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The reaction between aluminum and iodine: demonstration experiment in a jar overhead projector demonstration

La reacción entre aluminio y yodo: demostración en un experimento

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Abstract:

The chemical reaction of direct synthesis of aluminum iodide is a well-known chemical experiment, especially due to the spectacular initiation of this process by water, self-ignition and the emission of violet iodine vapors. These three elements make this experiment extraordinary attractive and impressive. However, the possibility for performing of this experiment is limited due to the emission of iodine in the air, causing a direct contamination of the air breathed by the experimentalists carrying it out and students as well. Due to these reasons, performing this experiment is limited to educational institutions (schools and faculties) that actually have a fume hood. In the present work we propose two relatively safer ways of performing this experiment. According to the first one, the experiment is carried out in a big jar or a big laboratory beaker, while in the second one, the experiment is carried out in optical projection using an overhead projector. The main advantages of the proposed methods consist of keeping the dispersal of iodine vapors within a limited space.

Key words: *laboratories and demonstrations, overhead projector demonstrations, synthesis of salts, aluminum iodide.*

Resumen:

La reacción química de síntesis directa de yoduro de aluminio es un experimento químico muy conocido, especialmente debido a la apertura espectacular de este proceso por el agua, la auto-ignición y la emisión de vapores de yodo, violeta. Estos tres elementos hacen que este experimento sea extraordinario, atractivo e impresionante. Sin embargo, la posibilidad de realización este experimento es limitado debido a la emisión de yodo en el aire, causando una contaminación directa del aire respirado por los que conducen el experimento y también los estudiantes presentes. Debido a las razones anteriormente mencionadas, la realización de este experimento se limita a las instituciones educativas (escuelas y facultades) que tienen una campana de extracción. En el presente trabajo se proponen dos formas relativamente seguras de llevar a cabo este experimento. En la primera, el experimento se lleva a cabo en un frasco grande o un vaso de precipitados mientras que en la segunda, el experimento se realiza en proyección óptica utilizando un retroproyector. Las principales ventajas de los métodos propuestos consisten en mantener el sistema disperso que contiene vapores de yodo dentro de un espacio limitado.

Palabras clave*: laboratorios y demostraciones, demostraciones de retroproyector, la síntesis de sales, el yoduro de aluminio.*

INTRODUCTION

Chemical experiments concerning reactions for synthesis of salts are an unavoidable, integral part of the education in chemistry at all levels. These types of reactions, on the other hand, may be classified in more than 15 categories. However, for primary and secondary schools, the simplest and most fundamental reactions are at the same time the most important ones. Among these are the reactions of direct synthesis starting from metal and non-metal. These reactions are particularly important and unavoidable. When the chemistry teachers demonstrate the salt synthesis by a direct reaction between metal and non-metal, they may choose from a vast amount of experiments such as direct reactions between: sodium and chlorine (Shakhashiri,1992; Summerlin, 1987), aluminum and bromine (Shakhashiri,1992), phosphorus and bromine (Shakhashiri,1992; Summerlin, 1987; Fowles, 1959), phosphorus and chlorine (Shakhashiri,1992), antimony and chlorine (Shakhashiri,1992), aluminum and iodine (Fowles, 1959; McCulloch, 1947; Azmatullah, 1955; Roesky, 1996), zinc and iodine (Shakhashiri,1992), zinc and sulfur (Fowles, 1959), iron and chlorine (Shakhashiri,1992), antimony and iodine (Roesky, 1996), mercury and iodine (Summerlin, 1988), and a number of other example reactions. The set of these experiments is obviously very wide. When choosing a demonstration experiment for salt synthesis the chemistry teacher should take care for the following criteria to be satisfied:

a) The experiment should be safe, and not harmful to health;
b) The experiment should be attractive – spectacular;
c) The teacher should have the required equipment and chemicals readily available;
d) Performing the experiment should be cost-effective;
e) The experiment itself should be simple and successful;
f) The experiment should not take too much of the class-time;
g) It should also be ecologically suitable, etc.

If the teacher takes care of all the mentioned criteria (principles) in situations when a fume hood is not availablethen a large number of the previously enumerated experiments will be excluded from the choice. For example, the reactions with chlorine and bromine will be excluded due to their toxicity, those including sulfur will be excluded due to emission of sulfur dioxide, which is also unwanted. Reactions with iodine could also be excluded due to iodine emission, but they may be included using the method proposed in the present paper.

The first proposed way of performing the experiment of direct synthesis with aluminum and iodine is on the bottom of a large glass or jar covered with a cotton layer.

The second proposed way of performing this demonstration experiment is in optical projection. The reaction mixture is placed on a porcelain plate, which is placed in a larger glass vessel covered with glass. The second beaker is put onto an overhead projector where the experiment is carried out.

The overhead projector is a device which nowadays most of the schools actually have. Its application becomes more and more important in chemistry, since besides its use for presentation of texts and figures to a large number of pupils and students, the overhead projector may be also used for performing a large number of experiments (Kolb , 1987). Various phenomena and properties may be demonstrated in this way, such as: the change in pH of the medium, forming of gaseous substances, formation of precipitates, reactions of electrolysis, synthesis of complex compounds etc. In this way the pupils come to the desired conclusions by direct observation of the changes produced and by logical considerations, by themselves or by their teacher's support. In this way, the educational efficiency and success is enhanced.

Performing experiments on an overhead projector is simple, quick, easy, cheap, and at the same time good visibility and a vivid event is achieved. At the same time, equipment with smaller dimensions is used, and also less waste materialis produced.

Due to all advantages which have been mentioned, a large number of classical demonstration experiments may be modified to allow performing them on the overhead projector. Syntheses of the basic types of inorganic compounds may be adjusted for demonstration in optical projection. Among these reactions, methods for salt syntheses can be mentioned, one of which is the direct synthesis between metal and non-metal.

Experimental

a) Demonstration in a jar

Equipment and chemicals

Aluminum powder, iodine, mortar and pestle, a jar with volume of 5 L (or an appropriate laboratory beaker), a pipette of 10 mL, a laboratory beaker of 50 mL, a glass stick, a porcelain plate or a small crucible, a spatula, spoons, latex glasses, cotton.

Performing the demonstration

One spoon of iodine (2 g) is powdered in mortar where also approximately 0.150 g of aluminum powder is added (one may not need to weight the reactants after several performances of this experiment). The system is mixed with spatula until a uniform color is achieved. The mixture is placed on a porcelain plate and shaped as a heap with a shallow crater on its top is formed as shown on Fig. 1.

Fig. 1. Porcelain plate with the Al-I_2 mixture

The plate with the mixture is placed on the bottom of the jar. From a laboratory beaker of 50 mL, in which distilled water has been previously put, a small volume of water (several drops) is taken by pipette. Two drops of water are put in the crater of the mixture. The top of the jar is covered by a cotton layer 1 cm thick (Fig. 2a). The process is observed with attention (Fig. 2b).

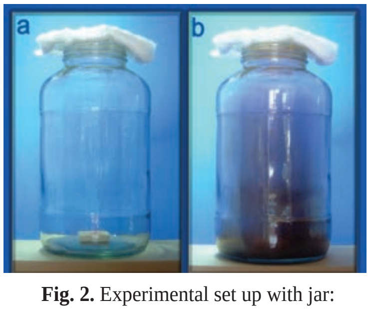


Fig. 2. Experimental set up with jar: before the reaction (a); after the reaction (b)

The demonstration can be successfully performed in a laboratory beaker (Fig 3).

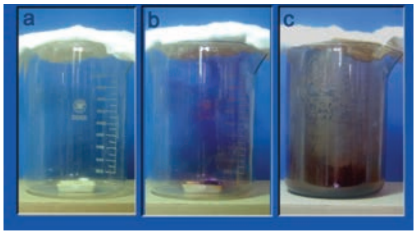
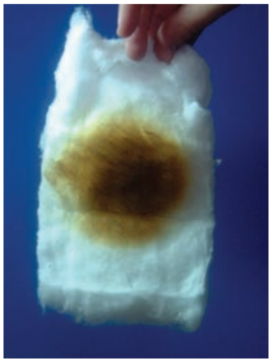


Fig. 3. Experimental set up beaker: before the reaction (a); during the reaction (b); after the reaction (c)



After the demonstration the cotton layer contains significant amount of iodine (Fig. 4)

Fig. 4. Cotton layer with iodine stain

b) Demonstration on Overhead Projector

Equipment and chemicals

Aluminum powder, iodine, a squared glass vessel with dimensions 12 cm x 12 cm x 4 cm with glass cover (or a large and relatively deep Petrie dish), a small mortar and pestle, small shallow crucible or a small porcelain vessel, dropper or a plastic pasteur plastic pipette, a laboratory beaker of 50 mL, a spatula, spoons, latex gloves, paper mask with holes: for the vessel, for a transparency with the title of the experiment and another for the chemical equation, pieces of transparencies with the printed title of the experiment and the chemical equation, an overhead projector.

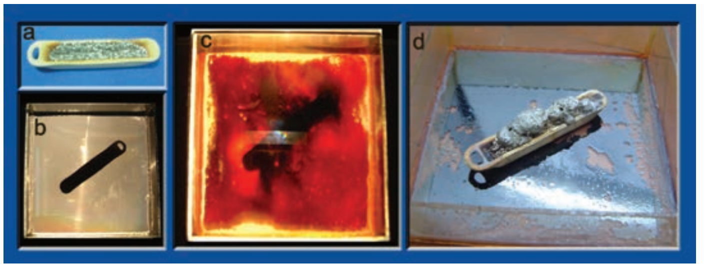


Fig. 5. Porcelain vessel (a); projection of the set up (b); photo during the reaction (c); reaction system after the reaction (d)

Performing the demonstration

A small quantity of iodine (pea-size amount) is powdered and the same quantity of aluminum powder is added to it. The mixture is homogenized and transferred on a small porcelain vessel (Fig. 5a). The porcelain vessel is placed in the glass vessel (Fig. 5b). On the overhead projector a paper mask is put, together with the foil with the experiment title on an appropriate place, while the hole for the piece of transparency with the chemical equation is temporarily covered with a piece of blank paper. The glass vessel with the reaction mixture is placed onto the overhead projector in the appropriate hole and the light is turned on. In the crater of the mixture one drop of water is added and the changes are observed (Fig. 5c). The vessel is immediately covered with glass and the changes are actually monitored in optical projection. After finishing of the reaction, the piece of paper with the printed chemical equation is uncovered, and afterwards the ceramic vessel on which the reaction product has been formed is shown to the auditorium (Fig. 5d).

RESULTS AND DISCUSSION

In both alternative experiments, the reaction is initiated by water. The mechanism of reaction initiation most probably includes reaction between iodine and water in the first step:

$$I_{2(s)} + H_2O_{(l)} \longrightarrow HI_{(aq)} + HIO_{(aq)}$$

The acids formed in this step further react with the aluminum present, which is accompanied by liberation of heat which contributes to the reaction initiation:

$$Al_{(s)} + 3I_{2(s)} \longrightarrow 2AlI_{3(s)}$$

After the addition of water to the mixture, the auditorium is enabled to follow a reaction which first manifests by liberation of violet vapors, which are easily noticed in the optical projection, while in the jar self-ignition of the mixture can be seen which is followed by open flame. The reaction is obviously exothermic and the iodine vapors are a consequence of this.

The reaction of direct synthesis of aluminum iodide is accompanied by liberation of large quantity of heat and therefore in the second way of performing the experiment it is suggested to work with a small quantity of the mixture. Due to the potential danger of fire, the prepared mixture should not be kept for longer time. While working with iodine, it is suggested to use latex gloves to avoid direct contact of iodine with the skin, which results in formation of yellow stains. The proposed demonstrations allow safe performance of the experiment, and a particular advantage of the second approach is that small quantity of the reaction mixture is used. Therefore, also a smaller amount of waste products is formed, and the experiment is cheaper. The waste containing aluminum iodide can be heated to remove iodine and kept for further use (e.g. for the experiment for synthesis of elementary iodine, displacement reaction of iodine by chlorine etc). The vessel in which the experiment is carried out contains a layer of iodine which can be cleaned by adding water and waiting for some time. The solution of the reaction product aluminum iodide provides iodide ions that enhance dissolution of the iodine. The remaining iodine residue can be cleaned with solution of sodium thiosulfate (Wikipedia) or alcohol.

$$2\ S_2O_3{}^{2-}{}_{(aq)} + I_{2(aq)} \longrightarrow S_4O_6{}^{2-}{}_{(aq)} + 2\ I^-{}_{(aq)}$$

The technique of performing experiments in a jar can be extended also to other experiments such as reactions between: magnesium and iodine, zinc and sulfur etc. In some experiments in which a considerable amount of heat is liberated, it is useful to add a layer of sand in order to protect the glass from the abrupt temperature changes.

One may want to perform the experiment with a smaller jar, but in that case the amount of the reaction mixture should be decreased and a flame during the reaction may not occur.

CONCLUSIONS

The proposed ideas provide safe performing of the reaction between aluminum and iodine. For those reluctant to perform such demonstrations due to the health issue, this articleshould motivate them to actually do the demonstration. The "jar idea" might be extended to a wide set of pyrotechnic demonstrations or reactions of simple combustion that generate smoke. In this case one should take into account to use small amounts of the reaction mixtures to restrain high flames that can ignite the cotton layer and a beaker with water should be kept next to the reaction set up for extinguishing fire.

Safety Tips and Hazards

Wear latex gloves to avoid contact with solid iodine that causes burns. Iodine vapor irritates the eyes and the respiratory system. Wear safety goggles at all times when performing chemical demonstrations.

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"Less is more!" - teaching numbers with drops

"¡Menos es más!" - enseñanza de los números con gotas

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Abstract

In primary school, children learn to identify the number and name it, the order of the numbers by value, understand the meanings of symbols, the ability to connect a number to its representative group, know that each number is greater by one than the number before it, write the number and solve simple problems. In this article, we propose the use of scientific activities to teach all of the above with respect to the number. By using the method of colored dots, we offer the children the tools and concrete materials to help them to count, add, subtract and carry out other mathematical activities.

Key words*: mathematics, science education, counting numbers.*

Resumen

En la escuela primaria los niños aprenden a identificar los números y a darles nombre, el orden de los números según su valor, entender los significados de los símbolos, la habilidad para conectar a un número con su grupo representativo, saber que cada número es mayor en una unidad a su predecesor inmediato, escribir los números y resolver problemas simples. En el presente artículo proponemos el uso de actividades científicas para enseñar todo lo anterior con respecto de los números. Mediante el uso de puntos coloreados, ofrecemos a los niños las herramientas y materiales concretos para ayudarles a contar, sumar, restar, y llevar a cabo otras actividades matemáticas.

Palabras clave*: matemáticas, ciencias, actividades, números.*

INTRODUCTION

Principles of Learning Math:

Mathematics helps children make sense of the world around them and find meaning in the physical world. Children learn best when they are interested and even excited about what they are doing. Through mathematics, children learn to understand their world in terms of numbers and shapes. They learn to reason, to connect ideas, and to think logically (Baroody, 1989; Smith, 1997; Brewer, 1995).

Since the science of mathematics is directly connected to the mind, the direct formal education alone does not give us the desired result. Therefore, children must develop it themselves through their personal experiences and meditation about the experiments (Case & Okamoto, 1996). No extent of verbal guidance or memorization can provide children with the possibility of building the concept of number. It is constructed by dealing with the physical environment, and through the organization of events and purposes that lead to the process of reflection, which is the basis of logical thinking. However, children do not acquire knowledge of mathematics through the adaptation of material alone. Social interactions with adults and with children of their age are essential to understand mathematics. In order for children to learn the value and content of mathematics, deal with it and get the confidence to solve mathematical problems, they must interact positively with: personal experiences, dealing with others, use of language and meditation. In order to help children to understand the basic concepts of the number, a different type of teaching method is required other than that suggested by conventional thinking. Many people think that teaching is telling or showing the children what they need to know; and asking them afterwards to repeat what they have seen and practice it.

In such direct teaching, there is undoubtedly a promotion of knowledge more than the number. For example, the repetitious reading of children books that have counting to ten and asking the children to repeat the reading can help children learn and it can also be beneficial in modeling the arbitrary sequence of the number words (Baroody, 2001; Thompson, 1994).

Quality teaching in mathematics is directed to the challenge and enjoyment rather than enforcement and pressure. In early childhood, mathematics is good, broader and deeper than just counting and addition. Quality teaching of mathematics the provision of a great number of unit cubes and a lot of time to use them; a request from the children to bring a number of pencils that is sufficient for all children in the group; and asking the children to estimate