

ELECTROLYTIC RECOVERY OF NICKEL FROM INDUSTRIAL HYDROGENATED VEGETABLE OIL (GHEE) WASTE

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Abstract

Solid waste of hydrogenated vegetable oil locally called ghee waste obtained from Bara Ghee Mills (pvt.) Ltd. Khyber Agency (tribal area) NWFP has been first de-oiled and then digested with 20% sulphuric acid in order to get the nickel dissolved into aqueous medium for electrolytic recovery. A 65% nickel with metallic, magnetic and shining properties has been recovered at a cell potential of 3.7 V, pH, 3.8, and addition of 3.2 ml of 6M NH₃ using stainless steel static sheet electrodes as a result of just 15 minutes electrolytic deposition.

Key words: ghee waste, stainless steel electrodes, electrolytic nickel recovery.

Introduction

Several workers¹⁻³ have electrolytically removed or recovered heavy metals such as Cr, Ni, Cd, Cu, Zn, Ag, Au, Co, Pb, Sn, Fe, etc. from different types of samples. Vergonova and Genkin⁴ have investigated and recommended the use of Ti electrodes together with steel electrodes for the removal of Ni, Zn and Cu from waste water containing these metals. A review with 29 references has been presented by Bergmann and Lourtchouk⁵ to discuss the removal of nickel from processing solution as a standard requirement in operating electroplating baths.

The present work is concerned with the rapid recovery of metallic nickel using different types of static sheet electrode couples in a simple cell at different parameters in a short period of electrolysis.

Experimental

Preparation of solutions

Standard solutions were prepared from analytical (Merck) grade salts of respective material. Distilled water was used for final washings and preparation of all solutions.

Oil extraction by sohxlet extractor⁶

A weighed quantity of well chopped and thoroughly mixed solid waste of hydrogenated vegetable oil (ghee waste) collected from Bara Ghee Mills (Pvt) Ltd. was placed in a thimble of filter paper kept inside the extraction chamber of Soxhlet extractor. A reflux condenser was fitted to the upper end while a one liter volumetric flask containing sufficient petroleum ether and acetone in 50% v/v ratio as solvent mixture to the lower end of the chamber. The whole assembly was vertically set in an electrothermally controlled mantle and heated to boiling at controlled temperature.

After 10-20 cycles, the oil extracted from the sample was collected in the recovery flask which was separated from solvent mixture by simple distillation method. The de-oiled sample was first dried at room temperature and then in an oven at 110 °C for 10-15 minutes. It was then cooled in a desiccator and reweighed.

Nickel determination

The de-oiled sample (1 g) from above treatment was digested with 20% H₂SO₄ solution for about one hour according to the same procedure as described for HNO₃ digestion.⁹ The final volume was adjusted to 1000ml mark with distilled water. Nickel was analyzed by three methods, i.e. volumetrically,⁷ photometrically⁸ and voltammetrically.⁹ The actual weight (average of three weights) was 724 ppm nickel. This solution was used as a stock standard for preparing dilute solutions of nickel ions whenever required. On a percentage basis the weight of different contents were; oil, 43.95%; nickel 40.60% and other solids 15.45%.

Electrolytic recovery of nickel¹⁰

100 mL of 200 ppm nickel ions containing solution having sufficient amount of 20% H₂SO₄ and 6M NH₃ was taken in electrolytic cell. The cell may contain different types of static sheet metallic electrode couples used for electro-winning. The stirring bar was put inside the cell already placed on a hotplate adjusted at 300 revolutions per minute (RPM). Pre-weighed electrodes (anode and cathode) were fixed in a holder at a 3 cm distance from one another and hung in the solution at fixed depth. The electrodes were then connected to a power supply. The electrolytic deposition of nickel was started by starting the power supply and stirring of solution at once.

As soon as the electrolysis was over, the current flow and stirring were stopped. The electrodes were taken out of the cell, detached from wires and holder and dried in an oven at 110 °C for 10 minutes. The electrodes were then cooled to room temperature in a desiccator and reweighed. The difference in two weights gave the quantity of deposited nickel. The mean of three replicate runs gave the actual value.

Results and discussion

The recovery of nickel on steel cathode and anodic deposition of nickel oxide (NiO) at different cell potentials using 6M NH₃ and 20% sulphuric acid for pH adjustment and as mixed electrolytic medium at some constant parameters like, pH, 7.0, volume of each electrode, 1.8×5.7×0.03 cm³, deposition time, 15 min and room temperature, 30 ±1 °C (mostly same for other figures) are evident from Figure 1.

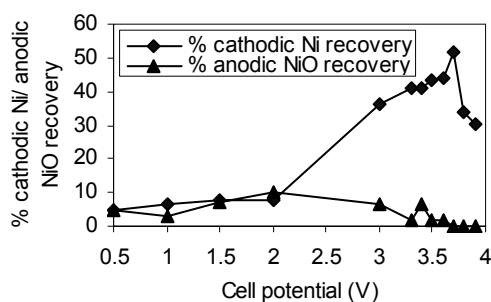


Figure 1. Effect of cell potential on cathodic Ni/ anodic NiO recovery using steel electrodes couple.

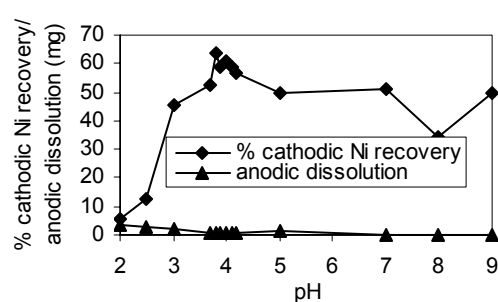


Figure 2. Cathodic Ni recovery/ dissolution of steel anode at different pH values.

The best recovery of 51.5% nickel with a standard deviation value of ±0.9 occurs at an optimum potential of 3.7 V with no deposition of NiO which is quite comparable with the value of 3.0 V, as described by Veraraghavan and Dambal¹² for best Ni recovery using steel electrodes couple.

Figure 2 shows the cathodic nickel recovery and dissolution of steel anode at different pH values at a potential of 3.7 V. The results tell that a maximum recovery of 64% is obtained at a pH value of 3.8 and a constant cell potential of 3.7 V with least value of ±0.1 standard deviation. The pH value of 3.8 is in good accordance with the pH ranges of 3-6 and 2-3 as mentioned in ref. 5 and ref. 12 respectively for maximum Ni recovery.

A 0.6 mg dissolution of anode also takes place at this pH, however, this value is less than other dissolution values.

Figure 3 describes the cathodic nickel recovery and anodic dissolution at different volumes of 6M NH_3 addition at optimized pH and potential values of 3.8 and 3.7 V respectively using steel electrodes.

The highest recovery of 66.5% nickel takes place at 3.1 ml addition of 6M NH_3 with 0.5 mg dissolution of anodic steel. To avoid the danger of anodic dissolution/ NiO deposition, 3.2 ml of 6M NH_3 was selected as optimum value which gives a 65% nickel recovery.

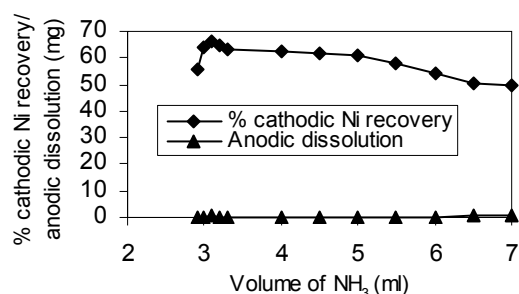


Figure 3. Dependence of cathodic Ni recovery / anodic dissolution on different volumes of NH_3 added.

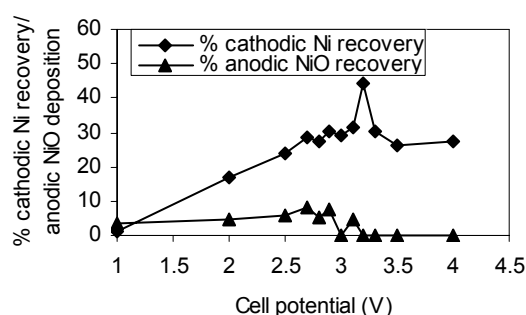


Figure 4. Effect of cell potential on cathodic Ni/ anodic NiO recovery using steel anode with copper cathode.

The results also show a minimum standard deviation value of ± 0.1 as compared to other values. The literature lacks such studies, in case of nickel; however, these values may be betterly described in the light of results reported by Jerzy et al.¹¹ who studied the effect of amount of ammonium hydroxide on silver recovery. Another example is the use of 0.2–0.3% NaCN solution in case of gold recovery.¹³

The use of copper cathode and steel anode couple electrodes has also been studied for the nickel recovery and NiO deposition at different cell potentials and pH, 7.0 with the remaining conditions same as for steel electrodes (see Figure 4).

The results tell that 44.0% nickel is recovered in just 15 minutes of electrolysis with a standard deviation of ± 0.8 at a cell potential of 3.2 V, as compared with 100% Ni recovery in 10 hours electrolysis on steel electrodes as reported.¹²

The electrolytic recovery of cathodic Ni and anodic NiO using steel anode and copper cathode couple was also studied at different pH values. Fortunately, the optimum

pH value obtained was also 7.0 with a maximum value of 44.0% cathodic Ni recovery. So the values are not indicated to simplify the study and avoid repetition of data.

This pH value is close to the pH range of 3–6 described in⁵ but quite different from pH range of 2–3, as cited earlier¹² for maximum nickel recovery. Our value of pH, 7 is however, advantageous by providing a neutral medium, which is helpful to minimize anodic dissolution. Furthermore, the NiO deposition in such studies protects anodic steel against dissolution, but its significant value can create concentration polarization thus decreasing the rate of cathodic nickel recovery.

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Conclusion

The overall results show that nickel recovery in case of using steel electrodes is superior to that of using copper cathode and steel anode due to best magnetic properties, metallic nature, greater recovery (65% as compared to 44.5%) and easily scratchable deposit.

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Povzetek

Podan je postopek za izolacijo niklja iz odpadka po pridobivanju olja iz rastlinskega materiala. Razoljen odpadek se izlužuje z 20%-no žveplovo (VI) kislino, dobljeno nikljevo lužnico uravna na pH 3,8 z dodatkom 6 M raztopine amoniaka ter elektrolizira z elektrodami iz nerjavnega jekla pri 3,7 V. Dobitek niklja je že po 15 minutah elektrolize 65%, produkt pa je lahko odstranljiv nikelj s kovinskim leskom in dobrimi magnetnimi lastnostmi. Obravnavan je tudi problem odlaganja nikljevega oksida na anodo in raztapljanja le-te.