peaks and C. the reproducibility of eight replicate peaks for fluorescein

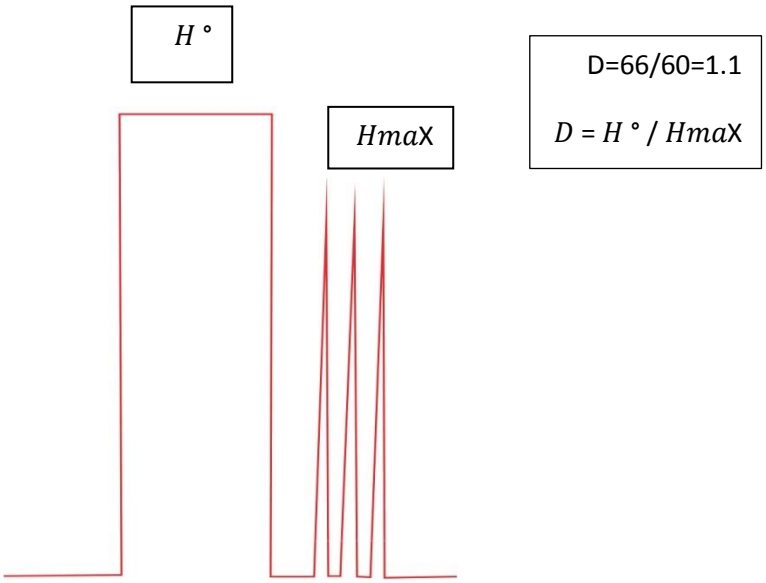

Fig 6. The dispersion coefficient measurement of fluorescein

By using the optimum conditions listed in Table1the methylene blue was determined the and the calibration curve for determination of methylene blue was set up. Linearity was found in the range (0.2-1) x10^{-4} mol/L) as shown in table(3) and Fig 7(A and B) with regression coefficient of 0.9996.The repeatability was studied via measurements r.s.d% for the eight replicates was ± 0.88% as shown in Fig 7 (c). And detection limit was 2×10^{-5}mol/L. The sample throughput was 180 samples per hour and the dispersion coefficient of the manifold (Fig. 4A) was 1.153as shown in Fig.8.

Table(3) Concentration values and peak heights (mm) for methylene blue .

Peak Height(mm)	Conic(mole/L)
10	2x10^{-5}
21	4x10^{-5}
31	6x10^{-5}
41	8x10^{-5}
52	1x10^{-4}

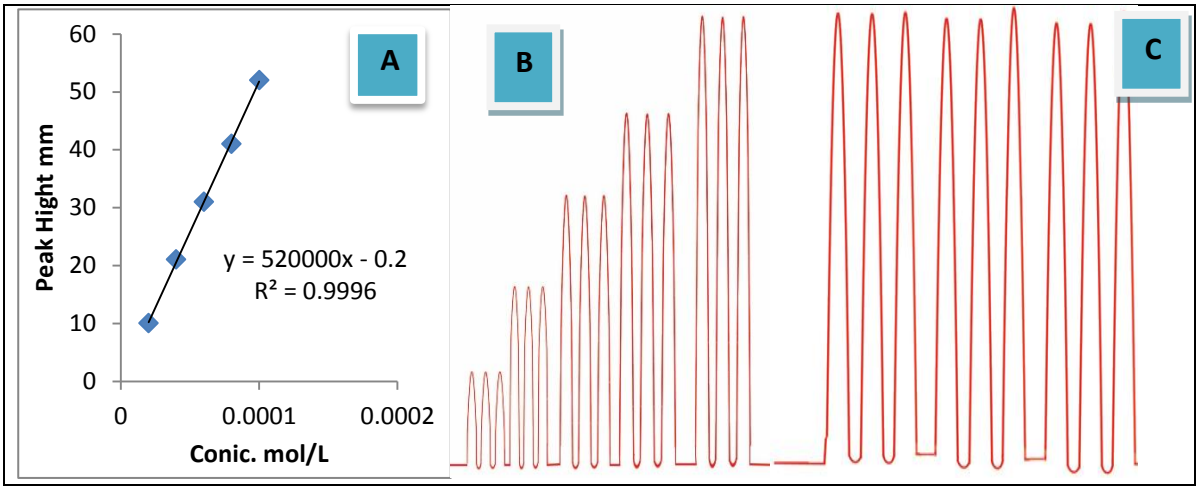

Fig.7. A. The calibration graph B. The corresponding peaks and C. the reproducibility of eight replicate peaks for methylene blue.

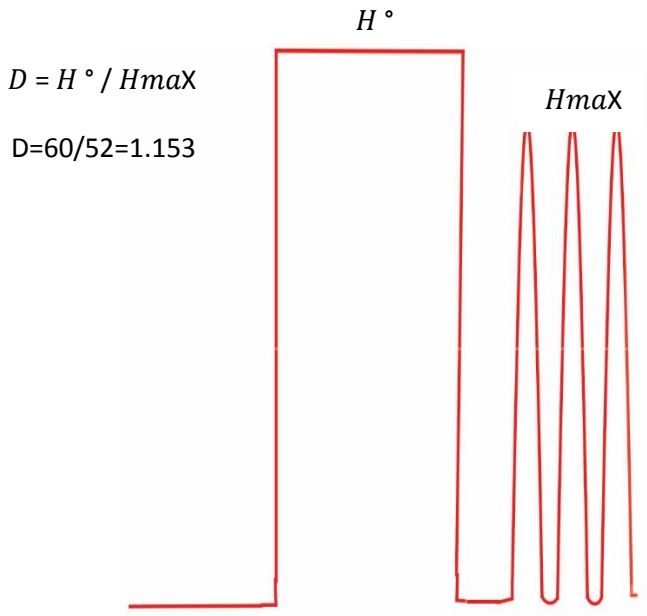

Fig.8. dispersion coefficient measurement of methylene blue.

Conclusion

The Lab-Build combined fluorimeters and photometer as a dual detector can be easily assembled and joined with FI technique .This system was constructing with aid of 3D printer that was used to household all components in one box manufacture from black plastic. It is Also, up to our knowledge this proposed system is for the first time design in university of basrah .In our Advance analytical laboratory, college of education and pure science, Basrah University. This simple, accurate, reproducible

and low cost, systemis able to offer an excellent educational tool to be used in undergraduate laboratory. Itcan be applied successfully for photometric and Fluorometer determination for methylene blue and fluorescein respectively.

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