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Research Article

Precise Evaluation of the Essential Metal Ions in Oral Rehydration Solution by Flame Emission Spectroscopy

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Abstract

Three rapid, precise, and reliable analytical methods have been established for determining the concentrations of sodium and potassium in two distinct ORS formulations. The first method, use only one standard means measuring how bright the flame is for a sample solution and comparing it with the brightness of a standard solution, means known solution. The second method uses two standard solutions. It involves standardizing a reference substance using two-point bracketing, and the final result is calculated using mathematical formulas. The third method is a linear curve, which means finding how much of a substance is in a sample by comparing it to other sample with known amount. The concentration of a substance in an unknown sample is determined by measuring its flame intensity and comparing it with that of standards, since flame intensity is directly proportional to concentration. The linear range for sodium and potassium is in the range of 0-100 µg/ml. The developed methods were effectively utilized for the precise evaluation of sodium and potassium in commercially available ORS formulations. Accurate percentage yield indicate that all three methods are rapid, precise and reliable for the estimation of sodium and potassium in two different formulations of ORS.

Keywords: Metal ions, Oral Rehydration Solution, Flame emission spectroscopy

I INTRODUCTION:

flame atomic emission spectroscopy, is an analytical technique that measures the concentration of certain metal ions, especially alkali and alkaline earth metals, by observing the intensity of light they emit when heated in a flame. The element is identified by the wavelength (color) of the emitted light, while its concentration is determined by the intensity of that light. This method is used in various fields, including clinical chemistry, agriculture, and food and beverage analysis, to determine levels of elements like sodium, potassium, and calcium. When excited atoms relax to a lower energy level, photons with a recognizable wavelength (Na: 589 nm, K: 766 nm) are also released.[1] The concentration of specific atoms in the flame determines the intensity.

Keeping the right balance of fluids and electrolytes is very important for good health at any age. When a person suffers from diarrhea, gastroenteritis, cholera, or dysentery, the body loses a lot of water and salts (electrolytes), leading to dehydration.

Oral Rehydration Therapy (ORT) is a simple treatment in which a person drinks a solution of salt and sugar to replace the water and electrolytes lost from the body.

The main positive ion (cation) in the fluid outside our cells is sodium. It helps control the amount of water in the body. Potassium, on the other hand, is the main cation inside our cells. It is important for keeping the heartbeat regular and for muscle function.

The amount of sodium and potassium in Oral Rehydration Solution (ORS) must be enough to make up for their loss and to correct low sodium (hyponatremia) or low potassium (hypokalemia) levels. However, their levels should not be too high, because too much sodium (hypernatremia) or potassium (hyperkalemia) can be dangerous and may even cause death.[2]

As a result, it is needed to find out concentration of sodium and potassium in the ORS formulation. So, this work reported a simple flame emission spectroscopy approach for estimating concentration of sodium and potassium in ORS formulation.

II EXPERIMENTAL

Materials

A Flame Photometer (Systronics Model 130) is an instrument used to measure the concentration of metal ions such as sodium (Na^+) and potassium (K^+)in a sample. It has a sensitivity of 1 PPM (part per million), meaning it can detect very small amounts of these elements.

In this experiment, sodium chloride (NaCl) and potassium chloride (KCl) solutions are used as standards. These standard solutions help in calibrating the instrument that is, setting a reference to compare and accurately measure the unknown concentrations of sodium and potassium in other samples.

The commercially available sachet of ORS- Sample 1 ORS CARE (Manufactured by: Advacare) and sample- 2 **REBALANZ ORS** (Manufactured by- **Dr. Reddy's**) were procured from the local market. Distilled water is used as a solvent.

Preparation of Standard Stock Solution and Linear Curve

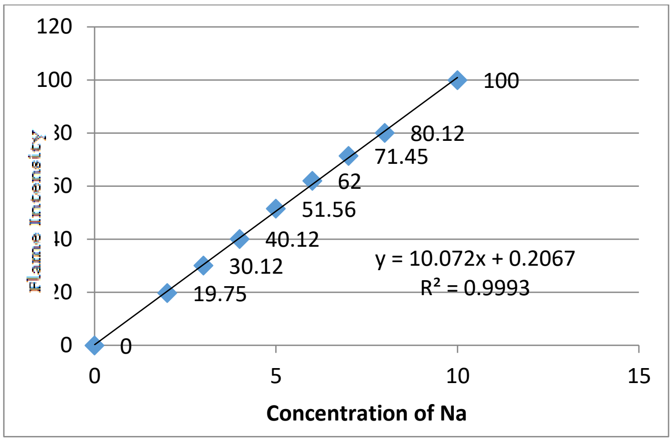
Standard stock solutions of sodium chloride and potassium chloride were prepared by accurately weighing 10 mg of each salt and dissolving them separately in 100 mL of distilled water using volumetric flasks. This yielded stock solutions with concentrations of 100 µg/mL for both sodium chloride and potassium chloride. From these stock solutions, a series of dilutions were prepared to obtain concentrations in the range of 2–10 µg/mL. A calibration curve was then constructed by plotting the flame intensity values of these diluted solutions against their respective concentrations [3]

Characteristic emission color from alkali metals under the flame

Alkali metals	Characteristic wavelength	Flame color
Sodium	589 nm	Yellow color
Potassium	766 nm	Violet color

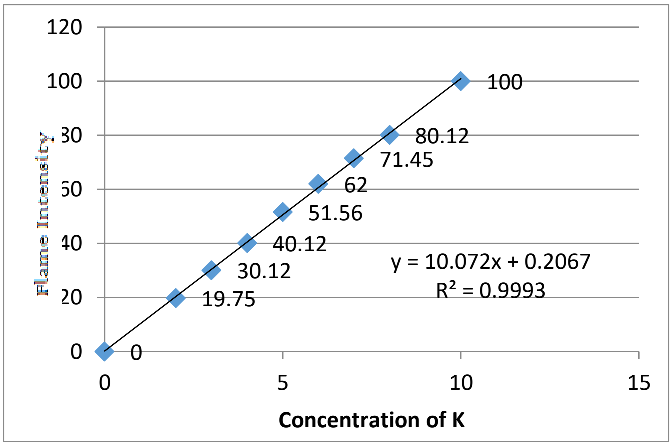
Flame intensity of standards sodium

Sr No	Concentration µg/mL	Flame intensity
1	2	19.80
2	3	31.12
3	4	39.45
4	5	50.12
5	6	62.12
6	7	72.47
7	8	80.00
8	10	100



Flame intensity of standards potassium

Sr No	Concentration µg/mL	Flame intensity
1	2	19.75
2	3	30.12
3	4	40.12
4	5	51.56
5	6	62.00
6	7	71.45
7	8	80.12
8	10	100



Preparation of test solution [4]

Accurately weighed quantities of powder samples 1 and 2, each equivalent to 10 mg of sodium, were transferred into separate 100 mL volumetric flasks. The samples were dissolved in distilled water, and the volume was made up to the mark with the same solvent to obtain the stock solutions. From these stock solutions, working standards containing 2 µg/mL and 4 µg/mL of sodium were prepared for samples 1 and 2 respectively.

An identical procedure was followed for the preparation of potassium stock and working standard solutions for samples 1and B

Method I: One-point calibration [5]

The one-point calibration method entails the determination of flame emission intensities for both the sample solution and a standard solution containing the reference element. The concentrations of sodium and potassium in the sample are then quantified based on the direct proportionality between emission intensity and analyte concentration, as described by the principles of flame emission spectroscopy.

$$C_{test} = \frac{FI_{test} \times C_{std}}{FI_{std}}$$

Where FI_{test} and FI_{std} are the flame intensities of the test and standard solutions, respectively, and C_{test} and C_{std} are the concentrations of the test and standard solutions, respectively.

Analysis data of ORS formulation of Test 1 and Test 2 for method I

	Conc. (µg/Ml)	**Flame intensity**	Conc.obtained **µg/mL**	% Obtained
For Sodium				
Test 1	2	19.85	2.00	100.00
	4	41.23	4.18	104.00
Test 2	2	20.12	2.03	101.5
	4	40.12	4.06	101.5
For Potassium				
Test 1	2	21.41	2.16	108.00
	4	41.03	4.09	102.25
Test 2	2	21.11	2.13	106.5
	4	39.27	3.91	98.00

Method II: Two-point calibration

A two-point calibration method is used to determine the concentration of sodium and potassium in the test solution. This method involves comparing the test solution to two standard solutions of known concentrations. The concentration of sodium and potassium in the test solution can then be calculated based on these comparisons, typically using a mathematical equation that relates the absorbance (or another measured property) of the test solution to that of the standard solutions."

If you have a specific equation for the process or need further clarification, feel free to share it!

A two-point bracketing standardisation is used to determine the concentration of the test solution. The concentration of the sodium and potassium in the test solution is given by the equation

$$C_{test} = \frac{(FI_{test} - FI_{std1})(C_{std1} - C_{std2}) + C_{std1}(FI_{std1} - FI_{std2})}{FI_{std1} - FI_{std2}}$$

Where FI_{test} and FI_{std} are the flame intensity of the test and standard solutions respectively, and C_{test} and C_{std} are the concentration of the test and standard solutions respectively.

Analysis data of ORS formulation of Test 1 and Test 2 for method II

	Conc. (µg/mL)	**Flame intensity**	**Conc.obtained µg/mL**	**% Obtained**
For Sodium				
Test 1	3	29.85	2.95	98.33
Test 2	3	30.12	3.03	101.00
For Potassium				
Test 1	3	30.45	3.12	104.00
Test 2	3	30.15	3.08	102.6

Method III: Regression Equation Method

A regression equation is a way to determine the amounts of sodium and potassium in a sample by comparing it to a set of standard solutions with known amounts. A calibration curve is a graph that shows how the instrument's measurement changes as the concentration of the substance being measured (the analyte) changes. For this type of analysis, if you plot the flame intensity (the instrument's response) against the concentration, you get a straight line. To find the concentration of the substance in your sample, you measure its response, then use the calibration curve to figure out the concentration by looking at where the response fits on the graph. The concentrations and instrument responses of the standards are used to create this straight-line relationship using linear regression. This yields the equation $Y = mx + c$ where Y is the instrument response, m represents the sensitivity, and c is a constant that describes the background. The analyte concentration x of samples calculated from the regression equation.[6]

Analysis data of ORS formulation of sample 1 and sample 2 for method III

	Conc. (µg/mL)	Flame intensity	Conc.obtained µg/mL	% Obtained
For Sodium				
Sample A	4	40.84	4.05	101.47
Sample B	4	40.42	4.01	100.42
For Potassium				
Sample A	4	40.03	3.93	98.30
Sample B	4	40.27	3.95	98.91

III RESULTS AND DISCUSSION

The linearity range was found to be 0-10 µg/mL for sodium and potassium and coefficient of correlation was found 0.999 for both standards. Both standards showed good regression values at their respective concentration so that concentration of sodium and potassium in ORS formulation could be accurately determined by the proposed methods. Percentage estimation of sodium and potassium found in ORS formulation are ranges from 98.00 to and 108.00.in all three methods.

IV CONCLUSION

The Flame photometric method is almost free of interferences from other elements as specific element filter is utilized. Therefore these are simple, rapid, and accurate methods for quantification of sodium and potassium in ORS formulation which can be used for routine analysis of ORS formulation.

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