

Utilization of Used-Up Consumer Product Razor Blade for Developing New Experiment

Sudesh Bhaskar Ghoderao

Associate Professor

Department of Chemistry,

RNC Arts, JDB Commerce and NSC Science College, Nashik Road, Nashik, India.

Abstract: The razor blade has become a commonly available article or consumer product of everyday use. In the present work the double edge stainless steel blades available of some companies in market have been analyzed for their quantitative chemical composition, especially for their important constituents - iron, chromium and to a less extent nickel. Gravimetric method is used for analysis of iron, whereas volumetric method is used for determination of chromium. The spectrophotometric method is tried for estimating nickel. The determination of iron, chromium and nickel from used-up razor blade are newer alternative for usual samples of stainless steel. The work in this study is such that the student of chemistry may get its benefit in learning of experiment developed involving analysis of a common used-up consumer product, razor blade. The student may later think about the relationship between the properties and composition of the material also. This is an attempt for designing an experiment for Analytical Chemistry which may be necessarily incorporated in the practical curriculum for post graduate students of chemistry.

IndexTerms - Chemistry Education, Pedagogy, Low Cost Experiment, Razor Blade, Stainless Steel.

I. INTRODUCTION

The razor blade is used in almost all the houses. Its basic use is for shaving. In the early safety razors, carbon steel razor blade was the replaceable part to be changed after three or four shaves. As more and more people discarded ordinary razors and started shaving with safety razors, the demand for razor blades grew by leaps and bounds. Today blade- making happens to be one of the major industries of the world.

Initially there was used carbon steel for preparing razor blades. This is the martensitic stainless steel, a ternary alloy containing iron, chromium and carbon (18 % Cr and 0 - 7% C) [1] which is useful for cutlery, cutting tools and razor blades. The presence of carbon permits heat treatment for producing a fine cutting i.e. wear-resistant and corrosion-resistant edge.

A major advance in razor blade technology was the use of stainless steel [2, 3] instead of carbon steel. In fact, stainless steel came in mainly because of its suitability for the new technique of polymer coating on the edge. The stainless steel blades outperform carbon steel blades in shaving comfort, durability and resistance to corrosion.

The further development in razor blade technology is sputtering a noble metal like platinum on the blade edge to make it extra smooth and durable. Together with new techniques of heat treatment, grinding and stropping the sputtered and coated stainless steel blade of today is a far cry from the primitive razor. One can say, however, that the study of chemical composition of razor blade may be considered to be important for chemistry practical.

The razor blade has become a commonly available article or consumer product of everyday use. It is also thought, naturally, that whether the used-up blade (although considered as a waste) may be useful for any other purpose. It has been considered previously as a source of iron for determining iron by redox titrations like Fe (II)-Cr (VI) reaction using HgCl_2 - SnCl_2 , method [4] or TiCl_3 method [5]. There was also an investigatory project on corrosion and rusting of different brands of blades [6]. There is, however, no report on detailed study of chemical composition of blades.

In the present work the double edge stainless steel blades available of some companies in market have been analyzed for their quantitative chemical composition, especially for their important constituents - iron, chromium and to a less extent nickel. Gravimetric method is used for analysis of iron, whereas volumetric method is used for determination of chromium. The spectrophotometric method is tried for estimating nickel. This is, thus, an attempt for designing an experiment for Analytical Chemistry.

II. THEORETICAL BACKGROUND

Preparation of sample, suitable for disintegration:

The used-up blade may have certain material deposited on it which may develop scales on it. The adhering material may be waxy material (used before packing the blade), shaving cream, hair, or, dust particles, etc. Before starting analysis the blade is first cleaned with water, followed by organic solvent such as alcohol or acetone [4, 5]. Then it is dried and weighed.

Disintegration of sample [4]

The weighed sample of blade is disintegrated by heating it with hydrochloric acid (1:1) when all the constituents i.e. metals get converted to their chlorides which remain in soluble form. It is diluted on cooling to a known volume.

Separation of chromium, iron and nickel

An aliquot of the above-mentioned diluted solution is treated with sodium hydroxide (2 M) and hydrogen peroxide (6%) followed by heating. With this oxidizing agent, chromium (III) is converted to chromate i.e. chromium (VI), iron (II) is converted to iron (III) and alkali helps to precipitate the iron (III) hydroxide and nickel (II) hydroxide. The precipitated hydroxides are separated by filtration. The precipitate is washed with hot water till free from chloride. To the filtrate are added the washings. To this solution containing chromium (VI) is added sulphuric acid (conc.) till acidic and it is diluted to a known volume. In this, chromate on acidification gets converted to dichromate.

The precipitate containing hydroxides of iron and nickel is dissolved in hydrochloric acid (1:1). On treatment with ammonia (1:1) and ammonium chloride, iron is reprecipitated as $\text{Fe}(\text{OH})_3$ while nickel forms soluble $[\text{Ni}(\text{NH}_3)_6]^{2+}$. The precipitate is digested for half an hour, filtered, and washed with ammonium nitrate solution (1 %) till free from chloride. The filtrate and washing containing nickel as $[\text{Ni}(\text{NH}_3)_6]^{2+}$ are diluted together to a known volume.

Determination of chromium by volumetry (Redox titration)

Chromium is determined by back and blank titration. In back titration a known excess of Fe (II) solution is added to chromium (VI) solution and the excess Fe (II) reacts with standard potassium dichromate. In blank titration aliquot of Fe (II) solution same as that used for back titration is titrated against standard potassium dichromate solution. An internal indicator diphenylamine is used in Fe (II)-Cr (VI) titration and phosphoric acid is added before the titration. Phosphoric acid complexes with Fe (III) (which if present and when forms in solution) and avoids its conversion to Fe (II). By taking the difference in readings of blank and back titration and using following relation the chromium content can be calculated.

Equivalent for titrimetry: $K_2Cr_2O_7 / 6 = Fe / 1 = FeSO_4 / 1 = Cr / 3$

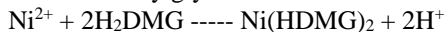
Determination of iron by gravimetry [7]

The precipitate of hydrated ferric oxide is ignited in a silica crucible till constant weight is obtained and then weighed as Fe_2O_3 . From this the amount of iron is calculated using following relationship.

Equivalent of gravimetry: $Fe_2O_3 / 2 = Fe / 1$

Determination of nickel by spectrophotometry [7, 8]

When dimethylglyoxime is added to an ammoniacal solution containing nickel ions, a pink red coloration is obtained.



This reaction is made more sensitive using an oxidizing agent such as bromine water. The oxidation by hypobromite formed is complete in one-to-two minutes. The red complex formed here contains nickel in a higher valency state. This has been regarded as nickel (III)-dimethylglyoximate and also as nickel (IV) dimethylglyoximate. The complex formed which is insoluble in chloroform absorbs at 445 nm, provided absorbance readings are made within 10 minutes of mixing.

The "dimethylglyoxime oxidizing agent method" is different from the "nickel (II)-dime thylglyoxime" method. The later yields a nickel (II)-dimethylglyoximate, soluble in chloroform and this step is used initially to make nickel free from other transition metal ions. The nickel (II)-dimethylglyoximate goes in chloroform layer while other metal ions remain in aqueous phase. The chloroform layer may be decomposed by shaking with dilute hydrochloric acid. Nickel is transferred to aqueous phase, whereas dimethylglyoxime remains in the chloroform. Now the "Ni-DMG oxidizing agent method" is used. Prior to it, also, citrate is added to prevent interference of iron (if any). The color of Ni-DMG is developed again for the aqueous phase using bromine water and ammoniacal solution. The intensity of this color is measured.

The method of spectrophotometry requires the construction of a standard curve for the constituent being determined (here nickel (II)). Suitable quantities of the unknown or sample solution are taken and treated in the same way as those of standard solution for the development of color. The measurements of the optical density at the optimum wavelength are done. The optical density, is plotted against the concentration (or volume in mL), a straight line plot is obtained for standard in the range where Beer's law is obeyed. The curves or lines for standard and sample then may be used for the determination of constituent (here nickel (II)) in the sample.

III. EXPERIMENTAL

The setting of procedure is done by using a synthetic mixture prepared from stock standard solutions of iron, chromium and nickel. The work is presented as

- Preparation of stock solutions of iron, chromium and nickel
- Standardization of these metal stock solutions
- Preparation of synthetic mixture
- Analysis of this synthetic mixture
- Analysis of razor blades for iron, chromium and nickel.

The detailed procedure is given below and the results are given in Table 2. The results of some of the commonly used razor blades mentioned as 'stainless steel' blades are used for the analysis are given in Table 3.

(a) Preparation of metal stock solutions:

Iron (III) solution (10 mg/mL): 8.630 g of $NH_4Fe(SO_4)_2 \cdot 12H_2O$ is dissolved in ~ 50 mL water containing - 5 mL of H_2SO_4 (3 M) and the solution is diluted to 100 mL exactly.

Chromium (III) solution (8 mg/mL): 4.099 g $CrCl_3 \cdot 6H_2O$ is dissolved in ~50 ml water containing a trace of concentrated HCl and the solution is diluted to 100 mL exactly.

Nickel (II) solution (3 mg/mL): 1.48625 g of $Ni(NO_3)_2 \cdot 6H_2O$ is dissolved in ~50 mL water containing ~ 1 mL of HNO_3 (1 M) and the solution is diluted to 100 mL exactly.

(b) Standardization of metal stock solutions:**Standardization of Fe (III) solution**

Reagents: Sulphuric acid (3 M), Zinc dust, Phosphoric acid (85%) and Potassium dichromate (standard solution) (0.025 N)

Diphenylamine indicator (1 %): This is 1% solution of diphenylamine in H_2SO_4 (conc.).

Procedure:

An aliquot of 10 mL from stock solution of Fe (III) is taken in a 100 ml volumetric flask. It is diluted with water upto the mark. Then, 25 mL of this diluted solution is pipetted out in a conical flask. To it 10 mL of sulphuric acid (3 M) is added. It is heated to ~ 70 °C on hot plate and - 0.5 g of zinc dust is added. The conical flask is covered with a watch glass. After 5 min, 5 mL of sulphuric acid (3 M) is added. The flask is swirled until all the zinc dust is consumed and evolution of hydrogen gas has stopped. To this solution 5 mL of sulphuric acid (3 M), 5 mL of phosphoric acid (85 %) and 3 drops of diphenylamine indicator (1 %) are added. The solution is titrated with standard $K_2Cr_2O_7$ solution (0.025 N) until persistent blue-violet color is obtained. The blank titration is carried out..

For the standardization, 25 ml of diluted iron solution gives the mean burette reading: 19.5 mL of $K_2Cr_2O_7$ (0.025 N)

1mL 1N $K_2Cr_2O_7$ = 55.85 mg Fe

19.5 mL 0.025 N $K_2Cr_2O_7$ = $(55.85 \times 0.025 \times 19.5)$ mg Fe
= 27.2268 mg Fe

i.e. 25 mL aliquot of diluted solution contains 27.2268 mg Fe

Therefore, 100 mL diluted solution will contain 108.9075 mg of Fe

- i.e. 10 mL of stock solution contains 108.9075 mg of Fe
- i.e. 1 mL of stock solution contains 10.89075 mg of Fe
- i.e. the prepared stock solution of Fe (III) is 10.89 mg/mL.

Standardization of chromium (III) solution:

Reagents: H_2O_2 (6%),

Ammonium ferrous sulphate (~ 0.025 N): 4.90175 g of $(\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$ is dissolved and diluted to 500 mL with water.

Sodium hydroxide (2 M): 8 g of NaOH pellet dissolved and diluted to 100 mL.

Procedure:

To an aliquot of 5 mL of stock solution of Cr (III) are added 15 mL NaOH (2 M) and 3 mL H_2O_2 (6%). Then, this mixture is boiled in water bath till oxygen is expelled. Then it is diluted to 250 mL exactly.

Back titration:

An aliquot of 10 mL of this diluted solution is taken in a conical flask and made acidic with sulphuric acid (3 M). To this acidified solution, excess 5 mL of sulphuric acid (3M) and exactly 25 mL of ammonium ferrous sulphate (0.025 N) is added. It is titrated against standard $\text{K}_2\text{Cr}_2\text{O}_7$ solution (0.025 N), after adding 2-3 drops of diphenylamine indicator, till the color changes from faint pink to violet blue.

Blank titration:

To an aliquot of 25 mL of ammonium ferrous sulphate (~ 0.025 N) of same stock solution are added ~ 6 mL of H_2SO_4 (3 M) and 2-3 drops of diphenylamine indicator. It is titrated against standard $\text{K}_2\text{Cr}_2\text{O}_7$ solution (0.025 N) till color changes from light green to violet blue.

For the present study, it is seen that the mean titration readings for each of the titrations are as follows:

Blank titration: 25.0 mL of $\text{K}_2\text{Cr}_2\text{O}_7$ (0.025 N)

Back titration: 21.3 mL of $\text{K}_2\text{Cr}_2\text{O}_7$ (0.025 N)

(Blank-Back) reading =: 3.7 mL of $\text{K}_2\text{Cr}_2\text{O}_7$ (0.025 N)

1 mL 1 N $\text{K}_2\text{Cr}_2\text{O}_7$ = 17.33 mg Cr

Therefore, 3.7 mL 0.025 N $\text{K}_2\text{Cr}_2\text{O}_7$ = $(3.7 \times 0.025 \times 17.33)$ mg of Cr
= 1.60302 mg Cr

i.e. An aliquot of 10 mL diluted solution contains 1.60302 mg Cr

Therefore, 250 mL diluted solution will contain 40.0756 mg Cr

i.e. 5 mL Cr (III) stock solution (~ 8 mg/mL) contains 40.0756 mg Cr

The prepared stock solution is of Cr (III) is (8.01510 mg/mL).

Standardization of nickel (II) solution:

Reagents: Standard zinc solution (0.01 M), EDTA solution (0.01 M), Ammonia-ammonium chloride buffer (pH = 10) and Eriochrome black-T indicator (1 %), Hydrochloric acid (9 M): 76.2 mL of hydrochloric acid is diluted to 100 mL.

Procedure

Standardization of EDTA solution

An aliquot of 10 mL of standard zinc ion solution (0.01 M) is taken in a conical flask with pipette and neutralized with dilute ammonia (1:1). To it is added 10 mL distilled water, 2 mL buffer (pH 10) and Eriochrome Black-T indicator. The solution is titrated versus EDTA (approx. 0.01 M) till the end point as wine red to blue is obtained.

The standardization of Ni (II) solution is done by indirect method or complexometry.

Blank titration: It is carried out by taking 25 mL aliquot of EDTA (approx. 0.01 M) in a conical flask and titrating it against standard Zn (II) solution.

Back titration: An aliquot of 10 mL of the Ni (II) stock solution is diluted to 25 mL with hydrochloric acid (9 M). Then 5 mL of this diluted solution is taken in a conical flask to which exact 25 mL of EDTA solution (approx. 0.01 M) from same stock solution (as used for blank) is added. After neutralizing with 1:1 ammonia are added 5 mL ammonia-ammonium chloride buffer solution (pH = 10) and 5 drops of Eriochrome Black-T indicator. The contents of flask are titrated against standard zinc solution (0.01 M) till the end point blue to wine red color appears.

For the present study the observations are as follows:

Blank titration: 25.0 mL of Zn (II) solution (0.01 M)

Back titration: 14.7 mL of Zn (II) solution (0.01 M)

(Blank-Back) reading = 10.3 mL of Zn (II) solution.

The molarity of EDTA being exactly 0.01 M i.e. similar to that of Zn (II) solution, the same volumes of EDTA solution may be taken for calculating the concentration of Ni (II) solution.

1 mL 1M EDTA = 58.71 mg Ni

Therefore, 10.3 mL 0.01 M EDTA = $(10.3 \times 0.01 \times 58.71)$ mg Ni
= 6.0471 mg Ni

i.e. An aliquot of 5 mL diluted solution contains 6.0471 mg Ni

Therefore, 25 mL diluted solution will contain 30.2356 mg Ni

i.e. 10 mL of Ni (II) stock solution contains 30.2356 mg Ni

The prepared stock solution of Ni (II) is (3.0235 mg/mL).

(c) Preparation of synthetic mixture

Assuming the general composition of stainless steel as Fe (85 %), Cr (14 %) and Ni (1 %) the synthetic mixture for analysis has been prepared by mixing known volumes of previously standardized stock solutions of iron, chromium and nickel. The mixture containing 17.0 mL stock iron (III) solution + 2.0 mL of stock chromium (III) solution + 1.0 mL of stock nickel (II) solution is diluted to 100 mL with water in a volumetric flask and used for further analysis.

The expected amounts of iron (III), chromium (III) and nickel (II) in it can be calculated as follows:

100 mL of mixture contains,

17.0 mL of stock iron (III) (10.8908 mg/mL) solution (185.1436 mg Fe)

2.0 mL of stock chromium (III) (8.0151 mg/mL) solution (16.0302 mg Cr)

1.0 mL of stock nickel (II) (3.0235 mg/mL) solution (3.0235 mg Ni)

Therefore, an aliquot of 1 mL of above synthetic mixture contains 1.8514 mg Fe (III), 0.1603 mg Cr (III) and 0.0302 mg Ni (II).

(d) Analysis of the synthetic mixture for Fe (III), Cr (III) and Ni (II)

Reagents: HCl (1:1), Ammonia (1:1), K₂Cr₂O₇ standard solution (0.025 N), Ferrous ammonium sulphate (~ 0.025 N), Sodium hydroxide (2 M), Sulphuric acid (2 M), H₂SO₄ (6 %), Diphenyl amine indicator (1 %), Ammonia (conc.), Chloroform

Ammonium nitrate (1 %): 1 g solid NH₄NO₃ dissolved in water to get 100 mL solution.

Silver nitrate (0.1 g): 0.1 g AgNO₃ dissolved in 100 mL of water.

Citric acid (10 %): 10 g citric acid dissolved in water to give 100 mL solution.

Dimethyl glyoxime (1 %): 1 g of dimethylglyoxime in 100 mL of absolute alcohol.

Ammonia (1:30): Mixed 1 volume of ammonia (conc.) with 30 volume of water.

Hydrochloric acid (0.5 M): 4.4 mL of concentrated HCl is diluted to 100 mL.

Bromine water: (saturated i.e. ~ 0.2 M): 1.1 mL (3.25 g) of liquid bromine is dissolved in ~ 100 mL water.

Standard Ni (II) solution for spectrophotometry (0.01 mg/mL): It is prepared from the stock solution of Ni (II) (0.030235 mg/mL). From this solution is taken an aliquot of 33.1 mL and diluted to 100 mL exactly which will be the solution of Ni (II) (0.01001 mg/mL).

Procedure:

To an aliquot of 50 mL of the diluted synthetic mixture solution, 20 mL of NaOH (2 M) and 10 mL of H₂O₂ (6 %) are added. It is heated till all oxygen is evolved. Then solution is cooled and digested for half an hour. The precipitate of hydroxides of iron and nickel is filtered through filter paper. The precipitate is washed till free from alkali. The washings and filtrate are diluted to 250 mL capacity using a volumetric flask (Filtrate 1).

The precipitate is dissolved in minimum amount of hydrochloric acid (1:1). The resulting solution is heated to boil and treated with 4 g of ammonium chloride and ammonia (1:1) to precipitate iron (III) hydroxide completely. The precipitate is digested for half an hour. It is filtered through Whatman No. 41 filter paper. The precipitate is washed with hot ammonium nitrate (1 %) solution, till the washings are free from chloride ions (as detected by silver nitrate test). The filtrate and washings are collected in a 250 mL volumetric flask and diluted up to the mark with water (Filtrate 2). While the filtration is in progress, a silica crucible with lid, is heated on burner to red heat, cooled in a desiccator and weighed (W₁). After drying the precipitate the filter paper with precipitate is folded and transferred to the weighed silica crucible. It is heated gradually, and the paper is charred. Finally, the residue is heated at a red heat till constant weight of residue. Then crucible is cooled after closing with lid in desiccator for 15 minutes and weighed as Fe₂O₃ (W₂). The difference (W₂ – W₁) gives weight of Fe (III) oxide residue, using which the amount of iron in the mixture can be calculated.

The filtrate 1 is used in back titration for chromium determination. The procedure of back and blank titration is same as in the case of standardization of Cr (III) stock solution.

The filtrate 2 is used for nickel determination by spectrophotometry. The detailed procedure for this experiment is as follows:

To 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0 mL each of the standard nickel (II) solution (0.01 mg/mL), 5 mL of citric acid (10 %) is added. The solution is neutralized with ammonia (conc.) and few drops are added in excess (pH ~7.5). To this slightly alkaline solution 2 mL of dimethylglyoxime (1 %) solution is added. It is extracted with three 3 mL portions of chloroform, shaking for 30 seconds at each time. The combined chloroform extract is shaken with 6 mL of ammonia (1: 30) and chloroform extract is taken out. The ammoniacal phase is again shaken with 2 mL chloroform and the chloroform phase is added to the main chloroform extract.

The nickel is returned to the ionic state by shaking chloroform extract vigorously for 1 minute with two 5 mL portions of hydrochloric acid (0.5 M). The hydrochloric acid solution is transferred to a 25 mL-volumetric flask. To it 5 mL water, 1 mL bromine water (saturated) and 2 mL of ammonia (conc.) are added. It is cooled (below 30°C) and to it 1 mL of dimethylglyoxime (1%) solution is added. The contents are diluted up to the mark with water. The optical densities are measured at 445 nm after 5 minutes.

Similarly, taking a series of aliquots from the filtrate 2, the colored solutions are prepared, following the same procedure described above, and optical densities are measured for each solution at 445 nm. A graph of volume in mL vs. optical density is plotted for standard solution and solution from synthetic mixture. The concentration of nickel in synthetic mixture is determined by using the values of slopes of lines for standard and sample as well as the value of concentration of standard and the following relation.

$$C_{\text{synthetic}} / C_{\text{standard}} = \text{Slope}_{\text{synthetic}} / \text{Slope}_{\text{standard}}$$

(e) Analysis of used-up razor blades for iron, chromium and nickel

Preparation of sample suitable for analysis:

The used-up razor blade is thoroughly cleaned with water followed by organic solvent such as alcohol, acetone. It is dried in air and weighed exactly.

Disintegration of sample:

The disintegration is carried out using 25 mL of hydrochloric acid (conc.), 5 mL of distilled water and heating the contents in a 250 mL conical flask covered with a stem-cut funnel. After disintegration, the solution is cooled and mixed with 50 mL of distilled water. The stem-cut funnel is rinsed and these washings are mixed with the solution. It is then warmed and filtered through a filter paper. The filter paper is washed with distilled water till it is free from acid. The filtrate and washings are collected together and diluted exactly to 250 mL. An aliquot of 50 mL of this solution is used for determination iron, chromium and nickel by using the procedure used for synthetic mixture.

IV. RESULT AND DISCUSSION

Determination of constituents of the synthetic mixture:

Determination of Fe (III) (by gravimetry):

Weight of (crucible + lid), W₁ = 31.838 g

Weight of (crucible + lid + residue) after complete ignition, W₂ = 31.970 g

Weight of residue, Fe₂O₃ = (W₂-W₁) g of Fe₂O₃

$$= 0.132 \text{ g of Fe}_2\text{O}_3 = 132.00 \text{ mg of Fe}_2\text{O}_3$$

Fe₂O₃ = 2 Fe

159.694 = 111.694

132.0 mg residue = 92.324 mg Fe

i.e. 50 mL aliquot of stock solution of the synthetic mixture contains 92.324 mg of Fe

Therefore, 100 mL of the synthetic mixture contains 184.648 mg of Fe

Determination of Cr (III) (by indirect method of redox titration):

Titration readings:

Blank titration: 25.0 mL of $K_2Cr_2O_7$ (0.025 N)

Back titration: 24.2 mL of $K_2Cr_2O_7$ (0.025 N)

(Blank-Back) readings = 0.8 mL of $K_2Cr_2O_7$ (0.025 N)

1 mL 1 N $K_2Cr_2O_7$ = 17.33 mg Cr

Therefore, 0.8 mL 0.025 N $K_2Cr_2O_7$ = $(0.8 \times 0.025 \times 17.33)$ mg Cr = 0.3466 mg Cr

i.e. An aliquot of 10 mL of filtrate 1 contains 0.3466 mg Cr

Therefore, 250 mL of filtrate 1 = 8.665 mg Cr

i.e. 50 mL of stock solution of the synthetic mixture contains 8.665 mg Cr

Therefore, 100 mL of the synthetic mixture contains 17.330 mg Cr

Determination of Ni (II) (by spectrophotometry):

From the observations are plotted the curves for standard solution and the solution obtained from synthetic mixture (Table 1).

Table 1: Optical densities of standard Ni (II) and synthetic mixture solution

Volume mL	OD for standard Ni (II) (0.01mg/mL) solution	OD for synthetic mixture solution
0.5	0.14	0.08
1.0	0.32	0.16
1.5	0.38	0.26
2.0	0.50	0.36
2.5	0.66	0.4
3.0	0.72	0.48
3.5	0.86	0.58
4.0	1.0	0.66

The slopes for standard solution (concentration as 0.01 mg/mL) and solution from synthetic mixture are 0.2686 and 0.1696 respectively.

Now,

$$\frac{C_{\text{synthetic}}}{C_{\text{standard}}} = \frac{\text{Slope}_{\text{synthetic}}}{\text{Slope}_{\text{standard}}}$$

$$\frac{C_{\text{synthetic}}}{0.01} = \frac{0.1696}{0.2686}$$

$$C_{\text{synthetic}} = 0.006314 \text{ mg/mL of Ni}$$

The concentration of filtrate 2 is 0.006314 mg/mL of Ni

Total nickel in 250 mL filtrate 2 will be 1.5785 mg

i.e. 50 mL aliquot of diluted synthetic mixture (from which filtrate is obtained) contains 1.5785 mg Ni.

Therefore, 100 mL synthetic mixture contains 3.157 mg Ni

The values of iron, chromium and nickel in synthetic mixture are summarized in Table 2.

Table 2: Expected and observed values of iron, chromium and nickel from a synthetic mixture

Metal	Expected (mg)	Observed (mg)
Iron	185.1436	184.6480
Chromium	16.0302	17.3300
Nickel	3.0235	3.1570

Determination of constituents of the razor blade:

For the razor blades analyzed in the present work, details of analysis of a representative sample-B1- are as follows and the observations and results for all the samples are given in Table 3.

Razor blade sample: B1

Weight of the blade: 0.5370 g

Determination of iron:

Weight of the residue: 0.1320 g

$Fe_2O_3 / 159.694 = 2 \text{ Fe} / 111.694$

Therefore, 0.1320 g residue = 0.09232 g of Fe

An aliquot of 50 mL solution contains 0.09232 g of Fe

Therefore, 250 mL diluted solution will contain 0.4616 g of Fe

i.e. 0.5370 g of razor blade material contains 0.4616 g of Fe

Therefore, 100 g of razor blade material will contain 85.95 g of Fe.

Percentage of Fe is 85.95

Determination of chromium:

The titration readings are as follows:

Blank titration: 25.0 mL of $K_2Cr_2O_7$ (0.025 N)

Back titration: 21.8 mL of $K_2Cr_2O_7$ (0.025 N)

(Blank-back) readings = 3.2 mL of $K_2Cr_2O_7$ (0.025 N)

1 mL 1 N $K_2Cr_2O_7$ = 17.33 mg of Cr

Therefore, 3.2 mL 0.025 N $K_2Cr_2O_7$ = $(3.2 \times 0.025 \times 17.33)$ mg Cr

= 1.3864 mg Cr i.e. 0.001386 g Cr

An aliquot of 25 mL contains 0.001386 g of Cr
 Therefore, 250 mL diluted solution will contain 0.01386 g of Cr
 i.e. An aliquot of 50 mL of stock solution contains 0.01386 g of Cr
 Therefore, 250 mL stock solution from sample will contain 0.06932 g of Cr
 i.e. 0.5370 g of blade material contains 0.06932 g of Cr
 Therefore, 100 g of blade material = 12.90 g of Cr
 Percentage of chromium in blade is 12.90

Determination of nickel

It was tried to determine nickel in blade by spectrophotometry. But, as the nickel content is too low, only a pink color is developed with DMG which has no measurable optical density at 445 nm. After concentrating the solution to half the volume also, the optical density is not measurable.

Table 3 Determination of iron, chromium and nickel* in stainless steel double edge razor blades

Code no. and other information about sample	Weight of sample (g) diluted to 250 mL	Iron		Chromium	
		Weight of Fe ₂ O ₃ from 50 mL aliquot (g)	% Fe	Titer (Blank –back) mL K ₂ Cr ₂ O ₇ (0.025 N) for 25 mL aliquot	% Cr
B1 Micronised blade IS : 7331	0.5370	0.1320	85.95	3.2	12.90
B2 IS : 7371	0.5480	0.1370	87.42	3.2	12.64
B3 Super stainless	0.5700	0.1410	86.50	3.3	12.54
B4 Super stainless	0.5880	0.1450	86.23	3.4	12.52
B5 Stainless IS : 7371	0.5790	0.1450	87.57	3.4	12.72
B6 Super Platinum	0.6097	0.1510	86.61	3.8	13.50

(* Nickel present in razor blade is not detectable by spectrophotometry)

V. CONCLUSION

From the study of analysis of razor blade, it is found that

1. The properties or quality of razor blade may be related to the steps in processing. This study indicates that all these blades have almost identical composition with reference to major constituents. The trace constituent - a noble metal such as platinum - is said to be used in manufacturing of some blades is for its thin layer on the edges only. The amount of it, however, may be so small that it seems much difficult to determine it using even techniques such as spectrophotometry. Such step may be improving the properties of blade.

2. It is confirmed that the composition of razor blade is not given by any manufacturer and is kept secret [3]. The raw material for all the blades analyzed seems to be from one source only, as is indicated by their analyses. The stainless steel blade seems to have iron and chromium as important constituents. So it seems to be ferritic stainless steel.

3. This study is useful for designing an experiment for postgraduate students in Analytical Chemistry because of following reasons:

- Used-up razor blade samples are easily available and procuring of such products requires no cost.
- The samples are easy to disintegrate (probably being much thin-walled).
- The analytical procedure is easy and simple based on selective separation and determination.
- As compare to disintegration of stainless steel material, the time required for disintegration of razor blade is less. The experiment can be completed within a laboratory period.
- It involves variety in analysis because of different methods of analysis such as - gravimetry, volumetry (Redox) and spectrophotometry.
- The batch results can be obtained from the work of a group of students and the error-analysis is possible based on all these results.
- The study of analysis of used-up razor blade is interesting from the student's point of view, because, the sample is neither a synthetic mixture, nor a natural material with unknown and variable composition, but an easily available alloy material with definite and well-set composition. It is a consumer product from day-to-day life. One blade is useful for a batch of four students.

4. One can do following modifications to add new things to the routine procedure.

i. Iron and chromium, both can be determined by redox titration by using KMnO₄ after their separation. If titrimetry is used instead of gravimetry for iron [7], still less time will be required for complete analysis.

ii. The 'presto-type' blades of the disposable razors may be analyzed using similar procedure.

5. The determination of platinum in a sample of used-up 'Super-platinum' brand may be done by more advanced techniques in Analytical Chemistry like Atomic absorption spectrophotometry, Flame Photometry etc. because it is present in trace amounts which is not easily detected by spectrophotometry.

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