Available online at **www.joac.info**

ISSN: 2278-1862

Journal of Applicable Chemistry

2021, 10 (3): 302-307

(International Peer Reviewed Journal)

Iodometric System for Determining Vitamin C using Cu (II)

Chandramouli Manasa[1]*, Anitha Sudhir[1], Sowmya Palahally Thimmappa[1], and Kuriya Madavu Lokanatha Rai[2]

1. Department of Chemistry, Vidhyavardhaka College of Engineering, Mysore-570 002, Karnataka, **INDIA**
2. Department of studies in Chemistry, University of Mysore, Manasagangotri , Mysuru 570 005, Karnataka, **INDIA**
Email: kmlrai@yahoo.com

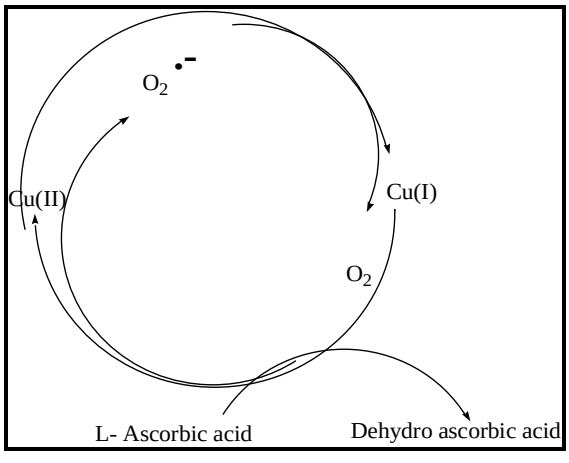
Accepted on 21st May, 2021

This paper is dedicated to "*J. Applicable Chemistry*" during first decadal publication celebration.

ABSTRACT

An easily understood method for the purpose of determining the molecular weight and amount of the ascorbic acid present in vitamin C supplements is marked out. The method include ascorbic acid undergoing oxidative dehydrogenation by copper in acidic medium, led by reaction of unreacted copper with potassium iodide through iodometry. The suggested method shows an improvement in iodometric titration and its applicability in the quantitative analysis of the ascorbic acid. The data in the results indicate that the oxidation of ascorbic acid proceeds by the reduction of Cu (II) to Cu (I). And hence, the mentioned titration method can be adopted for different samples of ascorbic acid to analyse them quantitatively as it shows advantage over the previous methods.

Graphical Abstract



Ascorbic acid undergoes oxidation by the reduction of Cu (II) to Cu (I).

.**Keywords:** Ascorbic acid, Vitamin C supplements, Iodometry, Copper (II).

INTRODUCTION

Ascorbic acid is widely present both in plants and animals [1]. Both in the physiology of plants and animals, ascorbic acid (also known as ascorbate or vitamin C) is a necessary molecule. The ability of its synthesis in plants and animals including humans is decreasing overall [2]. It is studied that there is no certain goal to increase the ascorbic acid content in fruit crops although fruits and vegetables in human diet are the major source of ascorbate. Recently, increasing the ascorbic acid content in fruit crops is being investigated [3]. Ascorbic acid is also called as hexuronic acid, which is L-gulonic acid. Through the passive diffusion or by active transport, ascorbic acid, which is absorbed, penetrates into the cells by a glucose transporter via a defined transport system. The daily intake of fruits and vegetables, supplements the body with this vitamin [4]. The deficiency which leads to a disease called scurvy [5]. It is also a resistant to various common infections [6]. Being a potent fighter of bacterial infections, in reactions involving detoxification, ascorbic acid is a powerful reductant and an antioxidant [7]. Vitamin C (Vit-C) is a strong antioxidant that has a variety of uses in the cosmetic and pharmaceutical industries [8]. More and more, these days it is used in almost all food commodities. The antitumor consequence of chemotherapy is increased or the toxicity is decreased through vitamin C supplementation [9] in patients suffering from cancer [10]. Blood cancer is often reported due to the deficiency of vitamin C. Hence it has to be investigated whether the supplementation of vitamin C can correct the deficiency [11]. A surge of its usage in pharmaceutical industries has been analyzed.

Many fruits are available locally in Ado Ekiti, Nigeria, and there is insufficient knowledge to estimate them using the iodometric and UV spectrophotometer methods [12].

In iodometric assay, the released iodine from potassium iodide solution having an oxidant is studied. For shielding antioxidants, iodometic method is a potent evaluation method [13]. Iodometry [14] is one of the method that is usually employed for the analytical quantitative analysis along with chromatography [15] and spectroscopy [16]. Since the observation is random, iodometry shows more reproducibility [17]. The principal objective of this method is to quantify the ascorbic acid in pharmaceuticals. Oxidation of ascorbic acid by Cu (II) is reported by iodometry, though several other procedures are spoken about namely potentiometric [18], reductrimetric [19], thermometric [20], formal titration [21]. Preceding to the current work, chloramine-T was put to use for determining the iodine content of oils and fats [22], molecular weight of neutral amino acids [23], and newly it is communicated that chloramine-T can act as a good oxidant in the estimation of carbonyl compounds by iodometry [24]. In continuity, producing the same with Cu (II) was studied through basic titration method for the determination of ascorbic acid and the same is conferred in the paper. It is noted in the procedure that, ascorbic acid undergoes oxidative dehydrogenation by Cu (II) to dehydroascorbic acid by taking in one molecule of Cu (II) for each one molecule of ascorbic acid. The ascorbic acid's molecular weight investigated showed high accuracy. The percentage deviation of the ascorbic acid is less than 2%, which is less than that reported in the statistics.

MATERIALS AND METHODS

Entire analytical grade reagents were used. All over it was distilled water that was used. Vit-C tablets was taken in a spectrum of 100-500 mg and 0.1M of $CuSO_4$ was prepared with distilled water. Sodium thiosulphate of 0.5M is reported to react with potassium iodide using starch indicator.

In a classic experiment, ascorbic acid was treated with known amount of Cu (II), which was added to it. Reaction on completion, was analyzed by iodometry by determining the unreacted Cu (II). Determination of the amount of Cu (II) consumed concurrently with the blank titration was done. Principally, since one mole of Cu (II) is for one ascorbic acid molecule, which is correspondent to one mole of iodine, the below equation (1) is used for the determination of the ascorbic acid's molecular weight 'm'.

$$m = \frac{1000}{(V_1 - V_2)\,M} \qquad \ldots 1$$

Where, V_1 and V_2 are the titrimetric readings of sodium thiosulphate for blank and experimental trials. M is the molarity of sodium thiosulphate solution. W is the tablet or ascorbic acid weight taken.

Determination of molecular weight of ascorbic acid: Ascorbic acid sample of weight close to 20-60 mg was made to dissolve in the distilled water in a conical flask. To the above solution, was added 40 mL of 0.1M $CuSO_4$. The reaction mixture was mixed well and was maintained at room temperature for a period of 30 minutes. After half an hour, to the reaction mixture was added 20 mL of 2N sulphuric acid and 20 mL of 10% potassium iodide along with 10 mL of distilled water. The liberated iodine was titrated against the 0.5M sodium thiosulphate solution by using starch indicator. In the same manner, a blank titration was performed without the addition of ascorbic acid or the Vit–C tablet. Difference in the volume of sodium thiosulphate solution consumed for the blank (V_1) and experimental trials (V_2), gives the molecular weight 'm' which is calculated using equation (1).

Estimation of ascorbic acid in the pharmaceutical Vit-C samples: A weight of 10-60 mg of the sample of Vit-C tablet containing ascorbic acid around a spectrum range of about 100-500 mg was powdered well and made to dissolve in 10 mL of distilled water in a conical flask. A 40 mL solution of 0.1M $CuSO_4$ was added to the same conical flask. The reaction mixture was mixed well and was maintained at room temperature for a period of 30 min. After half an hour, to the reaction mixture was added 20 mL of 2N sulphuric acid and 20 mL of 10% potassium iodide along with 10 mL of distilled water. The liberated iodine was titrated against the 0.5M sodium thiosulphate solution by using starch indicator. In the same manner, a blank titration was performed without the addition of ascorbic acid or the vitamin C tablet. Difference in the volume of sodium thiosulphate solution consumed for the blank and experimental trials, gives the amount of ascorbic acid 'W' present in the Vit-C tablet and can be calculate using the below equation:

$$W = \frac{m\,(V_1 - V_2)\,M}{100} \qquad \ldots 2$$

Where, M is the molarity of sodium thiosulphate solution, V_1 and V_2 are the titrimetric readings for blank and experimental trials and m is the molecular weight of ascorbic acid.

RESULTS AND DISCUSSION

The above procedure explains the determination of the ascorbic acid molecular weight and the estimation of the ascorbic acid present in the Vit-C tablets. The suggested method is much easier in comparison with the methods in the literature, involving several steps. It is notable that the deviation of the experimental values from the theoretical values was less than 1 corresponding to the molecular weight of ascorbic acid as shown in table 1. With respect to the amount of ascorbic acid present in Vit-C tablets, the error in relative percentage was less than 2% as shown in table 2. Calculation of the relative error is with respect to experimental values and the given values on the pharmaceutical samples.

Table 1. The experimental molecular weights obtained in time, 30 min compared to the theoretical value (176.13)

Trials	Amount of ascorbic acid taken	Experimental values	Average	Standard deviation
1	49.80	175.65	175.912	0.17
2	47.80	176.03		
3	37.60	175.94		
4	40.80	175.78		
5	29.6	176.16		
6	46.60	175.85	175.972	0.168
7	41.80	176.76		
8	37.0	175.64		
9	52.20	175.95		
10	37.80	175.66		

Table 2. Amount of ascorbic acid present in the pharmaceutical samples containing ascorbic acid

Trials	Name of the tablet	Amount taken in mg	Amount determined in mg	Relative error %	Trials	Name of the tablet	Amount taken in mg	Amount determined in mg	Relative error %
1	Limcee	65.24	64.94	0.45	1	Limcor	31.06	30.78	0.90
2		60.01	59.7	0.51	2		45.33	45.11	0.48
3		58.47	58.21	0.44	3		31.31	30.97	1.08
4		50.74	50.44	0.59	4		23.43	23.14	1.23
5		46.09	45.82	0.58	5		27.78	27.48	1.07
1	Celin	63.11	62.61	0.79	1	Alvizia	36.93	36.60	0.89
2		51.39	50.78	1.18	2	Alenglow	26.73	26.47	0.97
3		41.64	40.83	1.94	3	L-	42.69	42.41	0.65
4		38.82	38.42	1.03	4	Glutathione	36.84	36.55	0.78
5		36.26	35.61	1.79	5		24.79	24.52	1.08
1	Nature's	29.15	28.70	1.54	1	Citravite	34.36	34.02	0.98
2	velvet	38.11	37.81	0.78	2		30.53	30.25	0.91
3	vitamin C	39.70	39.43	0.68	3		25.32	25.03	1.14
4		27.06	26.74	1.18	4		33.74	33.40	1.00
5		27.13	26.96	0.62	5		29.68	29.39	1.14
1	Pharmagrade	24.98	24.64	1.44	1	HealthVit	39.16	38.95	0.53
2	Vitamin C	30.16	29.89	0.89	2	C-Vitan-Rh	22.61	22.35	1.14
3	tablet	38.38	38.08	0.78	3	Vitamin C	42.27	40.01	0.61
4		30.64	30.34	0.94	4		47.10	46.77	0.70
5		31.04	30.78	0.83	5		23.84	23.48	1.51
1	Nutree Pure	31.86	31.61	0.78	1	Frutcee	38.16	37.84	0.78
2	Advanced	23.98	23.77	0.87	2		24.99	24.61	1.52
3	Vitamin C	29.46	29.17	0.98	3		45.69	45.42	0.59
4	Tablet	26.41	26.11	1.13	4		51.75	51.42	0.63
5		34.55	34.26	0.83	5		28.76	28.26	1.73

APPLICATION

This titration technique can be applied in the estimation of ascorbic acid in various drug samples, vitamin supplements, food samples at laboratory conditions.

CONCLUSION

Through the results of the current work, it is concluded that, the method gives an easy, relating, quick, affordable, exact and an accurate way for the estimation of ascorbic acid in the pharmaceutical samples.

REFERENCES

[1]. K. B. Umesha, K. A. Kumar, K. M. L. Rai, Iodometric determination of ascorbic acid in bulk and Vitamin-C tablets using chloramine-T, *Oxidation Communications,* **2002**, 25(4), 566-570.

[2]. Zhao, Dake, Yang Yu, Yong Shen, Qin Liu, Zhiwei Zhao, Ramaswamy Sharma, Russel, J. Reiter, Melatonin syntesis and function: evolutionary history in animals and plants. *Frontiers in endocrinology,* **2019**, 10, 249

[3]. Fenech, Mario, Iraida Amaya, Victoriano Valpuesta, A. Miguel, Botella, Vitamin C content in fruits: Biosynthesis and regulation, *Frontiers in plant science,* **2019**, 9, 2006.

[4]. A. Shibata, A. Paganini-Hill, R. K. Ross, B. E. Henderson, Intake of vegetables, fruits, beta-carotene, vitamin C and vitamin supplements and cancer incidence among the elderly: a prospective study, *British journal of cancer*, **1992**, 66(4), 673-679.

[5]. Sauberlich, E. Howerde, Pharmacology of vitamin C, *Annual review of nutrition*, **1994**, 14(1), 371-391.

[6]. Hemilä, Harri, Vitamin C and infections, *Nutrients,* **2017**, 9(4), 339.

[7]. L. Mallesha, C. S. Karthik, B. K. Kendagannaswamy, H. M. Viswanatha, Investigation of Antioxidant Activity of 3, 5-Dimethoxyaniline Derivatives, *J. Applicable Chem.*, **2014**, 3, 2131-2137.

[8]. Caritá, Amanda Costa, Bruno Fonseca-Santos, Jemima Daniela Shultz, Bozena Michniak-Kohn, Marlus Chorilli, Gislaine Ricci Leonardi, *Vitamin C:* One compound, several uses. Advances for delivery, efficiencyand stability, *Nanomedicine: Nanotechnology, Biology and Medicine*, **2020**, 24, 102-117.

[9]. K. E. Manojkumar, S.Sreenivasa, N. R.Mohan, P. A. Suchetan, C. D. Raj, H. R. Naika, 2-[5-(2-fluorophenyl)-3-(trifluoromethyl)-1H-pyrazol-1-yl] benzoic acid: Synthesis, Characterization and Pharmacological Evaluation, *J. Applicable Chem.*, **2014**, 3, 64-73.

[10]. C. Jacobs, B. Hutton, T.Ng, R.Shorr, M. Clemons, Is there a role for oral or intravenous ascorbate (vitamin C) in treating patients with cancer? A systematic review, *The Oncologist*, **2015**, 20 (2), 210-223.

[11]. Gillberg, Linn, D. Andreas, Ørskov, Ammar Nasif, Hitoshi Ohtani, Zachary Madaj, W. Jakob. Hansen, Nicolas Rapin, Oral vitamin C supplementation to patients with myeloid cancer on azacitidine treatment:Normalization of plasma vitamin C induces epigenetic changes, *Clinical epigenetics*, **2019**, 11(1), 1-11.

[12]. Ezekiel, Adewole, Ojo Abiodun, Talabi Justina, Adewumi Funmilayo, Peters Omolara, Evaluation of Ascorbic Acid Contents in Selected Fruits using Iodometric method and UV Spectrophotometer, *Advances in Natural and Applied Sciences*, **2018**, 12(5), 21-24.

[13]. S. A. Mir, Z. Mohalla, L. Bazar, K. I. Srinagar, Iodometric assays for comparative evaluation of oxidants and antioxidants, *Journal of Emerging Technologies and Innovative Research*, **2019**, 6, 75-84.

[14]. D. W. Randall, L. K. Garibay, Statistical Comparison of Results of Redox Titrations Using K-2 CR-2O-7 and KIO-3 in the Undergraduate Analytical Chemistry Lab, *J. Applicable Chem.*, **2014**, 3, 1329-1336.

[15]. A. Solhjoo, H. Khajehsharifi, Multivariate calibration applied to the simultaneous spectrophotometric determination of ascorbic acid, tyrosine and epinephrine in pharmaceutical formulation and biological fluids, *Current Analytical Chemistry*, **2016**, 12, 580-593.

[16]. A. Parsa, M. Tajik, Determination of ascorbic acid using differential pulse voltammetry method on aniline-co-para–aminophenol modified electrode, *Polish Journal of Chemical Technology*, **2017**, 19, 125

[17]. Gheysen, Lor, Céline Dejonghe, Tom Bernaerts, Ann Van Loey, Luc De Cooman, Imogen Foubert. Measuring Primary Lipid Oxidation in Food Products Enriched with Colored Microalgae, *Food Analytical Methods*, **2019**, 12(10), 2150-2160.

[18]. M. Łabańska, P. Ciosek-Skibińska, W. Wróblewski, Critical evaluation of laboratory potentiometric electronic tongues for pharmaceutical analysis-an overview, *Sensors*, **2019**, 19, 5376.

[19]. H. S. Gowda, S. A. Ahmed, N-substituted phenothiazines as indicators in titrations with chloramine-T, *Analytica Chimica Acta*, **1978**, 99, 343-349.
[20]. A. R. Meyer's, C. G. Taylor, Determination of ascorbic acid in multivitamin tablets by thermometric titrimetry with cerium (IV), *Analyst*, **1987**, 112, 507.
[21]. K. B. Umesha, K.M. L. Rai, K. A Kumar, Iodometric estimation of ascorbic acid in bulk and vitamin- c tablets using chloramine-T, *Oxidation communication*, **2002**, 4, 566-570.
[22]. K. M. L. Rai, C. Anjanamurthy, S. Y. Ambekar, Determination of iodine number of oils using Chloramine-T as reagent, *Analyst*, **1995**, 120, 2769.
[23]. K. M. L. Rai, K. B.Umesha, H. S. Yathirajan, Determination of molecular weight of neutral amino acids with chloramine-T, *J. Ind. Chem. Soc*., **1999**, 76, 170.
[24]. K. B.Umesha, K. M. L.Rai, K. A. Kumar, A New Approach to the Determination of the Number ofOxo Groups in Carbonyl Compounds Using the Chloramine-T Oxidative Method, *Chem. Anal.*, **2001**, 46, 269