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The Science of Miracles - Chemistry

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ABSTRACT

The chemical experiment (laboratory or demonstration) motivates the study of chemistry as a field of science. Our earlier report has revealed the relationship between the scientific side of the chemical experiment and its attractiveness. The purpose of the current communication is to demonstrate the relation between the science of chemistry and its miracles, especially studying the second main group of the periodic system. The names of the selected experiments are wonderful, which excites the interest of learners: „Magical light", „The Gin", „Poppin candy", „Snake of fire", „Falling clouds", „Jellyfishes", „Cotton candy", „Devil's milkshake". The selected experiments are not just miracles, but they also reveal the basic properties of the metals from the second main group of the periodic system and their compounds. These experiments are appropriate for a great variety of learners of different ages: pupils and students.

Keywords: chemistry, chemical experiment, education, second main group.

INTRODUCTION

Chemistry is the science that deals with the substances and the changes they undergo but it is also the science of magic and miracles. Known from ancient times - the first "chemists" were the primitive men. With their understanding of fire they started using the chemical process of burning in their life. Thus, chemistry as if with a mysterious wand gives the beginning of the primitive man's development. The ancient people in Egypt, India, and China manage to master other chemical processes such as fermentation, distillation, leather tanning and much more. In this manner they learnt how to make wine, how to process iron, wood, leather. In the distant past the people used to have astonishing knowledge and skills! Quite often though they weren't able to explain the processes, for them these were miracles, nonetheless they collected their knowledge which was passed down from generation to generation. And so, the miracles were transformed in a science - chemistry.

Bit by bit chemistry made its way into household, textile, cosmetics, jewelry, industry etc. Chemistry surrounds us, it's wherever we look, it's inside us. Everything is chemistry and chemistry is filled with wonderful miracles which today we visualize through chemical experiments.

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The chemical experiments are the most fascinating part of chemistry - on one hand it reveals the essence of chemistry and on the other its miracles. They are also interesting, mysterious, fascinating and extraordinary. The chemical experiment is in the same time a method, an instrument and a requirement needed in order to acquire natural science literacy and discipline [1]. It develops the skills and abilities to interpret results, to work on your own and together in a group depending on the nature of the experiment, to plan the experiment, to be considered, to work safely in the laboratory.

Learning through chemical experiments has a list of advantages [2]. The chemical experiment is a tool which increases the students' attention during the hours of practice. The students understand, acquire knowledge and remember it much more easily. This increases effectiveness as well leading to longer lasting and fuller knowledge. Executing a given experiment, the students acquire specific chemical knowledge. They develop professional labor discipline (order and workspace tidiness; strictly following the safety technique) as well as aesthetics (the proportionality criteria is developed, order and purity of apparatus construction). Last but not least is the environmental-healthy knowledge while working with gasses, controlling the apparatus' sealing; acquire knowledge and skills for working with poisonous, suffocating, flammable and explosive substances, the safety measures about them in our daily life and in the laboratory [3].

In our previous publication through chosen chemical experiments a variety of ways to illustrate the connection between the attractiveness and scientific impact of the chemical experiment were shown [4]. In addition, the fact that the application of these experiments in natural sciences will undoubtedly increases the pupils' and students' attention, to obtain natural sciences literacy and increase the motivation to learn. In another research this was specifically shown through the study of the first main group of the periodic table [5].

In this paper for the first time, we demonstrate the relationship between science and attractiveness, particularly in studying the second main group of the periodic system.

EXPERIMENTAL

A brief description, implementation method and a photo of selected interesting experiments are presented [6-8], (Fig. 1-7).

Brightness and shine

Necessary equipment and reagents. Tweezers, pre-sanded magnesium tape (about 10 cm), spirit lamp, petri dish.

Procedure. Light the spirit lamp. Take the magnesium - ribbon with the help of the tweezers and bring it to the flame of the spirit lamp. Hold this until the Mg-strip lights up, you will see a blinding white light. Then turn off the spirit lamp and hold the Mg-strip, over the petri dish, until it stops burning.

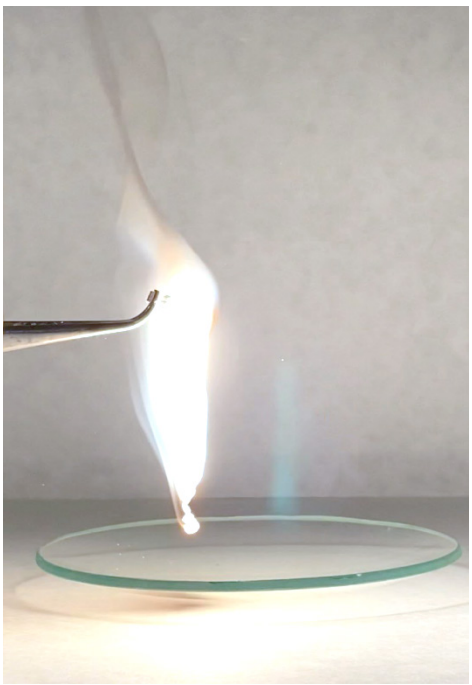
Observed changes. Magnesium ignites when heated and burns with an extremely bright white flame. A white substance is obtained - magnesium oxide. It is not recommended to look directly into the flame, as the intense light can damage your eyes (Fig. 1)!

If the magnesium tape is set on fire and then submerged in a container filled with carbon dioxide, not only it does not extinguish its fire, contrary to the expectations, but it burns even lighter.

Magical light

Necessary equipment and reagents. Tweezers, pre-sanded magnesium tape (about 10 cm), spirit lamp, petri dish, beaker, acetic acid, sodium hydrogen carbonate.

Procedure. Firstly, in the beaker add sodium hydrogencarbonate. Add acetic acid and wait until the reaction has taken place. In this way carbon dioxide is produced. Light the spirit lamp.



$$2Mg + O_2 \rightarrow 2MgO$$

Fig. 1. Brightness and shine.

Take the magnesium - ribbon with the help of the tweezers and bring it to the flame of the spirit lamp. When the Mg-strip is ignited submerge it into the beaker. You will notice that it does not extinguish and this time the light is brighter than before. Turn off the spirit lamp and hold the Mg-strip, over the beaker, until it stops burning.

Observed changes. Magnesium ignites when heated and burns with an extremely bright white flame even in carbon dioxide environment. Magnesium oxide and carbon gas are obtained. It is not recommended to look directly into the flame, as the intense light can damage your eyes. This is „Magical light" (Fig.2).

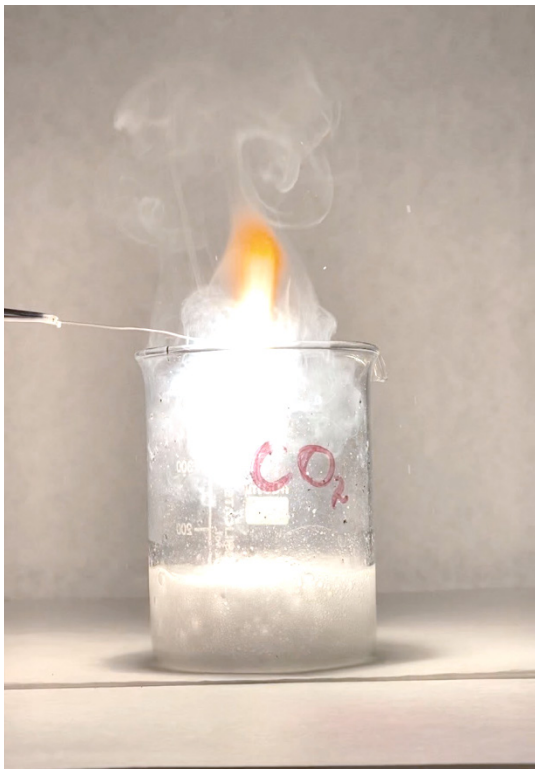


Fig. 2. Magical light.

$$2Mg + CO_2 \rightarrow 2MgO + C$$

The Gin

Necessary equipment and reagents. Magnesium powder 2 g, iodine 4g, hot water, pipette, porcelain vessel (unglazed).

Procedure. Into the porcelain vessel add the powdered magnesium and iodine. Mix gently. Add a few drops of hot water and observe the reaction.

Fig. 3. The Gin.

Observed changes. Magnesium reacts easily with iodine when water and heat are been added, (Fig. 3). Make sure that the chemical experiment is executed outside or under the fume hood, as the iodine vapors are irritant and toxic. Unfortunately, ***„The Gin"*** cannot grant you a wish.

$$Mg + I_2 \rightarrow MgI_2$$

Poppin candy

Necessary equipment and reagents. Magnesium silicide powder, hydrochloric acid, pipette, petri dish.

Procedure. Onto the petri dish using a pipette add some hydrochloric acid. Then from about 15 cm height let a small amount of magnesium silicide fall.

Observed changes. Magnesium silicide reacts easily with hydrochloric acid in an exothermic reaction, (Fig. 4). Make sure that the splashes formed by the explosive bubbles do not enter in contact with skin or eyes. Although it looks like a ***„Poppin candy"*** be sure NOT to try it.

$$Mg_2Si + 4HCl \rightarrow 2MgCl_2 + SiH_4$$

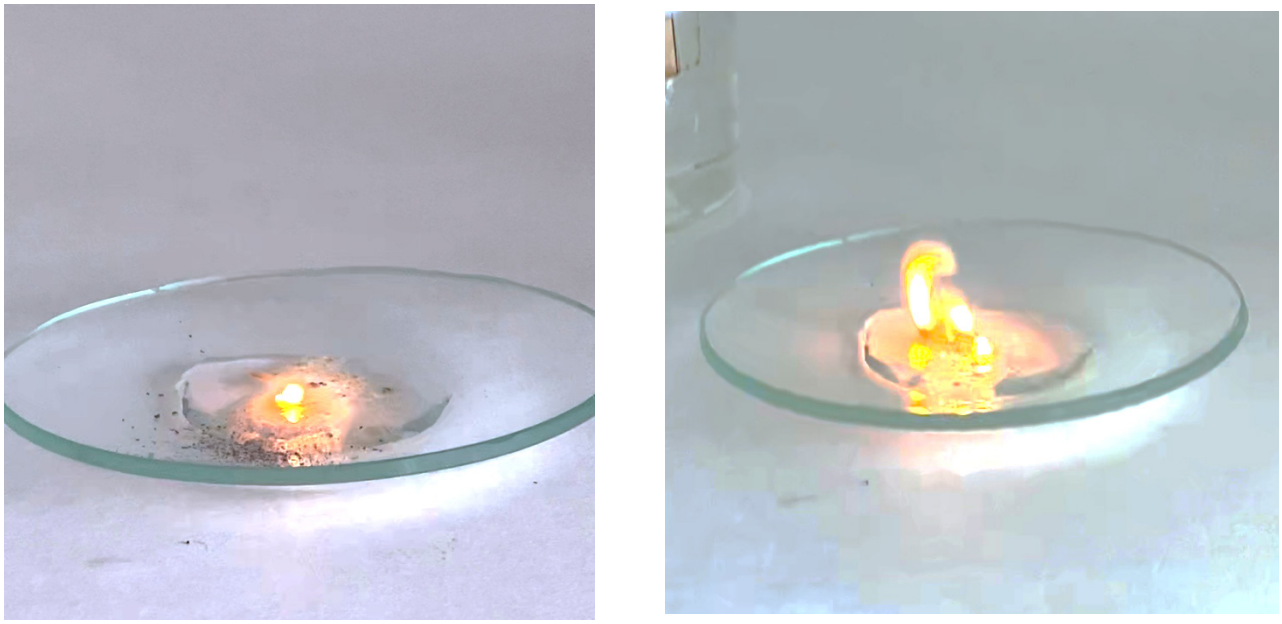


Fig. 4. Poppin candy.

Fig. 5. Snake of fire.

Snake of fire

Necessary equipment and reagents. Calcium chloride, methanol, ethanol, pipette, watch glass, iron pencil basket, small aluminum container, cotton.

Procedure. Onto the watch glass place the aluminum container and add into it calcium chloride and some ethanol. Use the cotton soaked with methanol and spread the alcohol on the iron pencil basket. Ignite the calcium chloride and cover it with the iron basket. Now rotate the watch glass and observe.

Observed changes. The calcium chloride burns intense, due to the ethanol, and longer, due to the methanol which slows down the reaction comparing it to the flame in oxygen environment. By rotating the watch glass the fire starts rotating like a dancing ***„Snake of fire",*** (Fig. 5).

Falling clouds

Necessary equipment and reagents. Calcium chloride (solution), strontium chloride (solution), barium chloride (solution), phenolphthalein, litmus (solution), sodium hydroxide, 2 beakers, pipettes, 3 test tubes.

Procedure. Into the test tube using pipette insert the calcium chloride solution. Afterwards using another pipette drop a single drop of sodium hydroxide followed by others. For the other two test tubes a solution of sodium hydroxide must be prepared in beakers - in one with litmus in the other with phenolphthalein.

Observed changes. The calcium chloride solution is rich in Ca^{2+} cations which stand before Na^{+} in the electrochemical series and therefor the following reaction occurs:

$$CaCl_2 + 2NaOH \rightarrow Ca(OH)_2 + 2NaCl$$

The calcium hydroxide is formed in what appears as ***„Falling clouds"*** which without mixing rise to the surface, (Fig. 6 (a)).

Using a pipette add the prepared sodium hydroxide solutions in the following test tubes:

Jellyfishes

In a test tube with added strontium chloride, add a few drops of the hydroxide-litmus solution

Fig. 6 (a) Falling clouds.

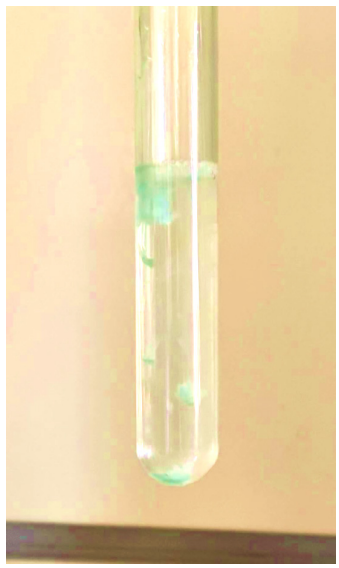


Fig. 6 (b) Jellyfishes.

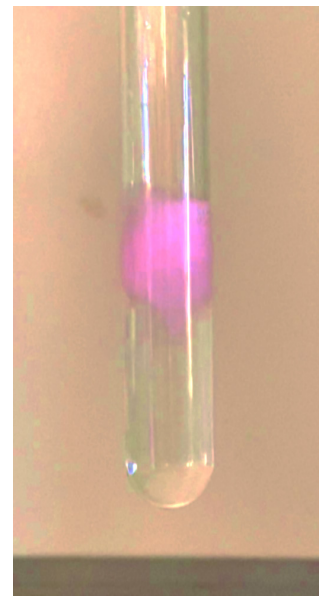


Fig. 6 (c) Cotton candy.

– as soon as the drops enter in contact with the strontium chloride blue colored ***„Jellyfishes"*** appear, (Fig. 6 (b)).

$$SrCl_2 + 2NaOH \rightarrow Sr(OH)_2 + 2NaCl$$

Cotton candy

In a test tube with added barium chloride, add a few drops of the hydroxide-phenolphthalein solution – if we do not mix the barium hydroxide will rise to the surface, (Fig. 6 (c)). Due to its pink color it resembles to a delicious ***„Cotton candy"***. But do NOT try it - it is toxic.

$$BaCl_2 + 2NaOH \rightarrow Ba(OH)_2 + 2NaCl$$

Devil's milkshake

Necessary equipment and reagents. Calcium carbide, water, phenolphthalein, beaker, lighter.

Procedure. Into the beaker water and phenolphthalein are added. A piece of calcium carbide is added into the beaker.

Observed changes. As the calcium carbide is inserted into the water it starts reacting and calcium hydroxide is produced, the solution is colored by the phenolphthalein in red as it is alkaline. In addition, acetylene is produced:

$$CaC_2 + 2H_2O \rightarrow Ca(OH)_2 + C_2H_2$$

Acetylene is lighter than air and it is flammable. Approaching the beaker with a lighter it sets on fire, (Fig. 7). Although it is dangerous for our health it seems like a really delicious milkshake but as we set it on fire the name ***„Devil's milkshake"*** fits it better.

RESULTS AND DISCUSSION

Miracles of the metals from the second main group of the periodic system and their compounds

The choice of chemical experiments to be demonstrated is very important. It should be a curiosity and a delight or as Epitropova et al. summarize to be „interesting, unpredictable, to arouse curiosity, accompanied by effects that have a strong effect on the senses, give rise to aesthetic perceptions and ideas, enjoy delight, provoke the activity of the mind and ignite the imagination" [2, 6].

The selected experiments: „*Brightness and shine*", „*Magical light*", „*The Gin*",

Fig. 7. Devil's milkshake.

„*Poppin candy*", „*Snake of fire*", „*Falling clouds*", „*Jellyfishes*", „*Cotton candy*", „*Devil's milkshake*" attract the students' attention as soon as they are announced, their names are mysterious and arouse curiosity and impatience. All experiments should be carried out in accordance with safety rules for chemical laboratories, using appropriate protective equipment: cloth, glasses, gloves, etc. The experiments should be carried out under the direct supervision of a teacher.

„*Brightness and shine*", „*Magical light*", „*The Gin*"- these experiments can be used both to illustrate the chemical properties of magnesium and to study oxidation-reduction processes.

The remaining experiments („*Falling clouds*", „Jellyfishes", „Cotton candy") help to present and more easily understand the chemical properties of some compounds of the chemical elements of the second main group. In addition, they can also be successfully used in the study of ion-exchange chemical reactions, obtaining sediments. The selected experiences are interesting, fascinating and memorable.

„*Devil's milkshake*" - this experiment, besides illustrating the chemical reaction between calcium carbide and water, at the same time shows the production of ethyne and calcium dihydroxide. This reaction is extremely important from a practical point of view. This experiment can be used when studying ethyne or calcium dihydroxide.

After conducting a survey among students, it was found that the following experiences generate exceptional interest among them: *„Snake of fire"* and „Devil's milkshake".The experiences accompanied by sound, light or fire are more attractive, or the more senses involved in learning of experiment, the more interesting and fascinating it is. This, in turn, facilitates understanding a given chemistry topic.

Each experiment gives results that enrich the learner with new knowledge, competences and skills, and they themselves help to build a correct view of life and our surroundings. Experiments lead to causality, cognition and conclusions because for a variable factor assumed to be the cause of the phenomenon under study, the other factors having real or assumed influence are held constant. The scientific chemical experiment as a teaching method participates in the achievement of certain aspects of the main pedagogical goals - cognitive, affective and psychomotor. The use of a chemical experiment in education (the so-called educational chemical experiment) leads to the realization of a constructive learning environment and the acquisition of important practical skills [5]. The chemical experiment contributes to the development of independence, initiative, creativity, critical thinking in students and orients them to a specific effective result. The use of innovations in the teaching and learning process contributes to a large extent to increasing the motivation for active independent work.

CONCLUSIONS

In this study, several wonderful chemistry experiments have been selected. They could be performed both in school or university and in extracurricular activities. The selected experiments both present the fun of chemistry and reveal the essence of chemistry as a field of science. The wonders of chemistry and the science of chemistry are combined into one whole. An option of realizing the connection between the attractiveness of the chemical experiment in the study of the second main group is demonstrated. The selected chemical experiments and the possibilities for their application in education are only a cursory illustration of the various options for realizing the connection between the attractiveness and the scientific nature of the chemical experiment. Maximizing the use of this connection in science education can undoubtedly lead to an increase in interest in them, as well as to the formation of science literacy and increasing the motivation for learning.

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