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### Original Article

# Analytical method development and validation for Aluminium

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**ABSTRACT:** Aluminium comprises about 8% of earth's crust so there is possibility that aluminium can contaminate the natural resources, with references to previous researches on determination of aluminium, we developed a simple, rapid, and economic colorimetric method for the detection of aluminium from various sources. Aluminium has an electric charge and a small ionic radius of about 0.51Å, conferring upon it strong polarizing capabilities. Standard reduction potential for reacting  $Al^{+3}$  is -1.67 V. This high electronegativity makes aluminium highly reactive. 8-hydroxyquinoline-5-sulphonic acid has been used for chelation and subsequent determination of aluminium content from samples. It is a light-yellow coloured compound and is a derivative of heterocyclic quinoline substituted with the hydroxyl group on carbon number 8 and sulphonic acid group at carbon number 5. Sulphonic acid improves the solubility of the molecule and of the corresponding fluorescent complexes in polar solvents. Aluminium readily complexes with 8-hydroxyquinoline-5-sulphonic acid in acidic buffer and remains stable for 30 mins. The maximum absorbance of aluminium and 8-hydroxyquinoline-5-sulphonic acid complex was determined using UV spectrophotometry at 359 nm. Concentration of aluminium in the sample was found to be linear within the range of 1.2–2.8 mM with acceptable precision and accuracy, as per guidelines. The developed method was validated according to ICH (Q2R1) guidelines. The developed method was used to assess the aluminium content in a marketed antacid formulation. The recovered aluminium content was within the industrial acceptance limit. The developed method is thus effective for accurate determination of aluminium from marketed samples.

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## INTRODUCTION

Aluminium is the third most abundant element on earth after oxygen and silicon comprises 8% of the earth's crust. Since aluminium is abundantly present in earth's crust aluminium may contaminate resources such as water, food, soil, pharmaceutical formulation [1, 2, 3, 4].

According to previous researches, continuous exposure of aluminium may cause severe health related problems like Alzheimer's disease, dialysis encephalopathy, renal osteodystrophy and pulmonary fibrosis [4, 5, 6]. This concludes that there is a need for simple method that can detect the presence of aluminium in various sources.

There are various methods that are used for detecting and analysing aluminium like Atomic absorptive spectrometry inductive coupled plasma atomic spectrometry and neutron activation analysis [7] having good sensitivity but poor precision. Other methods like UV-Vis diffuse reflectance spectroscopy, adsorptive stripping voltametry, cloud point extraction, micellar liquid chromatography RP- HPLC and ion pair chromatography are precise [8, 9, 10] but these methods have their own disadvantages such as excessive cost, use of organic solvents and interference of matrix.

Therefore, we developed a novel method for minimizing the disadvantages in analysing aluminium.

## MATERIALS AND METHODS

8- hydroxyquinoline 5- sulphonic acid was procured from Anami organic, Gujrat India.

Aluminium chloride and sodium acetate were procured from CDH fine chemicals. Sulphuric acid, glacial acetic acid, potassium hydroxide and hydrochloric acid were procured from S.D. Fine-Chem Limited. Distilled water used for dilutions was prepared in house.

UV-Visible double beam spectrophotometer (Jasco Model V-630) was employed with a spectral band width of 1 nm and a wavelength accuracy of 0.3 nm (using automatic correction with a pair of 1 cm matched quartz cells). Analytical balance used for weighing the standards and micropipettes of make TARSON were used for making the dilutions.

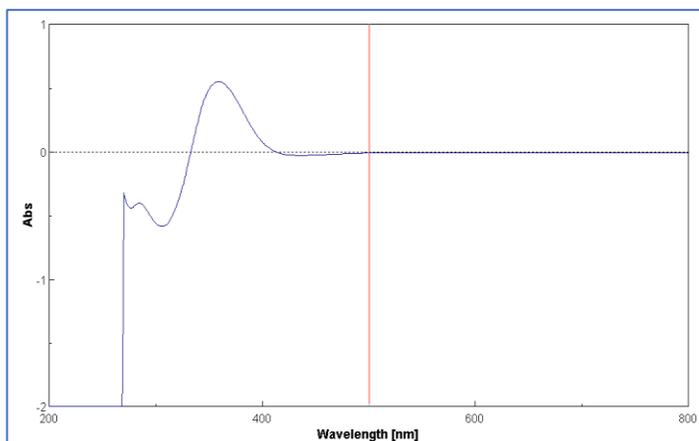
Method- Absorbance spectra of AL: 8HQS was developed and subsequently the wavelength of maximum absorbance was determined which was used for further analysis. The concentration of 8HQS was determined by analysing different ratios of AL: 8HQS. Further stability of the complex was determined by optimization of the reaction time. The developed method was validated in accordance with ICH guidelines for linearity, range, accuracy, and precision, limit of quantitation (LOQ), robustness, ruggedness and system suitability testing.

## RESULTS AND DISCUSSIONS

### Method development [11, 12]

#### Selection of detection wavelength

A solution of aluminium and 8HQS was mixed in acidic buffer solution and absorbance was recorded in UV-Vis spectrophotometer at 800 - 200 nm in contrast to reagent blank a maximum absorption was detected at 359 nm. (figure 1).



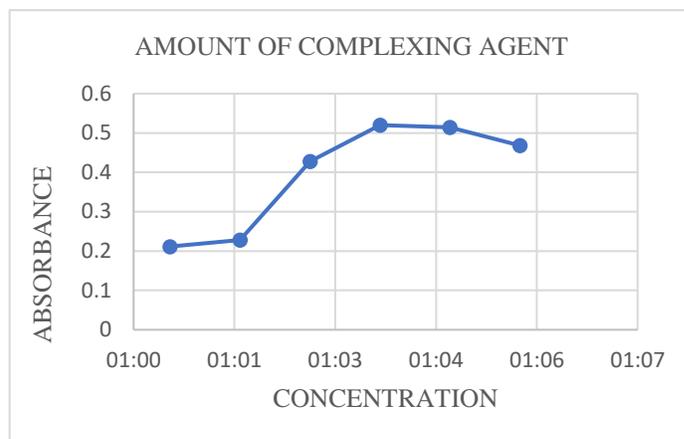
**Fig. 1: Maximum absorbance shown by Al- 8 HQS complex at 359 nm**

#### Amount of complexing agent

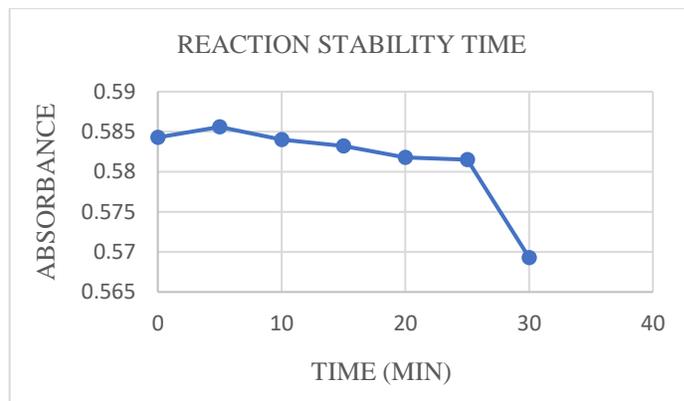
The Amount of complexing agent was determined to optimize metal to chelate ratio. The optimum metal to chelate ratio was observed to be 1:4 (figure 2).

#### Reaction stability time

The reaction stability time was determined by measuring absorbance at 5 min intervals against a reagent blank. The absorbance of reaction mixture samples was found to remain constant for 30 min (figure 3).



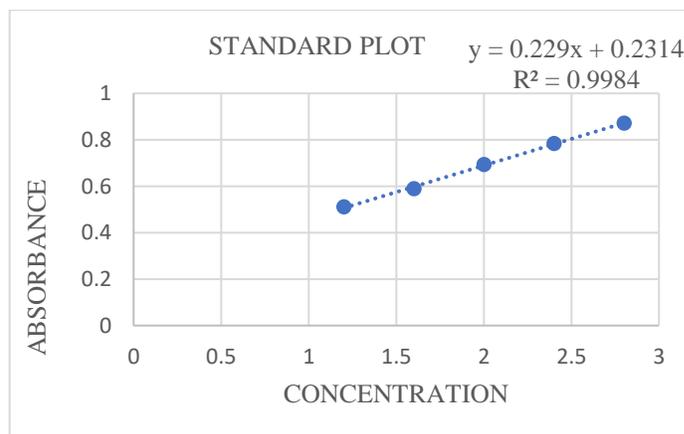
**Fig. 2: Amount of complexing agent**



**Fig. 3: Reaction stability time**

#### Standard plot

Standard plot for aluminium was in the range of 1.2 - 2.8 mM with regression coefficient of 0.9984 (figure 4).



**Fig. 4: Standard plot**

**Method validation [13, 14]****Linearity and Range**

Linearity was established for the calibration curve within a range of 1.2 - 2.8 mM with the regression coefficient of 0.9984 and relative standard deviation being consistently  $\leq 2\%$ . (Table 1).

**Precision**

The repeatability of the method was verified by calculating the percent relative standard deviation (%RSD) of six replicates

**Table 1: Linearity and range of Al: 8HQS complex**

Concentration (mM)	Absorbance	Absorbance	Absorbance	Mean	S.D.	%RSD
1.2	0.5102	0.5057	0.5159	0.5106	0.005111	1.0
1.6	0.5963	0.5841	0.5848	0.5884	0.006850	1.16
2	0.6841	0.6878	0.7073	0.6930	0.012464	1.7
2.4	0.7873	0.7854	0.7796	0.7841	0.004011	0.5
2.8	0.8674	0.8820	0.8628	0.8707	0.010024	1.15

**Table 2: Precision**

Analyte	Repeatability (%RSD)	Intermediate precision (%RSD)
Aluminium	2.00	0.63

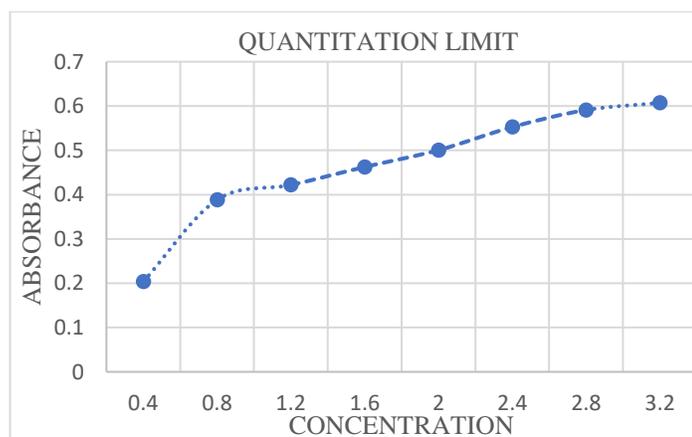
(n=6) \*n= No. of determinants

**Table 3: Accuracy**

Amount of sample (Mm)	Amount added (%)	Amount added (Mm)	Total amount (Mm)	Mean recovery (Mm)	%recovery	%RSD
1	80	0.2	1.2	1.19	95.8	0.19
1	100	0.6	1.6	1.6	100	1.3
1	120	0.9	1.9	1.94	102	0.19

**Lower limit of quantitation**

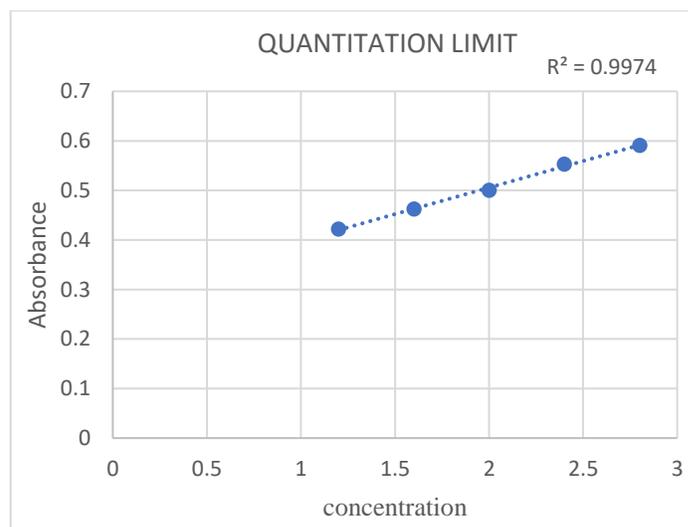
The quantitation limit of an individual analytical procedure is the lowest amount of analyte in a sample which can be quantitatively determined with suitable precision and accuracy. For quantitation limit, visual method was adopted. Three concentration points below the lowest concentration obtained from standard plot were studied and linearity and precision were calculated. A response below 1.2 mM was observed as nonlinear and not precise. So accordingly, 1.2 was considered as the quantitation limit. (Figure 5 and 5A).

**Fig. 5: Quantitation Limit**

with 100% concentration on the same day. For intraday precision % RSD was calculated from repeated studies (Table 2).

**Accuracy**

To ensure the reliability and accuracy of the method, recovery studies were performed. Accuracy was calculated as the percentage of recovery by the assay of the known added amount of analyte in the sample together with confidence intervals. (Table 3).

**Fig. 5A: Quantitation Limit****Robustness**

Small changes in the operational conditions were allowed and the robustness of method was determined. The change in absorbance following a deviation of  $\pm 1$  nm in the detection wave length and  $\pm 5$  min in the detection time, were individually determined. Solutions of middle test concentration with the specified changes in the operational conditions were analysed in triplicate (Table 4).

**Table 4: Results for Robustness**

Parameters (n=3)	%RSD
Absorbance at 358 nm	0.38
Absorbance at 360 nm	0.32
Absorbance at 0 min	0.99
Absorbance after 5 min	0.54

**Ruggedness**

Ruggedness is a measure of the reproducibility following normal and expected change in the operational conditions from laboratory to laboratory and from analyst to analyst. Ruggedness is determined by the analysing the aliquots from homogeneous stocks by different analysts. Solutions of middle test concentration with the specified operational conditions were analysed by two different analysts in triplicate. % RSD obtained is reported in the table 5.

**Table 5: Results for Ruggedness**

Parameters n=3	%RSD
Analyst 1	0.87
Analyst 2	0.34

**Table 7: Results Assay of Marketed Formulations**

Brand name	Analyte	Concentration estimated (2mM)	%Concentration estimated	%RSD
Gelucil	Al	2.0	100	0.07

**DISCUSSIONS**

8-Hydroxyquinoline-5-sulfonicacid used as a complexing agent is a derivative of oxine, that forms water-soluble complexes with aluminium. 8-Hydroxyquinoline-5-sulfonicacid exists in an anionic form in aqueous solution and forms fluorescent complexes with aluminium ions. Developed method was used for analysis of aluminium in antacid tablets and can be applied for detection of aluminium from other sources.

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**System suitability testing**

System suitability testing was performed by recording absorbance of the lower, middle and higher concentrations for six replicates and relative standard deviation was calculated and shown in table 6.

**Table 6: System suitability testing**

Concentration (mM)	Mean n= 6	%RSD
1.2	0.5215	2.0
2	0.6860	1.9
2.8	0.85865	1.9

**Assay of Marketed Formulations**

Aluminium content was determined from the antacid tablets (Gelucil) using the developed method. A 2mM solution of aluminium from the tablet was prepared by dissolving accurate amount of tablet powder in dilute hydrochloric acid and volume was made up to 10 ml. A replicate study was performed to confirm the precision. Results obtained are shown in table 7.

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