

OBTAINING LEAD IODIDE IN THE LABORATORY: LOOKING FOR ANSWERS

Manuela Ortigão¹, Fátima Paixão²

¹Escola Secundária Daniel Faria, Baltar (Portugal)

²Escola Superior de Educação, Instituto Politécnico de Castelo Branco, Castelo Branco e Centro de investigação Didática e Tecnologia na Formação de Formadores, CIDTFF – Universidade de Aveiro (Portugal)

manuelaortigao@ua.pt, mpaixao@ipcb.pt

Abstract

Everything we hear, see, smell, taste, and touch involves intricate series of chemical reactions and interactions in our body. Chemistry is not limited to beakers and laboratories. It is all around us, and the better we know chemistry, the better we know our world.

Can we learn chemistry without experimental work? No. We can not truly learn chemistry without experimental work. We can observe changes during chemical reactions including color changes, bubbling, "disappearance" of solid reactants, flame or formation of precipitates. Starting from the traditional reaction of precipitation of lead iodide, we present an articulated set of experimental activities guided by problem-questions aiming to develop the abilities of interpretation, handling and drawing conclusions, of the students of 8th grade (13-14 years old). To help students understanding precipitation reactions and also the very concept of chemical reaction, this concept is explored in three levels of analysis: macroscopic, submicroscopic, and symbolic [1].

These activities can be developed in the context of the classroom or explored, for example, in a non-formal educational context.

1. Introduction

Due to the fast technological and scientific advances, one of the great challenges of the current school comes from the education and training of young people needed to prepare them for an unpredictable future. This concern is critical also in chemistry education, leading teachers and educators to rethink about effective teaching-learning strategies promoting greater motivation on the students.

Curiosity about the world leads us to observe, analyze and try to respond to everything that surrounds us. Experience makes part and is present in our daily life, therefore, experiment should be included in the day-to-day students' lives in school. This idea is advocated by several authors [2-4] who recognize how experimental work is important for learning science. Experimental work can, among other aspects, helps to reduce difficulties in the learning of chemistry and generate enthusiasm and motivation due to the controversy that can be generated with the various hypotheses set by the students and their interpretations [2]. Students like to perform experiments but have difficulty in explaining phenomena, obtained often only through macroscopic and sensory analysis of the results of the activities done. In chemistry is appropriate the exploration of macroscopic, sub-microscopic and symbolic analysis because it is important and indispensable to emphasize the aspects relating properties and structure of substances and particles that constitute them as well as the relations between properties, structure and symbolic representation [5,6]. The effective operation at the three levels of analysis should be encouraged in order to help students in successive appropriation of the specific language of chemistry as an interpretive system [7].

Laboratory may provide excellent opportunities for students predict and test, planning experiential activities to be take place in the lab and draw conclusions. The whole idea of a laboratory activity where students follow a "recipe" and apply some techniques just to check if an experiment works illustrating the theory does not fit in the current education [8,9] and can even be ineffective, given its

closed and restrict character [10]. It is essential that in practical activities occur moments of reflection, creativity development and construction of scientific ideas, together with the development of relevant knowledge, appropriate abilities and positive attitudes [9].

In this paper we propose a different approach for the usually performed experience of formation of the yellow precipitate of lead iodide that teachers use to illustrate chemical reactions of precipitation.

2. Activities to develop in chemistry laboratory

The set of presented laboratory activities comes within the framework of the study of the didactic unit "Chemical reactions" in the curriculum of chemistry of 8th grade (13-14 years old) of the 3rd Cycle of Basic Education in Portugal. It also can be performed out of the regular classes in non-formal contexts (science clubs or science museums) because this set of experiments relates to the theme addressed in class but has some characteristics permitting to extend it as a challenge that students easily accept and adhere.

With the proposed activities we aim to create conditions for the exploration of the three levels of analysis already identified above, adjusting this analysis to the referred level of education. Along with the three activities, we want to promote the macroscopic and sensory analysis by identifying the occurrence of a chemical reaction, the submicroscopic analysis by interpreting the results according with the kinetic-corpusecular theory of matter and the symbolic analysis by writing the equations of chemical reaction. It is intended that students can simultaneously develop an experimental procedure that translates their predictions into supported responses to the problem-questions and correctly manipulate laboratory material respecting safety rules.

The three problem-questions guiding the proposed laboratory activities allow students to find the answers to small semi-oriented challenges appropriate to their age.

Table 1: Lab activities.

Activity	Problem-question	Time (min)	Local
1- Let's try...	Did a chemical reaction occur?	20	chemistry didactic lab (formal or non-formal context)
2- Dissolve or not dissolve?	How can we achieve the dissolution of the precipitate?	30	
3- React or not react?	Does it react?	10	

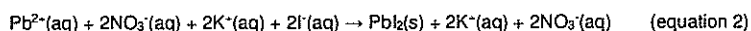
2.1. Precipitation reaction of lead iodide

Chemical reactions that occur in solution, in which is formed an insoluble salt from two water-soluble salts, are called precipitation reactions. The precipitate is an insoluble solid which is identified as one of the precipitation reaction products. The new substance separates from the solution of the other reaction product formed in the reaction because of strong ionic bonds established between the constituent ions and because that salt is denser than the aqueous solution. To predict if a precipitate is formed when two solutions are mixed, it is necessary to know its solubility indicated by the maximum amount of solute that can be dissolved in a certain amount of solvent at a given temperature. Adding two solutions, lead nitrate $[Pb(NO_3)_2]$ and potassium iodide (KI), it becomes clear the formation of an insoluble yellow product (PbI_2). The other product is the potassium nitrate (KNO_3), very water-soluble and colorless.

The molecular chemical equation (equation 1) shows the reaction as if all species existed as molecules or global units [11].

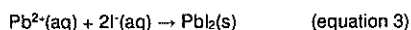


Three of the salts are in aqueous solution and behave as strong electrolytes; therefore, they are fully dissociated in their solvated ions, and we can write the ionic equation (equation 2) which will be more faithful to what really occurs:



When mixing the two solutions the formation of a yellow precipitate of PbI_2 is highlighted. The reaction in aqueous solution with formation of a precipitate occurs only between the ions $\text{Pb}^{2+}(\text{aq})$ and $\text{I}^-(\text{aq})$ ions.

So, the $\text{NO}_3^-(\text{aq})$ and $\text{K}^+(\text{aq})$ ions remain dissolved and are known as "spectator ions". We can then write the ionic equation simplified (Equation 3) including only the ions forming the yellow precipitate:



3. Experimental work

Students had already had contact with some examples of chemical reactions as well as notions about the nature of corpuscular matter and with writing chemical equations using the appropriate symbology. The set of experimental activities were implemented in two classes in the 8th grade who were in split groups (half the students of the class), having been possible to arrange them into three groups of 3/4 elements each one.

It was not provided to the groups a formal experimental protocol for conducting all the experimental activities, only a script with some issues of exploration. Each group selected labware according to experimental options proposed by them.

3.1. Let's try...

This first activity was initiated through the problem-question: Did a chemical reaction occur?

Students conducted the traditional experimental activity of the chemical reaction of precipitation of lead iodide from the junction of the solutions of lead nitrate and potassium iodide. The teacher provided the protocol of the experimental activity in order to familiarize students with the adequate terminology, indicating separately the laboratory equipment used the reactants and the experimental procedure. Students performed the activity and answered to some questions while the obtained mixture repose.

First of all, students described what they had observed in the experimental completion of the activity and if was been observed or not a chemical reaction. They identified and classified the reaction that occurred, wrote the chemical equation and indicated the name of the obtained precipitate using ionic tables of their textbooks [12]. Students took some photos to the final result (the precipitate formed in the reaction).

3.2. Dissolve or not dissolve?

This second activity began with the problem-question: How can we achieve the dissolution of the precipitate?

Once presented a problem situation close to the daily lives of students so that they could suggest a resolution to it: the act of continuous adding spoons of salt (for example, the well known sodium chloride) in a beaker containing water and how to dissolve it when the solution was saturated. Students discussed the situation in the working groups and proposed an alternative to increase the solubility of salt in water.

So, they observed the yellow precipitate of lead iodide that was formed in the first activity and propose and developed an experimental procedure that allowed the solubilization of the precipitate. We analyzed students' ideas and the respective procedure proposals which were then implemented by each working group. Upon completion of the students activities we photographed the mixture leaving it stand until the next class (one day later).

When students returned to the lab on the following day, they were greatly astounded and enthusiastic about the result: lots of crystals of lead iodide they called "golden pearls" and also "golden rain". The lead iodide had slowly crystallized as the result of a cooling process presenting a different aspect of the solid (powder) that was formed in the rapid precipitation reaction. They took photos of the apparatus comparing them with those taken in the day before (Fig. 1).

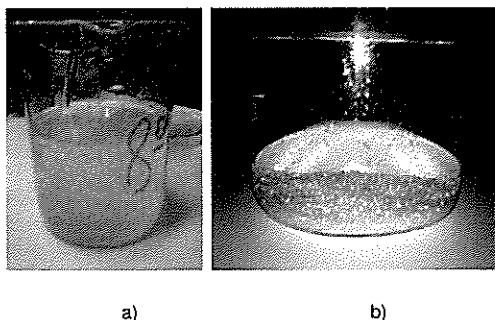


Fig.1. a) Initial appearance of the precipitate (stirred) in solution; b) Lead iodide crystals after 24 h.

The students also compared pictures intently (initial and final – Fig.1.) of the mixture obtained and remembered developed processes and findings.

Here is the astonished exclamation of a student: «As in the first photo we saw the crystals begin to form and looked like a **golden rain** and now the mixture is much clearer, the crystals are at the bottom of the beaker and are much bigger, they look like **golden pearls**».

3.3. React or not react?

Students were confronted with a new problem-question: Consider now that it was intended to perform the first activity using the reactants in solid state. Do you think that reaction occurs? Justify. The groups discussed the situation and made suggestions regarding this new question. We suggest that they design and execute an experimental procedure allowing them to test their predictions.

Most of the groups wrote: «no reaction will occur because we added water and therefore will not be able to form a precipitate». However, one of the groups explained a different idea: «The reaction will occur, because if we add the reactants in the solid state and we mix them, they can react». The corpuscles will shock and will bind differently thereby forming new substances».

Starting from the idea of the working group which considered that there must be reaction, students joined the two reactants in solid state. Nothing happened. However, using a mortar, suggested by the teacher, a yellow solid arose when they get joined vigorously the two reagents.

4. Conclusions

The proposed set of laboratory activities was an important tool to analyze the structure of knowledge of our students about chemistry at different levels: macroscopic, sub-microscopic and symbolic. All students were able to identify the occurrence of a chemical reaction through sensory perception of color change of the mixture (yellow) after the addition of two colorless solutions. To this color change

students associated the formation of new substances different from the initials, distinguishing thus physical from chemical changes. Students also distinguished the reaction of the presented activity from other reactions previously studied, such as combustion or acid-base, because of the solid formed and deposited on the bottom. Students were able to analyze new situations and suggest experimental procedures for their initial answer to the problem-questions. They conducted laboratory activities in a responsible manner revealing they know all the material and also safety rules which must be respected in the laboratory.

Writing the equation that translates the chemical reaction of the formation of lead iodide that occurred was also accessible to students but we are aware that this writing was partly based on empirical rules about writing the chemical equations that represent the reactions of precipitation and not completely arising from sub-microscopic interpretation. However students evidenced that they had the notion that those substances involved in the chemical reaction were all of them ionic compounds and that starting materials would "exchange pairs" and form new ionic compounds. They consulted the ions table and the solubility constants table in their textbooks and correctly wrote molecular chemical equation.

The concept of chemical reaction, based on the kinetic-particle theory also has become better understood with the interpretation of the reaction of formation of lead iodide starting from the reagents in solid state.

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