RECOVERY OF SILVER FROM SPENT PHOTOGRAPHIC SOLUTIONS USING METALLIC REPLACEMENT METHOD

AZEEZ, Oluwatosin Sarafa
Department of Chemical Engineering,
Federal University of Technology, Minna, Nigera
E-mail: azeezsarafa2002@yahoo.com
Phone No: +234-806-836-0923

Abstract
The recovery of silver from photographic effluent has been carried out. Photographic liquid wastes were collected from two photo laboratories labeled Sample A and Sample B. The recovery was done using metallic replacement method. The study was done by varying the volume of liquid waste and the number of runs for each sample. The results obtained show that an increase in the volume of sample and the number of runs lead to an increase in the amount of silver recovered. The highest amount of sample of silver recovered for Samples A and B are 0.58g/litre and 0.47g/litre respectively. The melting points of recovered silver which are 1115 and 1021 for Samples A and B respectively point to the fact that they contain impurities which increased their melting points. The research shows that it is possible to recover silver from liquid photographic effluent which constitutes environmental pollutant.

Keywords: *Pollutant, liquid, waste*

Introduction
Silver is a precious metal used in many industrial products, as such, there is great need for its conservation. Some of the places where silver can be used include the photographic industry, X-ray films and wire and cable industries (being good conductor of electricity) (Madamilola, 2006). It is also used in the making of coins, jewelries, decorative items. Finally, it is useful in the making of mirrors which is a component of telescope and microscope and other solar panels. The waste X-ray photographic films contain black metallic silver which can be recovered and re use (Nakiboglu *et al*., 2001). Silver is used in photographic films because of its high quality as a light sensitive material for creating a photographic image. However, silver can be recovered in photographic materials and re- use because it is not destroyed in the photographic process (El-Sattar *et al*, 2004).

The need for silver recovery arises because it is a valuable natural resource which is used in large quantities for many purposes (Nakiboglu *et al*., 2003). Moreover, its release into the environment needs to be strictly regulated because it can be a source of environmental pollution. The waste from photographic films containing black metallic silver is a very good source for silver recovery when compared with other types of film (Nakiboglu *et al.,* 2001). Also, recovering silver from image processing wastes can minimize the cost associated with image processing. It has been observed that 25 % of world's silver need is obtained by recycling of which photographic waster serve as a good source (Nakiboglu *et al*., 2003; Shankar *et al*., 2010).

Various studies have been carried out on the recovery of sliver from waste photographic films (Nakiboglu *et al*., 2003). Some of the methods reported were however, observed to cause environmental pollution (Shankar *et al*., 2010). Metallic replacement method was adopted in this study because it can recover good amount of silver with very few units. Moreover, it is more environmental friendly when compared with some other methods. Metallic replacement method makes use of canisters packed with steel wool and some plastic hose for plumbing connections. Silver can be recovered when the silver rich solution flows through the plastic hose and makes contact with the steel wool. The iron goes into the solution as an ion and the metallic silver is subsequently released. Silver can then be collected as sludge at the bottom of the canister or deposited on the steel wool. The silver bearing sludge can thereafter be refined to obtain pure

silver. This study therefore focuses on the recovery of silver from spent photographic solution. The method adopted in this study is environmentally friendly and sustainable.

Experimental Methodology

The chemical sample used for the recovery is spent photographic film. The equipment used in this work are as follows: Stainless canisters, Steel wool, Plastic hose for plumbing connection, Measuring cylinder, Funnel, pH meter, Beakers, Weighing balance Retort stand and clamp.

Collection of Samples

The wastes (Samples A and B) were collected from two different sources:
Sample A – A photo laboratory in Keteren-Gwari Road in Minna, Nigeria
Sample B – A photo laboratory in Mobil, Minna, Nigeria.

The colours of the samples were identified as follows:
Sample A – Clear blue black liquid.
Sample B – Clear blue black liquid.

Experimental set up

Each stainless canister was packed with steel wool and connected with plumbing pipes in series connection with one above the other. They were supported by a retort stand and a clamp. A funnel was placed over the first canister to allow easy passage of the liquid sample into the canister. A conical flask was placed under the second canister to receive the liquid that passed through.

Experimental Procedure

The silver bearing solution of varying volume was allowed to flow through the funnel placed over the canister. The solution then made contact with the steel wool so that the iron in the steel wool can go into the solution as an ion and the metallic silver could be released as solid particles and trapped within the steel wool. The yield of silver was determined by silver concentration in the solution. The silver particles were then washed off the steel wool using distilled water and then filtered through a filter paper. In this study, number of run is the number of time that a particular volume of silver bearing solution is run through the experimental set up before the weight of silver recovered is taken. The experiment was repeated for two and three runs. The residue in each case was dried, scraped off and weighed. The weight of these runs were recorded and compared. The pH of the liquid samples were also taken.

The amount of the recoverable silver in both samples was determined using Titrimetric Analysis. The residue was then taken in order to test for its purity using two physical properties (melting point and specific gravity) of silver. Each of Samples A and B was put into a crucible and placed in a Gallenkamp Muffle type furnace (5257 model) for the determination of melting points. The melting point in each case is shown in Table 5. The specific gravities of the samples were determined using a relative density bottle and the values of the relative densities are shown in Table 6.

Results and Discussions

Results of recovered Silver at different runs

Tables 1 to 3 show the mass

Table 1: Amount of Silver recovered when the silver solution was run once (1 run)

Sample Volumes	Weight of recovered silver (g)	
(litres)	Sample A	Sample B
0.5	0.25	0.18
1.0	0.35	0.28
1.5	0.62	0.56
2.0	0.83	0.71

Table 2: Amount of Silver Recovered when the silver solution was run twice

Sample Volumes	Weight of recovered silver (g)	
(litres)	Sample A	Sample B
0.5	0.33	0.25
1.00	0.56	0.30
1.5	0.80	0.68
2.0	1.15	0.87

Table 3: Amount of Silver Recovered when the silver solution was run thrice

Sample Volumes	Weight of recovered silver (g)	
(litres)	Sample A	Sample B
0.5	0.40	0.32
1.0	0.58	0.47
1.5	0.94	0.86
2.0	1.31	1.02

Table 4: Table showing the melting points, Specific gravities and the pH values of Samples A and B

	Melting Point (^oC)	Specific Gravity	pH
Sample A	1115	9.33	11.03
Sample B	1021	8.17	8.78

Discussion of Results

Different volumes of the samples were run once, twice and thrice as shown in Tables 1, 2 and 3 respectively. 2.05 g and 1.73 g of silver were recovered from the same volume (5 litres) each of samples A and B respectively for one run as shown in Table 1. Figure 1 shows the relationship between the volume of samples and the weights of silver recovered. From the graph, there is a steady rise in the amount of silver recovered from sample A with each increase in volume compared with the trend in sample B. Sample A appears to have a higher recovery than sample B. This could be due to Sample A containing more silver compound than Sample B.

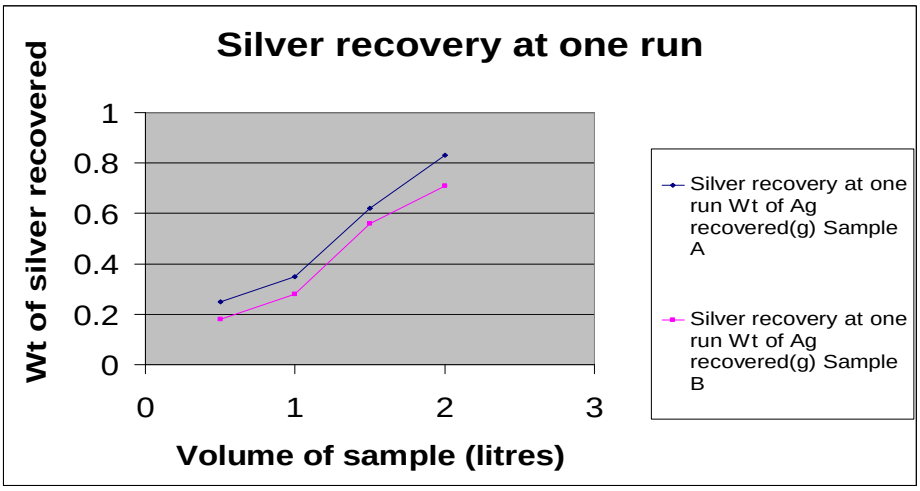

Figure 1: Figure showing amount of Silver Recovered at one run

The results in Table 2 expectedly show an increase in the weight of the silver recovered at two runs. It shows an increase of 0.79g in the weight of silver recovered from sample A while that of B gives an increase of 0.37g. The weight of Sample A recovered is more than that of sample B in a similar manner to one run.

In Table 3, the result of the silver recovered showed a difference of 0.56g between the amount of silver recovered from samples A and B. The weights of silver obtained when the solution was run thrice gave the highest recovery compared with the other two. The expected increase in the amount of silver recovered as the number of runs increase shows that more silver can be recovered as the number of runs increases.

The purity of silver recovered was tested by determining their melting points and specific gravities. The results of the melting point in each case as shown in Table 4 show that each of the melting points of Samples A and B is higher than the melting point of pure silver which is approximately 962^{o}C. This elevation of melting points is due to some impurities present in the recovered silver.

Table 4 shows a difference of 1.16 in the values of specific gravity between samples A and B. Sample A has a higher specific gravity than sample B and they are both less than the standard value of specific gravity of pure silver which is 10.5. The reason for this could be due to the impurities in the samples.

The pH value of sample A has a higher value of 11.03 than that of Sample B with a pH of 8.78. This signifies that the wastes are basic.

Conclusion

This study shows that silver could be recovered from liquid photographic waste. This process can be a mean of reducing environmental pollution as well as silver recycling. Metallic replacement method can be used to recover silver from different sources of photographic wastes although the recovered silver contains impurities.

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