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Eco-Friendly use of *Solanum tuberosum L.* in Quantitative Analysis Involving Redox Reactions-An Attempt towards Fuel Saving and Pollution Control

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Abstract

Lipoxygenase from potato tuber is reported to be used for oxidation of fatty acids and fatty alcohols. Potassium permanganate was standardised by titrating against standard solution of oxalic acid in the presence of potato tuber pieces (*solanum tuberosum L*), without heating, and with minimum quantity of sulphuric acid. Results were in good agreement with those obtained by the literature procedure involving no use of potato tuber. The standardized $KMnO_4$ was used for the estimation of sodium nitrite and potassium nitrite in the presence of potato tuber. Percentage purity of manganous sulphate in terms of manganese was also determined by titrating against standardized potassium permanganate in the presence of potato tuber. Methodology is eco-friendly.

Keywords: Potato tuber; Lipoxygenase; Potassium permanganate; Nitrite and manganous sulphate

Introduction

Potato tuber (*Solanum tuberosum L.*) is known to contain the enzyme lipoxygenase [1], along with other enzymes like catalase and amylase. Literature survey reveals that potato tuber Lipooxygenase has been used for oxidation of fatty acids like linoleic acid (Tables 1a and 1b), and alcohols like linoleyl alcohol [2]. Ripening of apples [3] starts with maturity controlled degradation of fatty acids by lipoxygenase into hexanal, followed by oxidation of aldehyde into hexanoic acid and further smaller carboxylic acids.

Lipooxygenase is an oxygenating enzyme. It is expected to oxidize the species like carboxylic acids, nitites, low violent metal ions, etc. Purpose of this study is to use the oxygenating property of lipoxygenase to develp an eco-friendly method based on use of potato tuber, for quantitative analysis involving redox reactions.

Present Work

Reports [Table 1b and Table 2] on oxidation of fatty acids and fatty alcohols by potato tuber lipoxygenase attracted our attention to investigate the use of potato tuber in quantitative analysis involving redox reactions. In view of the cost of the chemicals, time required and pollution; it is immense need of the time to use green chemistry in laboratories and industries.

Potassium permanganate is an important common oxidizing agent [4]. There are many volumetric analysis experiments based on potassium permanganate as the oxidant. In these experiments it is necessary to first standardize the given solution of $KMnO_4$. Oxalic acid is the primary standard used to standardize the potassium permanganate.

1	In Burette	$KMnO_4$ solution
2	In conical flask	10 cm^3 0.1 N Oxalic acid solution+20 cm^3 2 N $H2SO_4$
3	Indicator	$KMnO_4$ itself
4	End point	Colourless to pink

Table 1 (a): The normality of oxalic acid.

Level	Burette Readings cm^3			CBR X cm^3	Standard Deviation	Exact Normality of $KMnO_4$
	1	2	3			
Final	10.20	10.30	10.30			
Initial	00.00	00.00	00.00	10.30	0.0469	0.097 N
Difference	10.20	10.30	10.30			

(Exact normality of $KMnO_4$ was calculated using the formula, $N_1V_1=N_2V_2$)

Table 1 (b): Burette readings: Pilot Reading 10.00 to 11.00 cm^3

In this standardization procedure [4], about 20 cm^3 (one test tube) of 2N sulphuric acid solution is added to oxalic acid solution, and solution is heated up to 60-80°C. The hot solution is titrated against $KMnO_4$ solution. Exact normality is obtained from the constant burette reading (CBR) [5].

In view of saving fuel and reducing the volume of sulphuric acid, i.e. pollution control factor, we thought it worthwhile to investigate the use of potato tuber pieces as co-catalyst in quantitative analysis involving redox reactions, and to develop an eco-friendly procedure.

In the present work, potassium permanganate was standardized by titrating against standard oxalic acid solution, in the presence of potato tuber pieces without heating the reaction mixture prior to titration, and using minimum volume of sulphuric acid. Standardized potassium permanganate was used for estimation of sodium nitrite, potassium nitrite, and percentage purity of manganese sulphate in terms of manganese. There are no reports in the literature about use of potato tuber pieces in quantitative analysis involving redox reactions.

Reactions

Standardisation of potassium permanganate:

$$2KMnO_4 + 3H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 3H_2O + 5(O)$$

$$5H_2C_2O_4 + 5(O) \rightarrow 10CO_2 + 5H_2O$$

$$2KMnO_4 + 3H_2SO_4 + 5H_2C_2O_4 \rightarrow K_2SO_4 + 2MnSO_4 + 8H_2O + 10CO_2$$

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Determination of nitrite:

$$2KMnO_4 + 3H_2SO_4 \rightarrow K_2SO_4 + MnSO_4 + 3H_2O + 5(O)$$

$$5KNO_2 + 5(O) \rightarrow 5KNO_3$$

$$2KMnO_4 + 3H_2SO_4 + 5KNO_2 \rightarrow K_2SO_4 + 2MnSO_4 + 3H_2O + 5KNO_3$$

Similarly,

$$2KMnO_4 + 3H_2SO_4 + 5NANO_2 \rightarrow K_2SO_4 + 2MnSO_4 + 3H_2O + 5NaNO_3$$

Determination of percentage purity of manganous sulphate in terms of manganese:

$$2KMnO_4 + 3MnSO_4 + 2H_2O \rightarrow K_2SO_4 + 5MnO_2 \downarrow + 2H_2SO_4$$

Experimental

Oxalic acid (about 0.1 N) solution and Potassium permanganate solution (approx 0.1 N) were freshly prepared. Pieces of fresh potatoes available in the local market were used. Potasium nitrate, sodium nitrate, manganous sulphate and zinc oxide used were of analytical grade.

Standardization of potassium permanganate solution (Routine Procedure[3]): To oxalic acid solution (10 cm^3) in a 100 cm^3 conical flasks was added with sulphuric acid solution (2 N, 20 cm^3), and the mixture was heated to about 80°C. The hot solution was titrated against approx. 0.1 N potassium permanganate solutions, till permanent pink color developed. The normality of oxalic acid was determined from CBR (Tables 1a and 1b).

Determination of normality of potassium permangnate solution (Using potato pieces): To oxalic acid solution (0.1 N, 10 cm^3) was added sulphuric acid solution (5 cm^3, 2 N) in a 100 cm^3 conical flasks. To this solution, weighed amount of potato pieces were added and stirred. The solution was titrated without heating against potassium permanganate solution, till permanent pink colour developed. Normality of potassium permanganate solution was determined from CBR (Tables 2a and 2b).

Determination of amount of Nitrite in the stock solution: Stock solution of nitrite was prepared by dissolving 1.1 g of nitrite in 250 cm^3 distilled water.

Titration using routine procedure (without potato pieces): To potassium permanganate solution (0.1 N, 10 cm^3) in a 500 cm^3 conical flasks, was added sulphuric acid solution (1 N, 225 cm^3). This solution was heated to 40 to 50°C and hot solution was titrated against nitrite solution with constant stirring, and slow addition till pink colour disappeared. Tip of the burette was immersed deep in the $KMnO_4$ solution. Three burette readings were recorded and CBR was recorded as X cm^3 (Tables 3a-3c).

1	In Burette	$KMnO_4$ solution
2	In conical flask	10 cm^3 0.1N Oxalic acid+5 cm^3 2 N H_2SO_4+potato pieces
3	Indicator	$KMnO_4$ itself
4	End point	Colourless to pink

Table 2a: Normality of potassium permanganate solution was determined from CBR.

Sr. No.	Weight of potato pieces	Volume of $KMnO_4$ consumed cm^3			CBR Y cm^3	Standard Deviation	Normality of $KMnO_4$
		1	2	3			
1	1.00 g	10.60	10.60	10.50	10.60	0.04795	0.094 N
2	0.500 g	10.70	10.50	10.70	10.70	0.04764	0.093 N
3	0.250 g	10.60	10.60	10.50	10.60	0.04795	0.094 N
4	0.100 g	10.60	10.60	10.50	10.60	0.04795	0.094 N

Table 2b: Burette Readings: Pilot Reading 10.00 to 11.00 cm3.

Titration using potato tuber pieces: To potassium permanganate solution (0.1 N, 10 cm^3) in a 100 cm^3 conical flask, was added sulphuric acid solution (1 N, 90 cm^3). To this solution, potato pieces were added and the solution was slowly titrated against nitrite solution with constant stirring, till pink color disappeared. Tip of the burette was immersed deep in the $KMnO_4$ solution. Three burette readings were recorded and CBR was recorded as Y cm^3 (Tables 4a-4c).

Calculations:

A. For sodium nitrite

Factor used: 1 cm^3 1N $KMnO_4$ =0.0345 g $NaNO_2$

B. For potassium nitrite

Factor used 1 cm^3 1N $KMnO_4$ =0.0445 g KNO_2

Determination of manganese by Volhard's method

Stock solution of Manganese: 4% Stock solution was prepared in distilled water.

Routine procedure: 15 cm^3 of stock solutions were diluted to 100 cm^3 with distilled water. 10 cm^3 of this solution was taken in a 100 cm^3 conical flask. To this solution, ½ test tube of zinc oxide paste was added. The solution was heated on water bath to 40 to 60°C. To the hot solution, 2 to 3 drops of 2 N HNO_3 solutions were added to promote the settling of the precipitate of manganese dioxide at the bottom. The hot solution was titrated against 0.05 N (approx.) potassium permanganate solution, till faint pink color developed. The CBR was recorded as 'X' cm^3 (Tables 5a and 5b).

Procedure using potato tuber pieces: 15 cm^3 of stock solutions were diluted to 100 cm^3 with distilled water. 10 cm^3 of this solution was taken in a 100 cm^3 conical flask. To this solution, ½ test tube of zinc oxide paste was added. To the solution, potato pieces and 2 to 3 drops of 2 N HNO3 solutions (to promote the settling of the precipitate of manganese dioxide at the bottom) were added. The solution was titrated against 0.05 N (approx.) potassium permanganate solution, till faint pink color developed. The CBR was recorded as 'Y' cm^3 (Tables 6a and 6b).

Calculations: Exact normality of $KMnO_4$ was found to be 0.049 N, from titration against 0.05 N oxalic acid.

1	In Burette	Nitrite solution
2	In conical flask	10 cm^3 0.1 N $KMnO_4$ + 225 cm^3 1 N H_2SO_4
3	Indicator	$KMnO_4$ itself
4	End point	Pink to colourless

Table 3a: Three burette readings were recorded and CBR was recorded as X cm^3 for sodium nitrite.

Level	Burette Readings cm^3			CBR X cm^3	Standard Deviation	Amount of $NaNO_2$ found
	1	2	3			
Final	7.60	7.60	7.60			
Initial	0.00	0.00	0.00	7.60	0.00	1.058 g
Difference	7.60	7.60	7.60			

Table 3b: Burette readings. For sodium nitrite: Pilot Reading: 7.00 to 8.00 cm^3

Level	Burette Readings			CBR X cm^3	Standard Deviation	Amount of KNO_2 found
	1	2	3			
Final	11.60	11.60	11.40			
Initial	0.00	0.00	0.00	11.60	0.0943	1.099 g
Difference	11.60	11.60	11.40			

Table 3c: For potassium nitrite: Pilot reading 11.00 to 12.00 cm^3.

The percentage purity of $MnSO_4$ was calculated using following factor

1 cm³ 0.05 N $KMnO_4$=0.000824 g Mn.

Discussion

Results show that results obtained from both procedures are nearly same. Standard deviation in burette readings is within limit. The catalysis of reaction may be due to oxygenating property of the lipoxygenase present in potato tuber. Use of potato pieces makes the procedure eco-friendly.

Fuel saving

Important thing in this procedure is that it is not necessary to heat the solution prior to titration, which is required in routine procedure. This saves a lot of fuel –LPG gas.

Pollution Control

Normality of $KMnO_4$: All practical books describe the addition of about 1 T.T. (20 cm³) 2 N sulphuric acid to oxalic acid solution. Each pair of students has to take four burette readings, i.e. 80 cm³ of 2N sulphuric acid will be required. For 600 pairs, about 48 Litre 2N sulphuric acids will be required.

But if we use potato pieces, only 12 Litre of 2 N sulphuric acid will be enough. Thus, this procedure reduces wastage of sulphuric acid and minimizes pollution.

Percentage purity of manganous sulphate: Routine procedure requires 225 cm³ of 1 N H_2SO_4 for one reading, whereas in eco-friendly procedure, only 90 cm³ of 1 N H_2SO_4 is enough.

Conclusion

Potato tuber, i.e. *Solanum tuberosum* L. contains 9-lipohydroxy oxygenase enzyme along with other enzymes. Lipoxygenase catalyses the oxidation. It is deoxygenating enzyme. In this work, it is observed that in the presence of tuber pieces, it is not necessary to heat the reaction mixture prior to titration and quantity of the acid required is also very low, about 25% of that required in routine procedure. This implies that potato tuber enzyme acts as co-catalyst and catalyses the oxidation of oxalic acid, nitrites and manganous sulphate, this may be due to increased concentration of oxygen in the reaction mixture.

Thus, if this eco-friendly procedure is used in school and college laboratories, it will be helpful to save fuel and control the pollution.

1	In Burette	Nitrite solution
2	In conical flask	10 cm³ 0.1 N $KMnO_4$+90 cm³ 1 N H_2SO_4+potato pieces (0.5 g for $NaNO_2$ and 2.00 g for KNO_2
3	Indicator	$KMnO_4$ itself
4	End point	Pink to colourless

Table 4a: Three burette readings were recorded and CBR was recorded as X cm3 for nitrite solution.

Level	Burette Readings cm³			CBR Y cm³	Standard Deviation	Amount of $NaNO_2$ found
	1 cm³	2 cm³	3 cm³			
Final	7.90	7.90	7.80	7.90	0.0469	1.098 g
Initial	0.00	0.00	0.00			
Difference	7.90	7.90	7.80			

Table 4b: Burette Readings (In the presence of potato pieces). For sodium Nitrite (Stock solution: 1.1g/250cm³): Pilot Reading 7.00 to 9.00 cm³

Level	Burette Readings cm³			CBR Y cm³	Standard Deviation	Amount of KNO_2 found
	1 cm³	2 cm³	3 cm³			
Final	11.20	11.20	11.20	11.20	0.00	1.1 g
Initial	0.00	0.00	0.00			
Difference	11.20	11.20	11.20			

Table 4c: For potassium nitrite (Stock solution: 1.1 g/250 cm³): Pilot Reading 11.00 to 12.00 cm³

1	In Burette	0.05 N (approx.) $KMnO_4$ solution
2	In conical flask	10 cm³ $MnSO_4$ solution+½ TT ZnO paste+2-3 drops of 2 N HNO_3
3	Indicator	$KMnO_4$ itself
4	End point	Colourless to faint pink

Table 5a: Three burette readings were recorded and CBR was recorded as X cm³ for potassium permanganate solution.

Level	Burette Readings			CBR X cm³	Standard Deviation	Percentage purity of $MnSO_4$
	1 cm³	2 cm³	3 cm³			
Final	23.10	23.00	23.10	23.10	0.16	84.89%
Initial	00.0	00.0	00.0			
Difference	23.10	23.00	23.10			

Three burette readings were recorded and CBR was recorded as X cm³ for potassium permanganate solution: Procedure using potato tuber pieces.

Table 5b: Burette Readings: Pilot Reading 23.00 to 24.00 cm³

1	In Burette	0.05 N (approx.) $KMnO_4$ solution
2	In conical flask	10 cm³ $MnSO_4$ solution+½ TT ZnO paste+2-3 drops of 2 N HNO_3+potato pieces (2.5g)
3	Indicator	$KMnO_4$ itself
4	End point	Colourless to faint pink

Table 6a: The CBR was recorded as 'Y' cm³ by using potassium permanganate solution.

Level	Burette Readings			CBR Y cm³	Standard Deviation	Percentage purity of $MnSO_4$
	1 cm³	2 cm³	3 cm³			
Final	22.80	22.90	22.80	22.80	0.0469	84.34%
Initial	00.00	00.00	00.00			
Difference	22.80	22.90	22.80			

Table 6b: Burette Readings: Pilot Reading 22.00 to 23.00 cm³

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References

1. Kharchenko OV, Kulinichenko HI, Butovych IA (1999) Kinetic mechanisms of linoleic acid oxidation by 5-lipoxygenase from *Solanum tuberosum L.* Ukr Biokhim Zh 71: 40-44.
2. Galliard T, Phillips DR (1971) Lipoxygenase from potato tubers. Partial purification and properties of an enzyme that specifically oxygenates the 9-position of linoleic acid. Biochem J 124: 431-438.
3. Butovich IA, Lukyanova SM, Reddy CC (1998) Oxidation of linoleyl alcohol by potato tuber lipooxygenase: possible mechanism and the role of carboxylic group in substrate binding. Biochem Biophys Res Commun 249: 344-349.
4. De Pooter HL, Schamp NM (1989) Involvement of lipoxygenase-mediated lipid catabolism in the start of the autocatalytic ethylene production by apples (cv Golden Delicious): A ripening hypothesis. Acta Hortic.
5. Jeffery GH, Bassett J, Mendham J, Denney RC (1978) Vogel's Text book of Inorganic Quantitative Chemical Analysis. (5th Edn), John Wiley and Sons, New York, USA.
6. Adhav SR, Date SG, Pol PG, Kulkarni GC, Bhave AS (2000) Manganese by Volhard's method, Practical Chemistry for T. Y. B. Sc. (2nd Edn), Manali Publication, Pune 129.