Determining the Endpoint of Sediment Titrations by Smartphones

Muhaned Mohammed Eteya

Assistant Lecturer, Department of Chemistry, Thi-Qar Education Directorate, Thi-Qar, Iraq.

Abstract

In this research work, we have used the image processing technique for determining the end of sodium sulphate with standard barium chloride in precipitation titration. The white precipitate of barium sulphate produced by the reaction of barium chloride and sodium sulphate was dispersed in deionized water by magnetic stirrer and its images were taken by mobile phone camera. The resulting pictures were analyzed by Photoshop Software which shows that the intensity of magenta colour has maximum sensitivity by changing the mass of barium sulphate. Therefore; magenta colour was selected as the optimum colour. Also, to depict the calibration curve of sulphate anion, different concentrations of sulphate were prepared in buffered solutions and by addition of barium chloride to them, the intensity of magenta colour was calculated. The results show that the calibration curve was linear in the range of 5-75 $mg.L^{-1}$ of sulpahte with a correlation coefficient of 0.973. Finally, by titration of different real samples such as Tap, river and mineral waters containing sulphate anion with standard barium chloride, the variation of magenta colour was recorded and the concentration of sulpahte anion was determined.

Keywords: *Image Processing, Sulphate determination, Precipitation reaction.*

Introduction

Sedimentary Titration: Sedimentary titration is one of the strongest titration techniques, which belongs to the middle the year is 1800 AD. The endpoint in these titrations is based on sudden changes in the physical properties of the solution. There are many method for determining the endpoint in titration method, among which we can mention three common and widely used method. Determining the endpoint by a sudden change in the conduction of voltage or current between two electrodes and the determination of the endpoint is determined visually by changes in the color of the solution made by the detector. And determining the endpoint by changing the absorption of light by titrant or analyte(1). It should be noted, however, that this method does not apply to sedimentary titrations it is essential to select a standard method or method for determining the concentration of ions in solutions.

Hence, for anions such as halides, gravimetric and sedimentation titration method can be used. However, it should be noted that in general, the gravimetric method can be used only when the solution contains only analytes and is free of disturbing species. For example, when several halide ions are present in the system, the gravimetric method can only obtain the total concentration of ions but can not differentiate between them(2). In contrast to this method, with the deposition titration method, partial halide ions can be measured separately by sedimentation titration method (due to the difference in their solubility in water). Therefore, sedimentation titration techniques are superior to gravimetric techniques. Since the co-precipitation process occurs frequently in sedimentary method and it is also difficult to detect the endpoint of sedimentary titrations in dye solutions, potentiometric method are mainly used to detect endpoints in sedimentary titrations(3). In decomposition chemistry, Riley et al.(4,5) for the first time used a small amount of dye solution

Corresponding Author:
Muhaned Mohammed Eteya
Assistant Lecturer, Department of Chemistry, Thi-Qar Education Directorate, Thi-Qar, Iraq
e-mail: thafmoh111@gmail.com

instead of a detector in titration method. Based on this, different method based on color intensity changes were used for acid and base reactions(6–10) and metal detectors(7,7,9,11–16).

Today, one of the most important anions to measure is the sulfate ion. Sulfate is one of the major anions in drinking water and may be present in natural waters in concentrations ranging from a few milligrams to several thousand millilitres per litre. The presence of sulfate in drinking water can give it a bitter taste and very high amounts can cause gastrointestinal upset in humans(17).

Determining the correct concentration of sulfate ions in each water source is one of the basic tests in assessing chemical quality. Therefore, measurements that can determine valid data according to the conditions of each laboratory and available water sources are important. Measurement of sulfate ion concentration in drinking water samples is often done by two method of turbidity measurement and iodometric titrations, each of which has certain advantages and disadvantages.

The experimental method of measuring sulfate: To calculate the actual amounts of sulfate anion in the samples and compare with the proposed method. The following technique was used. One of the most common method is turbidity measurement to measure sulfate in the range 1- 40 mg per litre is suitable. Sulfate ion in the acidic environment by chlorobarium. The standard is in the form of insoluble barium sulfate and the amount of light absorbed by the solution. Barium sulfate suspension is measured using a standard sulfate concentration curve is calculated(18).

And there is a way too simple and inexpensive way to measure sulfate anion in ، samples in this study of a new method. Different blue has been used. After preparation of barium sulfate from the reaction of barium chloride and sodium. A certain mass of it is dispersed in 1 ml of distilled water and sulfate by the phone camera. The smart is photographed from the solution. The intensity of the purple colour was determined through image analysis. Barium sulfate shows the greatest changes with mass change. So purple too optimal title selected. By recording changes in the intensity of purple colour according to the change in the concentration of sulfate anion, it was determined that the curve calibration is linear in the range of 5-75 mg/L and has a relative standard deviation of 743%. By examining the effect of other ions, it was found that this method can measure sulfate in surface water samples. Finally, this method was used to measure sulfate in river and mineral water. Samples of different waters such as city water.

Reagents and working solutions:

Chemicals used: Deionized water was used in all stages of the experiment to prepare samples. Sodium salt/solution with a concentration of 1000 mg/L of sulfate ion was prepared by dissolving 0.1485 sulfates of German mercury in 100 ml of deionized water. Barium chloride from acetate company) of German mercury was prepared. To make a buffer from magnesium chloride salts (Merck Germany) Sodium German Merck (and Potassium Nitrate) Sigma Aldrich USA (with acetic acid) German Merck (used).

Used devices: Samsung Note 3 camera was used to capture images. Also from the application Company Designed and built and shown in Figure 1.

Figure 1. The internal layout of the lightbox used to capture images

Basis of the method: As mentioned in the previous chapter, this project is based on determining the endpoint of sedimentary titrations. It is concentrated by 9.16 g of barium chloride and 5.32 sodium sulfate by smartphones. For this purpose. We weigh sodium sulfate and then perform the following steps:

Add 250 ml of distilled water to sodium sulfate and 250 ml of distilled water to barium Chloride. Add sodium sulfate solution to barium chloride solution and then stir for two the watch. After mixing the mixture, leave it for 24 hours to get a white deposit the deposition is $BaSO_4$. After precipitation $BaSO_4$ should be stored at 40 °C for 72 hours to be ready to use. The buffer solution was prepared according to the following instructions. 3 g of $MgCl_2$ ، 0.5 g of 0.1 g of KNO_3 sodium acetate salt and 2 ml of 99% acetic acid solution in a 100 ml jouette balloon to prepare the desired buffer. To 0.001 g of barium sulfate precipitate 1 ml to optimize different parameters, it was first added distilled water and in a small cell (5 ml) was stirred for 2 minutes with a stirrer, then the intensity of purple colour was processed to examine its changes. It should be noted that to measure sulfate in real samples, the titration method is used. The buffer solution is added then by adding 0.5 ml of sample 0.2 in which different volumes of distilled water and barium chloride record the intensity of purple colour in the resulting turbid mixture.

Discussion of Results and Optimization

Optimization of various parameters:

Optimizing the intensity of different colours: Turquoise ، Yellow ، Mix of three colours red, green, blue ، Blue ، Green ، Different colours including red-purple and black to find the colour with the highest sensitivity to the mass of barium sulfate were studied, the results of which are shown in Table 3- 1. As it is known purple colour because it is more intense for different amounts of barium sulfate, Was selected as the optimal colour. As a result, this colour was used in the measurements.

Table 3-1. The slight intensity of different colors for barium sulfate

Sample number	g	K1	Y2	M3	C4	Sample RGB5	Sample B6	Sample G7	Sample R8
1	0.001	255	217.1	222.72	210.38	197.78	196.457	199.788	197.347
2	0.002	255	219.69	230.35	211.13	219.393	217.64	222.042	218.544
3	0.003	255	236.31	239.65	234.9	231.257	228.731	233.11	231.882
4	0.004	255	236.24	247.38	241.28	231.787	228.416	233.825	232.676
5	0.005	255	252.48	254.84	254.46	224.272	221.493	226.478	224.633

Indicates the intensity of black, indicates the intensity of yellow, indicates the intensity of purple shows, indicates the intensity of turquoise, indicates the colour combination of three colours, Shows the intensity of blue, Shows the intensity of green, Shows the intensity of red.

Optimization of vial volume and distilled water: Different masses of barium sulfate are used to optimize the volume of the vial and distilled water Medium and large by in vials with small volumes (0.001 – 0.005 g) range 1 and 2 ml volumes of distilled water were dispersed and photographed by the camera. Graph of purple colour intensity by mass of barium sulfate in volume 1ml (Figures 2), large (5 ml) Medium (10 ml) Distilled water in small vials (15 ml).

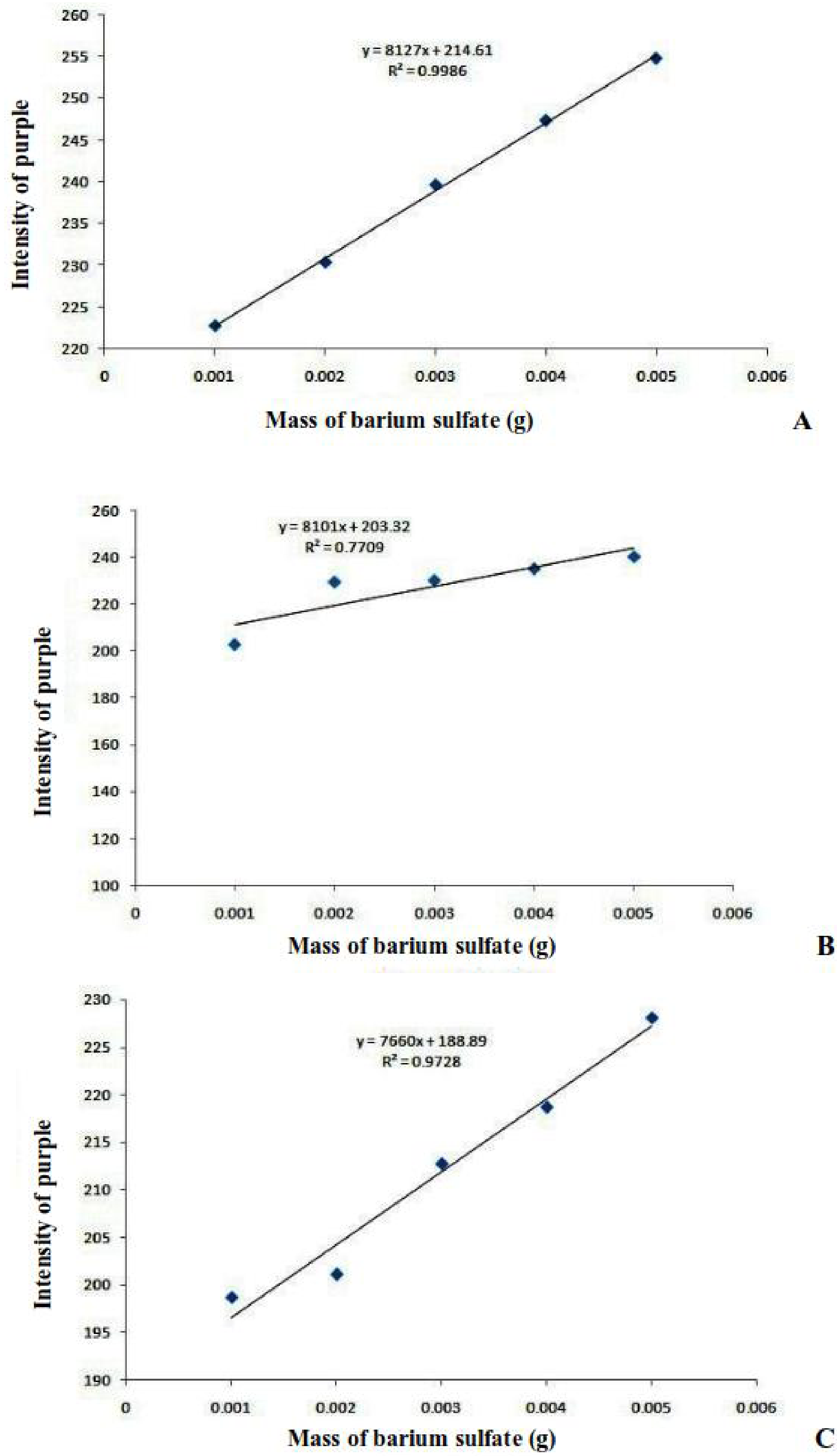

Figure 2. Image analysis results in containers (1) 5ml (2) 10ml (3) 15ml litres containing 1 ml of distilled water

Mass Optimization $BaCl_2$: Its different masses in the range 0.1- 0.5 of were investigated to optimize the weight of barium chloride. As shown in Table 2-3, the intensity of purple colour in of barium chloride was selected as the optimal mass/range and therefore became 0.1.

Table. 3-2. Results related to the change of purple color intensity with the change of barium chloride mass. 50 ml of Samples containing sulfate ions: 45 mg/L

Barium chloride mass (g)	0.1	0.2	0.3	0.4	0.5
Intensity of purple	164.81	164.38	164.84	165.77	165.45

Optimization of used lamps: Because purple dye has the highest sensitivity to measure sulfate green and blue at intervals of ، white ، to optimize the lamp used by different types such as yellow 10 cm and close 5 cm were examined. Results in (Figures 3) blue is shown at a distance of 5 cm (Figure 4, 5,6). As can be seen, has a wider range of color intensity change and uniformity with changing the volume of barium chloride is. As a result, use a blue lamp at a distance of 5 cm for further measurements took.

Disturbing ions: To evaluate the applicability of the method in real samples, different ions such as aluminium (Al^{+3}) Cobalt (Co^{+2}), copper (Cu^{+2}), in a solution containing sulfate ions at a concentration of 1000 mg/L were reduced by barium chloride to 1000 mg/L. The titration curves in Figures 7 to 8, 9 are shown. Also, the percentage of relative error of the disturbing ions mentioned in Table 3-3 shows that a very good percentage of relative error is observed in most cases.

Table 3-3. Results of disturbance ion analysis in the measurement of sulfate ions. Sulfate ion concentration 35 mg/L and the concentration of disturbing ions is 200 mg/L

Disturbing ions	The color intensity in the absence of disturbing ions	The color intensity in the presence of disturbing ions	Relative error percentage
Al^{+3}	158.39	168.83	6.6
Cu^{+2}	141.3	136.52	3.4-
Ca^{+2}	179.26	169.83	5.3-

Titration Method: In this method, first, the sample is titrated with barium chloride and through the volume of the endpoint of sulfate concentration in the sample we calculate.

River Water: To measure the sulfate ion, the titration method was used, the diagram of which is shown in Figure 10 is the amount of sulfate obtained/shown. Given that the final volume is 0.70 it is 37 mg/L, which is in very good agreement with the actual amount (38 mg/L)

Mineral Water: Figure 11 Spike mineral water titration curve with a specified amount of sulfate (500 mg/L) shows the endpoint in volume 0.74. The concentration of sulfate in the mineral water sample is 30 mg/L, which is compared to the amount Real (31 mg/L) is in great agreement.

Water City: Figure 12 shows the spiked titration curves of city water. Given that the point is the amount of sulfate obtained in this method is 76 mg/L final 0.78 ml. Which is in good agreement with its actual amount (80 mg/L).

Conclusion

In this project, a new processing-based method has been used to measure sulfate anions in aqueous samples. By diluting different masses of barium sulfate in distilled water, it was found that changes in the intensity of purple color show the greatest sensitivity and was selected as the optimal color. By optimizing various parameters such as vial volume and distilled water, barium chloride mass and type and distance of the lamp, it was determined that the calibration curve is in the range of 5-75 mg/L linear. One of the main advantages of this method is that it does not require advanced devices, and since photography is done using a simple smartphone camera, it makes the application of this method easy and low cost. Also, the effect of disturbance study of other ions showed that only disturbing species are measured in fluoride and carbonate ions. Also, this method was used to measure barium sulfate and also sulfate anion in city water samples, and mineral water by standardization method and sediment titration.

Ethical Clearance: The Research Ethical Committee at scientific research by ethical approval of both environmental and health and higher education and scientific research ministries in Iraq

Conflict of Interest: The authors declare that they have no conflict of interest.

Funding: Self-funding

Reference

1. Skoog DA, Holler FJ, Crouch SR. Instrumental analysis. Vol. 47. Brooks/Cole, Cengage Learning Belmont; 2007.
2. Ellwood MJ, Hunter KA, Cunninghame RG. Elimination of equivalence point errors in the potentiometric titration of chloride, bromide and iodide mixtures with silver nitrate. Microchemical journal. 2003;74(2):187–192.
3. Ni Y, Wu A. Simultaneous determination of halide and thiocyanate ions by potentiometric precipitation titration and multivariate calibration. Analytica chimica acta. 1999;390(1–3):117–123.
4. Reilley CN, Flaschka HA, Laurent S, Laurent B. Characterization of the color quality of indicator transition. Complementary tristimulus colorimetry. Analytical Chemistry. 1960;32(10):1218–1232.
5. Reilley CN, Smith EM. Chemical applications of complementary tristimulus colorimetry. Analytical Chemistry. 1960;32(10):1233–1240.
6. Bhuchar VM, Kukreja VP, Das SR. Evaluation of color changes of indicators. Specific color discrimination of phthalein and sulfonephthalein indicators. Analytical Chemistry. 1971;43(13):1847–1853.
7. Cacho J, Nerin C, Ruberte L, Rivas E. Evaluation of color changes of indicators. Analytical Chemistry. 1982;54(8):1446–1449.
8. Fernandez AC, Chozas MG. Colour specification of pyridine-2-aldehyde and 6-methylpyridine-2-aldehyde p-nitrophenylhydrazones as indicators for pH determination. Talanta. 1987;34(7):673–676.
9. KOTRLÝ S, VYTŘAS K. COLOUR CHANGES OF ION-COMBINATION INDICATORS. In: Essays on Analytical Chemistry. Elsevier; 1977. p. 259–280.
10. Bhuchar VM, Agrawal AK. Evaluation of colour changes of sulphamphthalein indicators: synthesis, purification and characterisation of phenol-and o-cresolsulphamphthalein. Analyst. 1982;107(1281):1439–1450.
11. Cacho J, López-Molinero A, Castells JE. Comparative study of metallochromic indicators for magnesium. Analyst. 1987;112(12):1723–1729.
12. Cacho J, Garnica A, Nerin C. Critical study of metallochromic indicators for calcium. Analytica chimica acta. 1984;162:113–122.
13. Calatayud JM, Marti MP, Vives SS. Screened indicators for the direct chelometric titration of lead (II). Analyst. 1985;110(7):837–839.
14. Prasad KK, Raheem S. Evaluation of colour changes of indicators in the titration of cadmium with EDTA. Analytica chimica acta. 1992;264(1):137–140.
15. Prasad KK, Raheem S, Vijayalekshmi P, Sastri CK. Basic aspects and applications of tristimulus colorimetry. Talanta. 1996;43(8):1187–1206.
16. Raheem S, Prasad KK. Evaluation of colour quality of complexometric indicators in the titration of Nickel (II) with EDTA by tristimulus colorimetry. Talanta. 1993;40(12):1809–1814.
17. Heizer WD, Sandler RS, Seal E, Murray SC, Busby MG, Schliebe BG, et al. Intestinal effects of sulfate in drinking water on normal human subjects. Digestive diseases and sciences. 1997;42(5):1055–1061.
18. Ouyang S, Kikugawa N, Chen D, Zou Z, Ye J. A systematical study on photocatalytic properties of AgMO2 (M= Al, Ga, In): effects of chemical compositions, crystal structures, and electronic structures. The Journal of Physical Chemistry C. 2009;113(4):1560–1566.