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Fire magic with alkali metals and their compounds

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The laboratory chemical experiment motivates the study of chemistry as a field of science. Our earlier report has revealed the relationship between the attractiveness and the scientific side of the chemical experiment. The purpose of the current communication is to demonstrate the connection between science and amusement, especially in the study of the first main group of the periodic system. The names of the selected experiments are mysterious, which excites the interest of learners: *"Fire snake", "Fire without matches", "Fire in water", "Floating flames", "Fire under water".* The selected experiments are not just fun, but also reveal the basic properties of the alkali metals and their compounds. These experiments are appropriate for a great variety of students of different ages.

Keywords: chemistry, chemical experiment, education, alkali metals.

INTRODUCTION

Besides being a complex science, chemistry can be also fun and interesting. This is most clearly illustrated through the chemical experiment. The experiment is the side of chemistry that attracts the attention of students of different ages to this difficult and simultaneously interesting science. The use of the experiment in education increases the interest and motivation, provokes the learners, excites them and provokes expectations and impatience. It is necessary to use the scientific experiment as a method of illustration in teaching.

Each subject in chemistry can be presented or touched with the experiment. This in turn contributes to the easier learning of the study material. In a previous report [1] we demonstrated how to realize the relationship between the attractiveness and the scientific side of the chemical experiment. The point of this communication is to apply the relationship between science and attractiveness particularly in studying the first main group of the periodic system.

Fire magic with alkali metals and their compounds

The selected experiments represent a *"fire magic"* with alkali metals and their compounds, demonstrating some of their basic properties. The alkali metals (Li, Na, K, Rb and Cs) refer to 1A group of the periodic system. In nature the alkali metals are found in the form of compounds – minerals. They are obtained by electrolysis of molten salts or metal hydroxides. The alkali metals are some of the most common chemical elements in the earth's crust. They form simple metal substances. Because of their high chemical reactivity, they are stored under oil. The alkali metals and their compounds are widely used in practice.

The experiment is a study of a given phenomenon by reproducing it under specific conditions or to deliberately influence their mechanism. Each experiment produces results that enrich the creator with new knowledge and skills, and they themselves help to build one's view of life. It is assumed that the experiments lead to a causal connection and conclusions because, for a variable factor, presumed as the cause of the phenomenon being investigated, the other factors, having a real or supposed influence are kept constant. Therefore, it can be stated that whatever effect is obtained in such cases, it was caused by the variable factor. The scientific chemical experiment as a learning method participates in the achievement of certain aspects of the main pedagogical goals – cognitive, affective and psychomotor. The use of a chemical experiment in training (so-called educational chemical experiment) leads to the realization of a constructive learning environment and the acquisition of important practical skills.

The choice of the experiment which is to be demonstrated is of great importance. It has to be fascinating, interesting. 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].

After a thorough review of various sites offering clips of chemical experiments (http://scienceland.co/resource.html, www.chemistry.alle.bg, http://www.az-deteto.bg/laboratoriya/cat.html, http://ucha.se, www.lyuboznaiko.com), as well as textbooks and eaching aids [3-6] related to the

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presentation of chemical experiments and the workin the chemical laboratory we have selected several interesting and fun experiments involving alkali metals and their compounds (Applications 1-5).

The selected chemical experiments are interesting and entertaining, and reveal some of the basic properties typical for the alkali metals and their compounds. They are suitable for undergraduates, but can be demonstrated to students, as well as to various forms of extracurricular activities. They attract the attention of the students with their announcement, their names are mysterious, and awaken curiosity and impatience: *"Fire in water", "Fire snake", "Fire without matches", "Floating flames", "Fire under water"* (Applications 1-5).

It is important to correctly select the exact location according to the curriculum for the presentation of an experiment so as to show the scientific part of chemistry, to explain the observed changes, to describe them by a chemical equation and so on.

With appropriate introduction and presentation, each of the selected experiments can be used at different levels in chemistry training, with the corresponding explanations and chemistry of the reactions being appropriate.

For example, *"Fire in water"* (Application 1) can be used in the Human and Nature Course to present and compare chemical activity in the interaction of metals with water, while the course in Chemistry and Environmental Protection should deepen the knowledge and to explain the chemistry of observed changes, to relate to the type of processes and to use other levels of representation (chemical equations, patterns, etc.).

The *"Fire snake"* experiment (Application 3) is easy to implement and is feasible with cheap and affordable materials. With good safety training and background in chemistry, this experiment can be accomplished by students.

The described chemical experiments involving alkali metals and their compounds, as well as the possibilities for their application in Chemistry and Environmental Education give little insight into the various options for realizing the link between fun and science in the chemical experiment. Making the most of the experiment in science education will undoubtedly lead to an increase in the interest of the student, a development of natural science literacy and an increase in the motivation for learning.

CONCLUSION

The relationship between the attractiveness and the scientific side of the chemical experiment is successfully reflected in the study of alkali chemical elements. *"Fire"* chemical experiments have been selected that could be used at different levels in chemistry training when introducing the first main group of the periodic system. The presented experiments are not only entertaining and interesting, but they reveal the essence of a particular problem that arises from the study of the alkali metals and their compounds, and at the same time they help to improve the understanding and easier learning of the study material. This in itself illustrates the relationship between mystery chemistry and science chemistry. These experiments can be successfully used, both in student training and during extracurricular activities. Future research aims to apply the link between the attractiveness and the scientific side of the chemical experiment in different thematic areas and levels in the study of chemistry science.

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REFERENCES

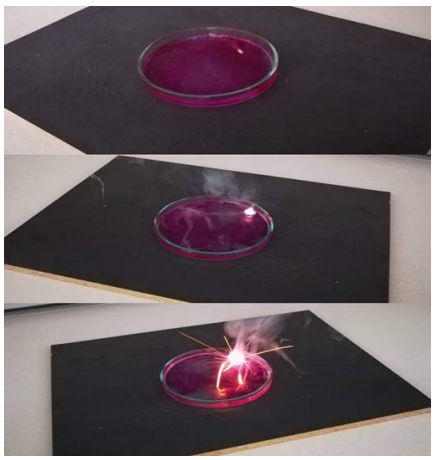
1. E. Chorbadzhiyska, V. Dimitrova, M. Shekerliyska, G. Baljova, M. Angelova, *Chemistry, Bulgarian Journal of Science Education*, **24**, 584 (2015).
2. A. Epitropova, Y. Dimova, K. Kamarska, Active education in natural sciences, Plovdiv, University Press "P. Hilendarski", 2012.
3. V. Dimitrova, M. Mitov, St. Manev, El. Chorbadzhiyska, Practicum in Inorganic Chemistry, Blagoevgrad, University Press "Neofit Rilski", 2015.
4. D. Lazarov, Inorganic Chemistry, Sofia, University Press "St. Kliment Ohridski ", 2019.
5. H. Malcheva, L. Genkova, V. Naidenova, Methodology and Technique of the Study Chemical Experiment, Blagoevgrad, University Press "Neofit Rilski", 2000.
6. M. Andreev, The Learning Process. Didactics, Sofia, University Press "St. Kliment Ohridski ", 2006.

APPLICATION 1

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.

"Fire in water"

Na, K, phenolphthalein, filter paper, tweezers, knife and two plates are required. Add water in one of the plates and drop 2 drops of phenolphthalein. Using tweezers, a piece of sodium is removed, placed on filter paper; grain size pieces are drained that are thoroughly filled with water. The same happens with the potassium metal.



It is observed that the batch of sodium is bounced on the water and that the water is colored in a raspberry color. When potassium reacts with water the reaction is more violent, a flame is being observed on the surface of the water.

$$2Na + 2H_2O \rightarrow 2NaOH + H_2$$

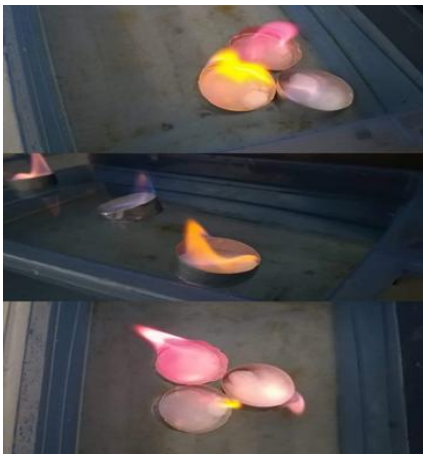
$$2K + 2H_2O \rightarrow 2KOH + H_2$$

The *"Fire in water"* experiment illustrates the interaction of alkali metals with water. The reaction is exothermic. This experiment can be demonstrated to students when they study the chemical element sodium, as well as in the study of oxidation-reduction reactions or in the study of the first main group of the periodic system.

APPLICATION 2

"Floating flames"

The following substances are essential: salts of lithium, sodium, potassium (salts must be of high purity), a bowl of water, walnut shells and ethanol. In each walnut shell place several crystals of the lithium, sodium and potassium compounds, respectively. Then wet with ethanol. Walnut shells are placed in a container of water and ignited with their contents. Floating fires colored in a different color are observed. The alkali metal vapor dyes the flames in different colors. The lithium compounds stain the flame in carmine red, those of sodium dye the flame in yellow and those of potassium – in purple.



A floating fire is observed, colored in a different color. The alkali metals vapors are dispersed in different colors. Lithium dyes the flame in carmine red, sodium dyes the flame in yellow and potassium – in purple. This circumcision is related to the low values of the ionizing energies. In the event of a high temperature impact, the energy is increased at high energy levels or within the boundaries of the electronic envelope. In this state the excited electron stays for a very short time – 10-8 seconds. The next transition to more internal energy levels is associated with a light emission that is mainly in the visible part of the spectrum. That`s why the flame is dyed.

An experiment with different colors attracts attention and, at the same time, helps to understand the topics that students can hardly imagine and realize – ionizing energy, excited state, electron transition, and so on.

APPLICATION 3

"Fire snake"

A dish, ethanol, sand, bread soda, powdered sugar and matches are needed. The plate is filled with sand and is soaked with ethanol. In the middle is inserted a mixture of powdered sugar and soda at a ratio of 4:1 by making a tight stack and then is ignited.

Carbonization of sugar and simultaneous decomposition of the baking soda is observed by the release of carbon dioxide, which gives volume to the resulting mass. As a result, the volume of the mixture is increased several times and crawling of a "snake" in black color is observed.

$$C_{12}H_{22}O_{11} \rightarrow 12C + 11H_2O$$

$$2NaHCO_3 \rightarrow Na_2CO_3 + CO_2 + H_2O$$

The *"Fire snake"* experiment is both an interesting and easy experiment that can be done at home, but under the necessary safety conditions. By means of materials that can be easily obtained, a very effective experiment is performed that could easily attract the attention of students of different ages.

APPLICATION 4

"Fire without matches"

An alcoholic lamp, 96% H_2SO_4, $KMnO_4$ and a porcelain crucible are required. Several crystals of $KMnO_4$ are ground and powdered in the crucible with a few drops of 96% H_2SO_4. The end of a glass rod is moistened with the prepared mixture and fed to the lamp wick.

Ignition of the alcoholic lamp wick is observed.

$$2KMnO_4 + H_2SO_4 \rightarrow K_2SO_4 + 2HMnO_4$$

$$2HMnO_4 \rightarrow Mn_2O_7 + H_2O$$

$$Mn_2O_7 \rightarrow 2MnO_2 + O_3$$

$$C_2H_5OH + 2O_3 \rightarrow 2CO_2 + 3H_2O$$

This experiment can be demonstrated to different age groups. It is also interesting for the smallest, as it looks like a magic wand, as without matches, the lamp flashes. This experiment is also appropriate in the study of oxidation – reduction processes.

APPLICATION 5

"Fire under water"

A large thick tube, tripod, 96% H_2SO_4, C_2H_5OH and $KMnO_4$ are required. In a tube vertically attached to a tripod pour 3 cm^3 of 96% H_2SO_4. Carefully pour 3 cm^3 of C_2H_5OH to the tube walls to form two layers. A few crystals of $KMnO_4$ are placed in the tube.

Small flashes are observed at the boundary between the two layers. There is a clear crack.

$$2KMnO_4 + 3H_2SO_4 + 5C_2H_5OH \rightarrow 5CH_3CHO +$$

$$K_2SO_4 + 2MnSO_4 + 8H_2O$$

This experiment can be used in the study of chemical equations: combining and equalizing oxidation – reduction processes, presenting strong oxidants and their properties.