Recovery of Hg(0) from the Aqueous Hg(I/II) Present in Analyte Solution after Quantitative Determination of Iron

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An easy and feasible approach to recover HgCl₂, used in quantitative determination of iron values, as Hg(0) was described. Both Hg(I) and Hg(II), present in the solution after quantitative determination of iron, was completely reduced to Hg(0) by the addition of aluminium chips in more slightly excess than the stoichiometric amount. The purity of recovered Hg(0) was verified by comparing the value of density with pure mercury. This simple method may be useful to remove the mercury from other waste aqueous solutions before their discharge into the environment.

1. Introduction

Mercury and its compounds are considered one among the priority hazardous contaminants in the environment which are harmful to human health and natural ecosystems [1–4]. The discharge of effluents from various mercury using industries like chloroalkali, paint, pharmaceutical, paper and pulp, and so forth and its use in pesticides are the major sources of mercury contamination in soil and water. In aquatic system, the major fraction of mercury as Hg(II) is stored in sediment by sorption and/or precipitation which is subsequently released into aqueous phase causing severe toxic effects to human and biota. In addition, the extensive use of HgCl₂ for routine quantitative analysis of iron in laboratories and iron-based industries followed by the discharge of the analyte solution also contributes to the mercury pollution to very small extent. Although the maximum permissible limits of Hg(II) in drinking water and effluents are 0.002–0.005 mg L⁻¹ and 0.01 mg L⁻¹, respectively, [5–7], the effluents discharged in the environment usually contain much higher range of mercury (0.058–0.268 mg L⁻¹). The conventional techniques for Hg removal from aqueous solution include sulphate or hydrazine precipitation, ion exchange, liquid-liquid extraction, adsorption by activated carbon, and other materials [8–10]. Supercritical fluid extraction and foam fractionation separation of Hg species from their aqueous solution has been described elsewhere [11, 12]. It is known that aluminium metal can reduce several metal ions to their metallic state under different conditions. Separation of iron(III) as Fe(0) by reduction with aluminium powder under hot condition from acid-leached solution of different ores/minerals has been reported earlier [13, 14]. On the other hand, the Fe(III) is reduced to only Fe(II) when the reduction is carried out at room temperature. The reducing ability of aluminium may be further exploited for recovery of other metals from their ions present in aqueous solution. In this context, the Al (Al³⁺ + 3e → Al (E⁰_{red} = 1.706 V) can favourably reduce both Hg(I/II) (Hg²⁺/Hg²⁺ + 2e → Hg, E⁰_{red} = 0.76–0.85 V) under acidic condition. Keeping the above in view, we report here a simple and effective way of recovering the left-out Hg(I/II) in analyte solution after volumetric estimation of iron by dichromate method.

2. Experimental

The analyte solution containing Hg(I/II), generated from standard volumetric analysis of iron by dichromate method
[15], was used for recovery of mercury as Hg(0). Aluminium chips (Merck, GR) were used as the reducing agent. All other chemicals/reagents used in this study were of AR/GR grades without further purification. In a typical lots, the analyte solution containing ~2.1 g/L Hg as Hg(I/II) was further acidified with 5% (v/v) HCl. A weighed amount of aluminium chips (0.12 g/L; 0.0045 M), slightly excess than the stoichiometric amount required for reduction of Hg(I/II), was then added into it, stirred well, and allowed for a predetermined time to complete the reduction. The reduced Hg(I/II), settled down at the bottom, was separated, washed successively with dilute HCl and distilled water. Under identical condition, Hg(0) was also prepared from acidified solution of pure HgCl₂ by reduction with Al chips. Finally, the density of isolated mercury was measured by standard method and compared the values with that of reported for standard mercury.

3. Results and Discussion

The HgCl₂ used in dichromate method of iron estimation is partly reduced to Hg₂Cl₂ while the excess quantity over and above the amount utilized for oxidation of SnCl₂ remains as HgCl₂ (1). On treatment with aluminium chips, Hg(I/II) reduces to Hg(0) (2), as follows:

\[
\text{SnCl}_2 + 2\text{HgCl}_2 \rightarrow \text{SnCl}_4 + \text{Hg}_2\text{Cl}_2 + \text{HgCl}_2 \text{ (excess)} \quad (1)
\]

\[
3\text{Hg}^{+} + 2\text{Al} \rightarrow 3\text{Hg} \text{ (steel grey)} + 2\text{Al}^{3+} \quad (2)
\]

It is seen that the rate of reduction is relatively slow and about 10 h is required to complete the reduction of Hg(I/II) to Hg(0) under the experimental condition used.

The mercury recovered from the analyte solution is presented in Figure 1. The purity of recovered Hg(0) is checked by measuring the density. The density of recovered Hg(0) from the analyte solution and pure HgCl₂ solution is found 13.44 and 13.48 g cm⁻³, respectively, which are close to that of standard value 13.534 g cm⁻³ indicating that recovered mercury is sufficiently pure and may be considered for its possible use in different purposes.

4. Conclusions

In conclusion, sufficiently pure metallic mercury can be easily recovered from waste analyte solution after iron estimation by dichromate method by reduction with Al chips. This method may be extended for mercury-containing waste, generated from other sources, for possible recovery of mercury to reduce the ensuing environmental pollution.

References


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