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Magnesium concentration in medicinal products using the fully controlled inkjet approach

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A R T I C L E I N F O

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A B S T R A C T

The measurement of magnesium ion in homemade ph samples has been designed using a fully automated microfluidic device. This study involved the design of two channel microchips (45 × 3 cm). Arduino mega microcontrollers were used to operate the suggested system. The DIY micro-peristaltic pumping was operated by the first type that was used for remove specimens and chemical agents extracted from the microchip and transfer them to the UV. Visible spect. We are use the apparatus a 7-microliter flow cell in our lab, also the second type called mega, was employed as logger's data to alter, it was received and record the outcomes since highest point corresponding to concentrations using an Office Excel 2016 application. A correlation coefficient (R2) 0.9997 and the linearity varied from 0.5 to 10 µg/mL. Ten measurements of Mg ion 8 µg/mL had a relative standard deviation of (0.872%).

1. Introduction

User correction with a standardized solution called the ethylene di amine tetra - acetic acid was the standard method in determining **magnesium(II)** and other suitable cations ethylene di amine tetra (EDTA)[1]. The EDTA has the structure depicted below figure(1)[2]. Typically, the USP or NF procedures are used to assess pharmaceutical products containing **magnesium**, these methods are use validated titration with the disodium salt of ethylene di nitrile tetra acetic acid (EDTA) using hydroxy naphthol blue as the indicator[3].The science and technology of systems that use microchips with tiny pores that are between tens and hundreds of micrometers in size to process small amounts of liquid (10^{-9}-10^{-18} liters) is known as microfluidics[4-6]. Due to microfluidics are widely and cheap method used to reduce analytical processes because of their many advantages it can be used to control the estimation of many elements in the form of solution , which include using a few amounts of samples and reagents are improving system performance by combining more than analytical processes into one tool [7]. These advantages include high sensitivity and accuracy in detection and separation operations, as well as short analysis times, low costs, and little production waste [8-10]. Total Microanalysis Systems, often known as chip-on-Lab technology, are systems that use very small quantities of liquid to carry out one or more chemical reactions for the purpose of analysis (LOC) [11-13]. Several metal as ions are react with electrons pair donors to form coordination compounds in the molecular or complex ions chemical [14]. The formation of a particulars as class of

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coordination compounds chemical, called chelates, are especially well suited for quantitative methods [15]. A chelate is formed when a metal ions can be coordinates with two (or more) donor groups of a single ligand in the molecular [16] . Tertiary amine compounds chemical such as ethylene di amine tetra acetic acid (EDTA) are widely used for the formation of chelates in more compound like use in analytical chemistry [17-21]. Complexometric titrations with EDTA have been reported for the analysis of nearly all metal ions [22, 23]. Because of the chemical nature EDTA has four acidic protons, the formation of metal-ion/EDTA complexes is dependent upon the ph chemically . For the titration of Mg^{2+} [24]. one must buffer the solution to a pH of 10 so that complex formation will be quantitative. The reaction of Mg^{2+} with EDTA may be expressed as [25-27 ENREF 25]:

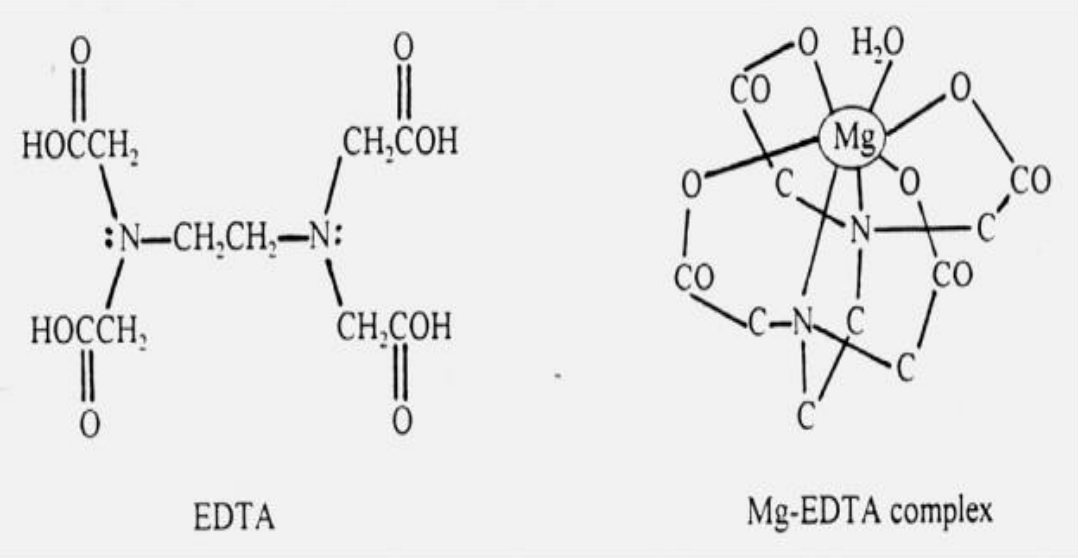


Fig.1. Stricture of EDTA with Mg(II).

Research goal: Create a DIY, entirely computerized capillary system to measure magnesium sulfate in pharmaceutical preparations. Applying EDTA reagent .

2. Materials and Methods

Microfluidic system design for determination of Mg^{+2}

A homemade microfluidic system designed was created to measure magnesium (II) in medications. A 45 µL × 4 cm three-channel micro disc was created, with a 15 µL volume in each channel. This allowed for the use of extremely tiny chemical and sample volumes. A peristaltic pump, which gathers samples and reagents, is controlled by an Arduino type of microcontroller, the first of which is a UNO type. Upon receiving the analog signal from the detector, the second type of mega transforms it into a digital signal and forwards it to the computer processor to draw the peak . The computer processor publishes the digital signal locally and as data in Microsoft Excel 2016.2.2 Solutions and reagents for measuring magnesium (II) in pharmaceutical formulations are prepared. High-purity chemicals of every kind have been employed, along with ion-free distilled water.

1. **magnesium** sulfate ($MgSO_4$) was used to create the standard solution of **magnesium** (II) at a concentration of 100 µg/mL.
2. Added 2ml of ammonium buffer solution chemical and one pinch EBT indicator colour were added in it. The colour of the solution become wine- red on mixing solution.
3. The solution was then titrated with given known strength EDTA solution chemical (taken in the burette) until the wine red colour turns to blue colour.

3. Result and Discussion:

Under the ideal conditions examined, the locally constructed microfluidic system Figure (2) with a wavelength (620 nm) in Figure was utilized to determine the amount of magnesium (II) in

pharmaceutical formulations(3). where the sample is represented by R1, the reagent by R2, and the current carrier liquid by R3.

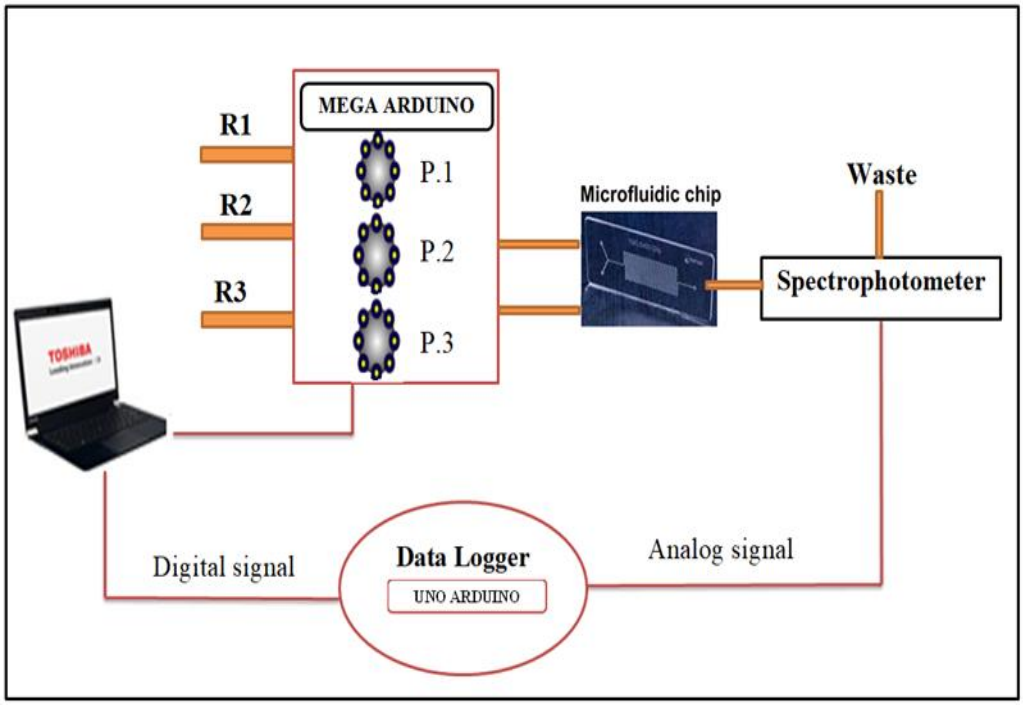


Fig. 2 Microfluidic Device for Magnesium (II) Measurement in Pharmaceutical Compounds

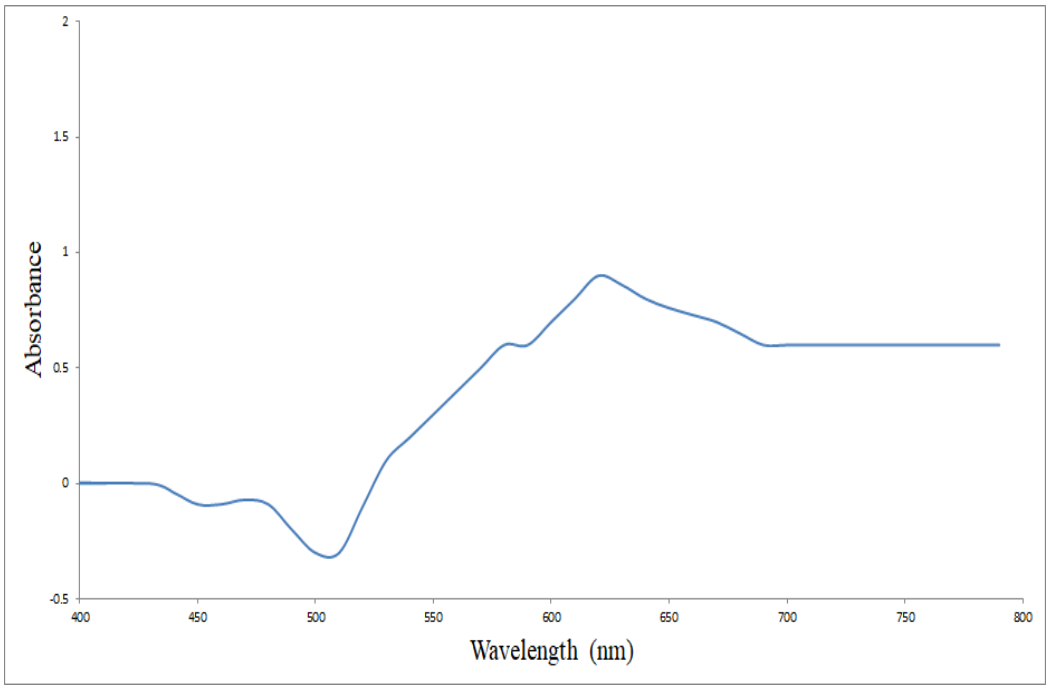


Fig. 3 The maxim wavelength of the MG -EDTA complex

3.1 Ideal Conditions for Magnesium (II) Measurement in Medicines

3.1.1 The effective of the flow rete:

A peak height resulting from Magnesium (II) reaction withdrawal (4 PPM) was tested in relation to flow rate between 0.5 and 3.5 ml/min, since the formation of the resulting complex causes the peak height to drop with higher flow rate table (1) and Figure (4). So, in order to get a quick analysis time and a quick modeling pace, the speed (1 ml/min) was used.

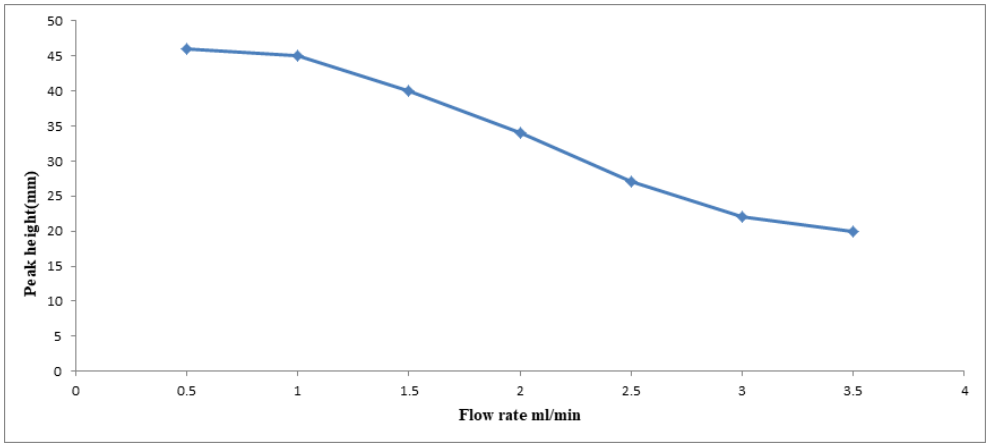


Fig. 4 Impact of flaw rete on peak height following withdrawal of magnesium (II) (4 µg/mL)

Table 1 The flaw's effect injection at the highest point as a result of the removal (4 µg/mL) of Magnesium (II).

Flaw rate (ml/mint)	peak height rate (mmeter)
0.52	46
1.20	45
1.51	40
2.01	34
2.50	27
3.00	22
3.5	20

3.1.2 Slide slit length's impact.

When the length of the slice's incision is increased, a peak height created by pulling away (4 µg/mL) When the slice's incision is extended, magnesium (II) exhibits a discernible rise in height that soon starts to drop within the acceptable range. (1-7 cm) due to the increse in dillution. deciding that the ideal incision length for further research should be 3 cm (Figure 5) and table (2).

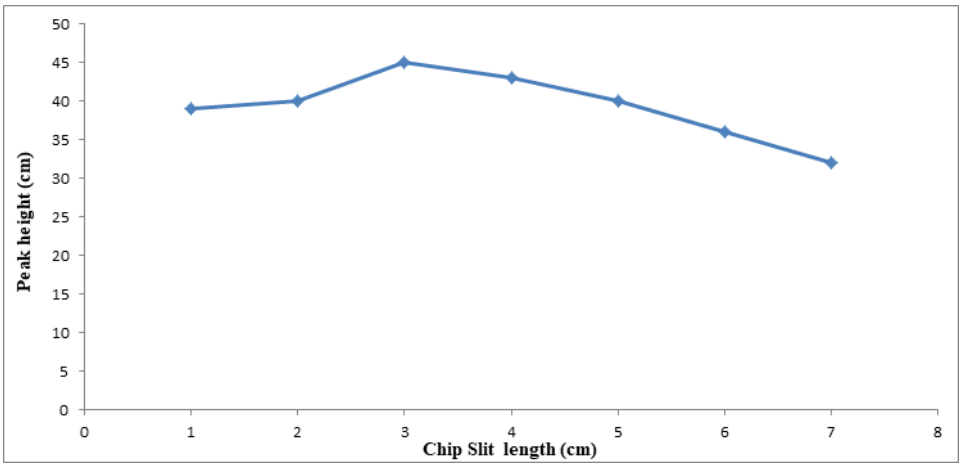


Fig. 5 Impact of the chip slit's length on the height of peak following the removal of 4 PPM of magnesium.

Table 2. The amount of magnesium (4 µg/mL) that is removed determines how long the slice is cut at the top.

Slit length (centimetre)	peak height rate (mm)
1	39
2	40
3	45
4	43
5	40
6	36
7	32

3.1.3 The effect of sample volume:

Upon increasing a sample value within the range of (10-70 µL), a rise Cloud formation at the top (4 %) was observed. This made it possible for the complex to form when the model's size was increased because we determined that the size of 50µ L was the ideal size to investigate other situations. After the reaction slit's length (3 cm) and velocity (1 ml/min) were stabilized, Figure (6) and Table (3) were created.

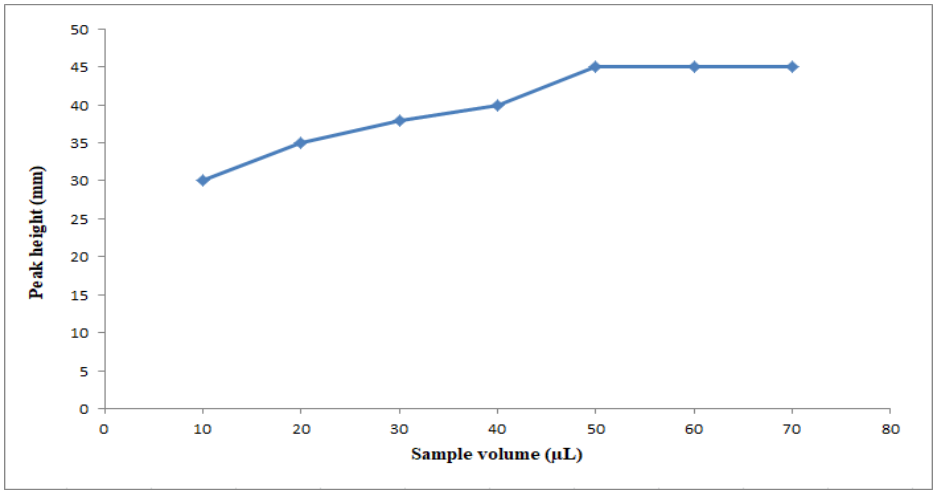


Fig. 6 Influence of quantity of sample on the peak's height following (4 PPM) removal of the Magnesium (II).

Table3: Impact for population of the sample on height of the peak following (4 µg/mL) magnesium withdrawal.

Sample volume (µL)	peak height rate (mm)
10	30
20	35
30	38
40	40
50	45
60	45
70	45

3.1.4 Effect of EDTA reagent concentration:

The fluid flow speed (1 ml/min), amount of sample (50 L), and sheet puncture area were all fixed. a rise in EDTA reagent concentration causes a rise in the highest point brought on by the removal of Magnesium (II) (4 µg/mL) (3cm). In order to use the sample used and the quantity of reagent that was available, the concentration (0.35 %) was selected for further research as soon as the peaks at high detector concentrations that measured began to decline and fell within the range used of (0.04 -0.4%). Figure (7) and table (4).

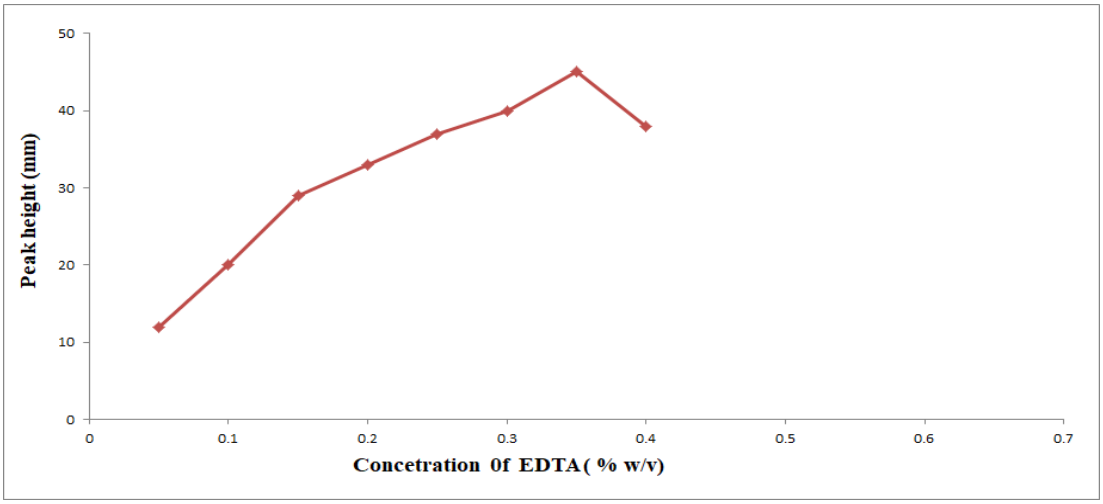


Fig. 7 Effect of EDTA focus on pinnacle ascent brought on by magnesium deficiency (4 µg/mL).

Table 4. Impact of EDTA dosage on withdrawal-induced peaks (4 µg/mL) of Magnesium

peak height rate (mm)	Conce. %
12	0.05
20	0.1
29	0.15
33	0.2
37	0.25
40	0.3
45	0.35
38	0.4

3.1.5 The volume of ammonium buffer solution effect:

Because of the lack of absorption at high acid volumes, when the volume of ammonium buffer solution increases within the range (1–2 ml), the rise in the peak caused by the removal of (4 µg/mL) of magnesium quickly experiences a decline. After adding the following parameters: a 50 µL sample volume, a 1 ml/min flow rate, and a 1.5 cm slide incision length were stabilized, the optimal volume for the study was determined to be 0.5 ml, as shown in Figure (8) and Table (5).

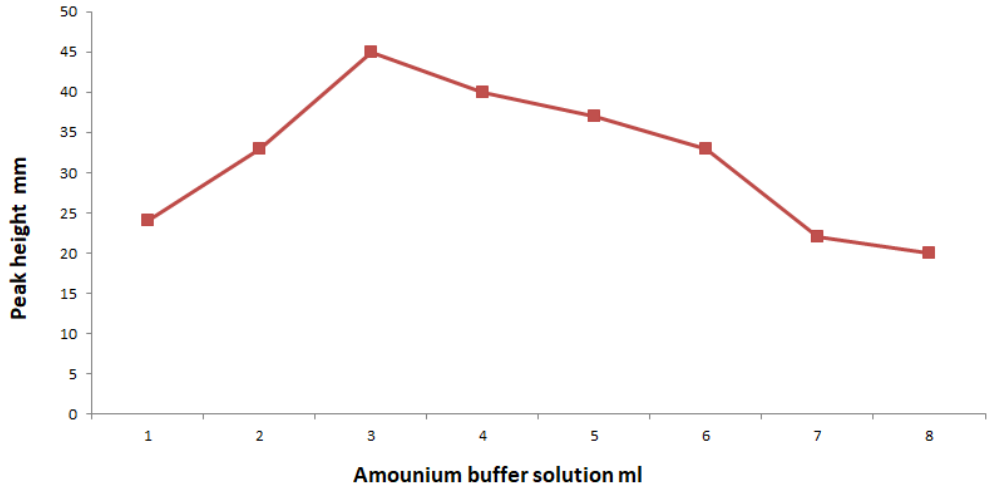


Fig.8. The impact of the Ammonium buffer solution on the highest possible following the removal of four parts per million of magnesium.

Table 5. The impact of NaOH volume on the highest point resulting from the removal (4 µg/mL) magnesium.

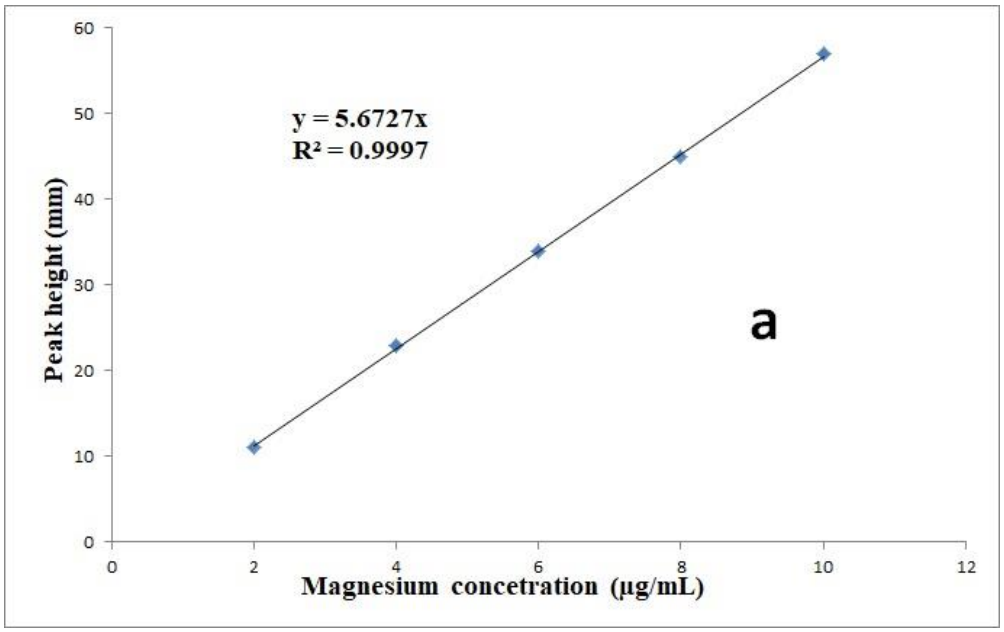
peak height rate (mm)	Volume of NaOH (ml)
1	24
5	33
10	45
15	40
20	37
25	33
35	22
40	20
1	24
5	33

Table 6. Ideal circumstances for measuring magnesium in pharmaceutical formulations.

The value	Factors
1	Flow rate ml\min
2	Ammonium buffer solution
50	Sample volume µL
3	Slit chip length cm
0.35	EDTA concentration w/v %

3.2 A Causal Conventional Circle.

When the ideal conditions were attained and the standard calibration curve for solution was examined as shown in Figure 9.a that used and Table (6) for the completely autologous microfluidic method of measuring **Magnesium** (II) ion in pharmaceutical preparations, the linear relationship within the range of (2- 10 PPM) was discovered for the peaks draw of concentrations magnesium with EDTA shown in Table (7) and Figure 9.a (9.b). In Figure 9.c, the correlation coefficient (R^2) for seven point scan be 0.9997 the result was good in use , the relative standard deviation (R.S.D%) for ten points is 0.872%, and the detection limit is 0.125 µg/mL . y = 5.6727x is an equation that describes the peak height.



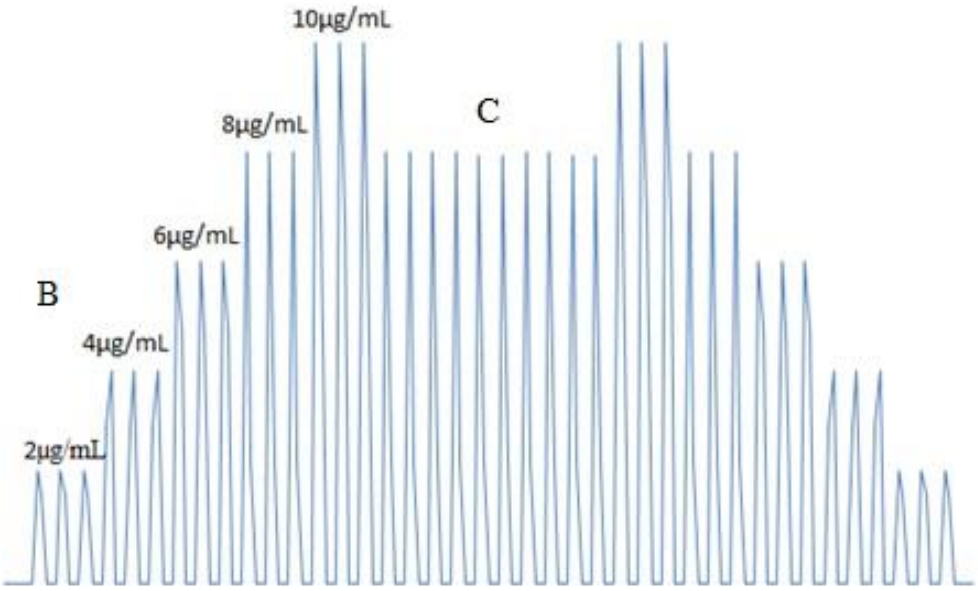


Fig. 9. (a) A curve calibration for the micro measurement of magnesium ions in drugs. (b) For every level, the corresponding magnesium peaks were extracted three times. (c) A peak levels brought about by the removal (8 µg/mL) magnesium

Table 7. The measurements of the calibration curve's peaks.

peak height rate (mm)	Concentration (µg/mL)
11	2
23	4
34	6
45	8
57	10
11	2
23	4

3.3 Distribution:

As shown in Figure (10), a manifold unit of the planned apparatus had a dilution factor of 1.05.

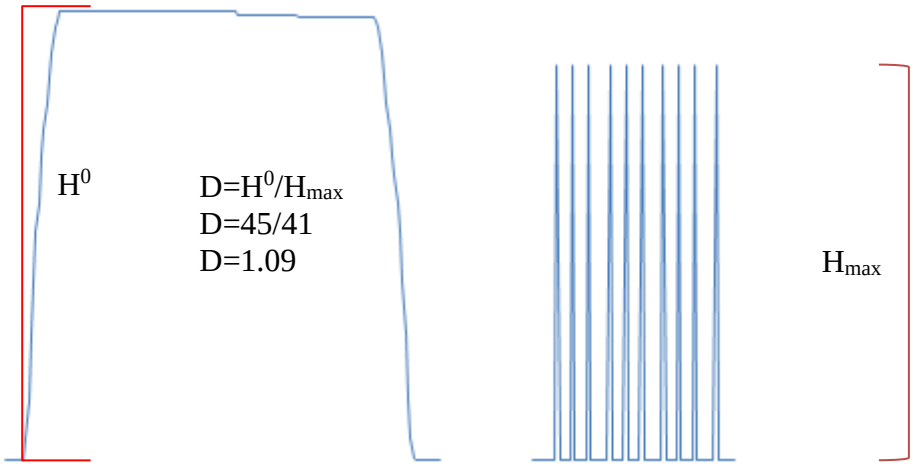


Fig. 10. The magnesium ion determination system's dispersion factor

3.4 Applications in analysis

Four on-site samples from pharmacies in the Basra region were tested using the microfluidic technology intended for measuring magnesium ions in the range 2–10 µg/mL Table (8).

Table 8. Magnesium concentrations in specific drugs.

Sample	Magnesium (ppm)	Total Magnesium (ppm)	Total Magnesium found (ppm)	Recovery %
Tablet 1	**8**	**0.2567**	**0.2459**	**96.86**
Tablet 2	**8**	**1.0389**	**1.0400**	**95.11**
Tablet 3	**8**	**0.1366**	**0.1359**	**95.78**

3.5 Interruptions.

Table 9 may be t shows the peak height that occurs when 8 PPM of magnesium is removed in the presence of 1, 10, 100, or 1000 µg/mL of positive ions Zn, Fe, Cu, Co, Ca and Mn. It was discovered that the majority of ions had no effect on the measurement of magnesium in pharmaceutical formulations within in field using due to stability in the peak's height.

Table 9. Impact of Interferences

Foreign captions (+2)	Peak height m meter			
	Ties up			
	1	10	100	1000
Zn	50	47	42	36
Fe	51	46	40	34
Cu	44	39	32	26
Co	47	41	34	29
Ca	52	44	38	31
Mn	56	53	50	41

4. Conclusions

- To determine the presence of **Magnesium** binary ions in pharmaceutical formulations, we developed For the first time, a fully self-contained microfluidic system using microfluidic chips was used in our university laboratory.
- Making micro-pumps using materials found at the neighborhood market, each of which had a variable speed that was managed by an Arduino microcontroller.
- Using the Mega controller to convert the data provided by the analog signal into simple-to-process digital signals and displaying them in Excel 2016.
- The designed system, which included the use of models and reagents, was environmentally benign in terms of waste disposal due to the ability to use extremely small volumes.

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تركيز المغنيسيوم في المنتجات الطبية باستخدام أسلوب نفث الحبر الذي يتم التحكم فيه بالكامل

احسان عاشور مكشف

قسم الكيمياء، كلية التربية للعلوم الصرفة، جامعة البصرة، البصرة العراق.

معلومات البحث

الاستلام 26 كانون الثاني 2024
القبول 9 حزيران 2024
النشر 30 حزيران 2024

الكلمات المفتاحية

نظام المايكروفلودك وكاشف EDTA وايون المغنيسوم الثنائي

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الملخص

تم تصميم جهاز محلي الصنع لقياس أيون المغنيسيوم في عينات باستخدام نظام ميكروفلوديك مؤتمت بالكامل. تضمنت هذه الدراسة تصميم شرائح دقيقة ذات قناتين (45 × 3 سم). تم استخدام المتحكمات الدقيقة من نوع Arduino لتشغيل النظام المقترح. تم تشغيل المضخات التمعجية الدقيقة كان النوع الأول الذي تم استخدامه لحقن العينات والكواشف الكيميائية التي تخرج من الشريحة المايكروية ونقلها إلى جهاز قياس الأشعة المرئية و فوق البنفسجية. ان الجهاز المستخدم وهوعبارة عن خلية ذات سعة 7 ميكروليتروالموجود في مختبرات قسم الكيمياء، وكذلك النوع الثاني يسمى Mega، تم استخدامه .كمسجل بيانات لتغييرها، وتسجيل النتائج من أعلى نقطة تتوافق مع التركيزات باستخدام تطبيق Office Excel 2016. وكان معامل الارتباط 0.9997 (R2) وتراوحت الخطية من 0.5 إلى 10 ميكروغرام/مل. كان انحراف المعياري النسبي لعشرة قياسات مستخدمة لأيون المغنيسيوم بتركيز 8 ميكروغرام / مل قدره (0.872٪).

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