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# Design and Fabrication of a Bench-top Gas Generator for Four Year Undergraduate Laboratory Classes

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**Abstract** A simple and cost-effective bench-top gas generator for its use in the laboratory classes is designed and fabricated. The set-up is meant for generation of hydrogen sulfide gas and is in use by the students at the chemistry laboratory of our college for the past eight years. However, other gases like carbon dioxide, hydrogen and acetylene can also be produced using the same set-up. This article describes the design and fabrication of the bench-top set up with special reference to generation of hydrogen sulfide gas. The new set-up is easy to use and requires few chemicals.

***Keywords:*** *hydrogen sulfide, Kipp's apparatus, alternative method, inorganic analysis, toxic gases*

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## 1. Introduction

The qualitative analysis of cations involves a systematic separation of the metals into groups in accordance to their reactions with a set of standard reagents. Hydrogen sulfide gas is one of the most important reagents used for this purpose. This gas can precipitate metal ions like arsenic, cadmium or zinc, manganese under either acidic or alkaline conditions. However, during 19th century the luxury of using gas cylinder of hydrogen sulfide was unthinkable. This led the Dutch pharmacist Petrus Jacobus Kipp to invent in 1844 the famous Kipp's apparatus. This useful apparatus is being used even today during qualitative inorganic analysis in chemistry practical classes. The Kipp's apparatus is mostly used to produce hydrogen sulfide, although the same apparatus can also be used for producing other gases like carbon dioxide, acetylene or hydrogen.

With increasing awareness about the toxic nature of various gasses commonly used in the laboratory classes (e. g. hydrogen sulfide is toxic), it becomes mandatory for the chemistry teachers to innovate new methods so that the toxic effects of such gases to individual users as well as on our environment is reduced. These innovations can be helpful as the students would be exposed to such harmful gases to the bare minimum during their laboratory classes.

## 2. Objectives

The purpose of this article is therefore to present an alternative to Kipp's apparatus where the hydrogen sulfide gas can be produced in minor amounts and unlike in Kipp's apparatus the gas is not stored in a reservoir (e. g. middle chamber of the Kipp's apparatus). Simple and common laboratory glass wares like the filter flask, burette, outlet rubber and glass tubings etc are used. A miniature bench-top set up is thus designed and fabricated for production and regular use of hydrogen sulfide gas ($H_2S$) in the laboratory. This new set up now replaces the expensive Kipp's apparatus in our college laboratory. As mentioned above, other gases like carbon dioxide, acetylene or hydrogen can also be generated for laboratory use with the same apparatus. The inherent advantages of this newly designed set up over routinely used Kipp's apparatus are also discussed.

## 3. Methods

Figure 1a shows the typical line drawing of the gas generator. The actually fabricated miniature bench-top set up for production of hydrogen sulfide gas in the laboratory is presented in Fig. 1b. As shown in the figure, a small amount of sodium sulfide flakes are placed in a 500 ml capacity filter flask. The filter flask has a side nozzle and is closed at the top with a rubber cork of appropriate dimension having a central-hole in it (Figure 1). Through the central hole a 50 ml burette is pushed through. The burette is filled more than three-fourths of its volume with 2 M HCl and held in vertical position with the help of a burette stand (Figure 1b). The side nozzle of the filter flask is fitted successively with rubber and glass tubes. In between the rubber and glass tubes a screw clip is used (not shown in Figure 1b).

### 3.1. Other Gases

In addition to hydrogen sulfide gas, it is important to note that there are a number reactions that are useful to generate gas through reaction between solid-liquid reagents, such as:

$$\text{Hydrogen}: Zn\,(s) + H^{+}\,(aq) = Zn^{+}\,(aq) + H_2\,(g)$$

$$\text{Acetylene}: NaC_2H + H_2O = Na^{+}\,(aq) + C_2H_2\,(g)$$

$$\text{Carbon dioxide}: CaCO_3\,(s) + H^{+}\,(aq) = Ca^{++}\,(aq) + CO_2\,(g)$$

The newly designed bench-top set up can be used to generate the above gases for laboratory use.

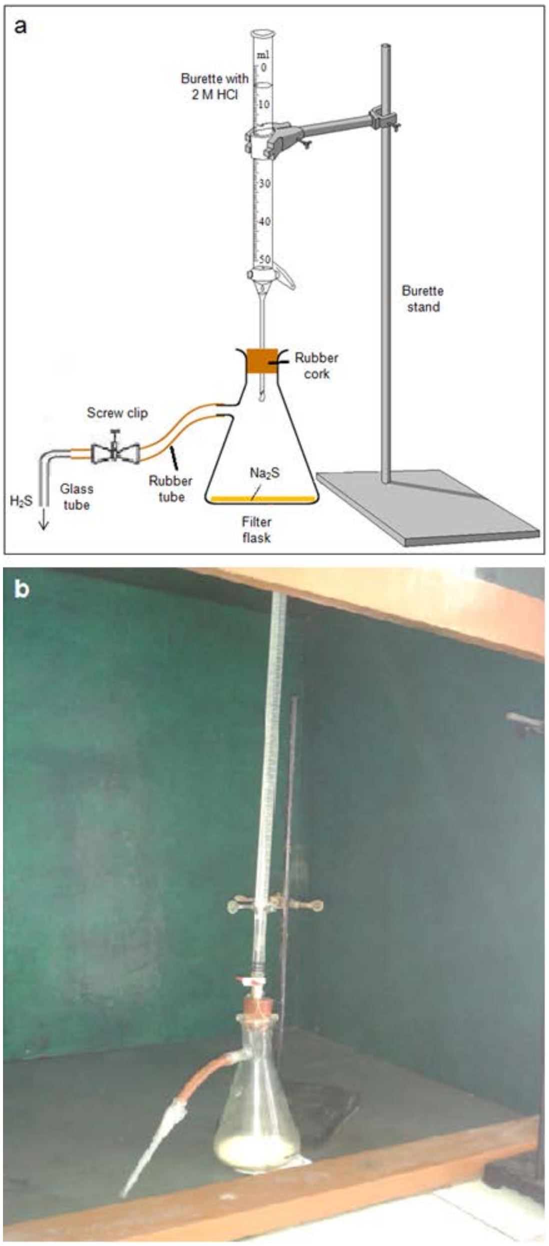


**Figure 1. a.** Design of the bench-top gas generator showing schematically production of hydrogen sulfide, **b**. Photograph showing fabricated bench-top gas generator

## 4. Results

Depending upon the number of students in a laboratory session, predetermined amount of sodium sulfide (or ferrous sulfide) flakes can be placed in the filter flask. Whenever hydrogen sulfide gas is needed, 3-4 ml of HCl are allowed to pour in by opening the stopcock of the burette. This causes reaction of sodium sulfide flakes present in the filter flask with the acid. The reaction produces hydrogen sulfide gas in accordance to equation:

$$Na_2S\,(s) + 2H^{+}\,(aq) = 2Na^{+}\,(aq) + H_2S(g)$$

Figure 2 shows the results of the fabricated gas generator where the evolved hydrogen sulfide gas is used by a student in metal ion precipitation. The bench-top gas generator can therefore be extremely useful to detect specific metal ions for their qualitative and quantitative analyses. The rubber tubing is clamped immediately after each use.

**Figure 2.** Bench-top hydrogen sulfide gas generator is being used in the laboratory for precipitating cadmium sulfide

## 5. Discussion and Conclusions

Both hydrogen sulfide and carbon dioxide gases are produced naturally and as a result of human activity. In this section first the toxic effects of these commonly used laboratory gases are briefed. This is followed by presentation of an account that highlights the inherent advantages associated with the bench-top gas generator.

Although hydrogen sulfide can be detected by its "rotten egg" smell at levels around 0.025 ppm (parts per million), it can cause eye pain at 5-10 ppm. Exposure to higher levels of around 150-250 ppm in most cases can cause the sense of smell to disappear. This means that a person exposed to even higher concentrations beyond 250 ppm may not sense the impending danger. Inhalation up to 500 ppm may cause immediate collapse leading to unconsciousness [1]. Likewise, higher exposure to $CO_2$ gas have adverse effects on human. Preliminary study indicates that at a level up to 1% of $CO_2$, prolonged exposure can be hazardous to human health [2]. Furthermore, to climate researchers and modelers carbon dioxide gas is a matter of great concern. For example, increasing anthropogenic input of carbon dioxide in the atmosphere can lead to more independent behavior of climate proxies like the sea surface temperature [3]. Therefore if appropriate measures are taken by us in the laboratory (may look insignificant to many at this stage!), it is possible to reduce drastically the adverse effects of these commonly used toxic gases on our environment. Towards this broad objective, the bench-top gas generator discussed in this article assumes significance.

There are several advantages of this newly designed set-up over Kipp’s apparatus.

(1) Firstly, the size of the set-up is tiny and hence less amount of chemicals are needed and it can be placed either in a small open space near the laboratory or in a fume hood.

(2) The innovative design helps in making decision for optimal use of chemicals based on number of students in the laboratory class and their requirements of hydrogen sulfide gas. This is an important step forward towards abrupt reduction of use and wastage of chemicals.

(3) Compared to the conventional Kipp's apparatus, the cost of the set-up is reduced drastically (~20% of the cost of a Kipp's apparatus).

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