Chemistry and Industry for Teachers in European Schools

FORENSIC CHEMISTRY

Scenario of a lesson

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Education and Culture

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INTRODUCTION

This paper presents a class scenario of a lesson to illustrate the relevance of chemistry to food and food preservation. We propose using the active teaching/learning method called circuit or modules method. This material contains:

- the description of the circuit method,
- the scenario of chemistry lesson,
- worksheets for students.

CIRCUIT / MODULES METHOD - DESCRIPTION

In education, a module determines the manner of activity consisting in performance of specific didactic activities. The circus method consists of the performance of a series of actions (tasks, modules) by groups of pupils. The results of individual actions serve to determine the mutual relations between the constituent elements of a certain entity (the topic of a given class). Individual activities (chemical experiments, working with texts, etc.) fulfil various functions in the method, constructing an overview of the problem as a whole.

In the module method, pupils perform tasks in small groups (2-3 persons), passing from one station to another (in a specific order or according to their own selection or according to the teacher's guidance).

At the beginning of the class, the pupils select the stations in an arbitrary manner, but each group must find one station (alternatively, the initial stations are assigned to the groups by the teacher). The groups of pupils perform a task which they are presented with at a given station and record the results on a worksheet which they keep themselves. Upon the teacher's signal (or after the completion of a task), they change stations and go on to another one (in a clockwise direction or to another station that is free at that time).

The teacher's task is to prepare a relevant number of stations (equipment, reagents, instructions for conducting experiments, source texts, sets of questions for the pupils, etc.), to organise the work of pupils, to provide assistance during problem solving, to make sure that health and safety regulations are complied with, to ensure that work places are cleaned by the groups after the completion of experiments and to supervise the smoothness of task implementation.

It is possible to introduce modifications to the traditional module method, e.g.: at the first station, the worksheet assigned to the station is left by the pupils with the incomplete side facing upwards; at the second station, the pupils not only perform the task and complete the worksheet, but also turn over the worksheet of the previous group and compare their results. They write down any differences. They take the sheet of the previous group with them and leave their own work sheet.

After completion of all tasks, the work is summarized in a form proposed by the teacher, e.g. oral presentation of results obtained at individual stations (or a presentation with the use of a projector). In this manner, each group presents the results obtained at one station. The summary is very important, due to the fact that it integrates the knowledge acquired in the course of a series of subsequent activities (modules).

When the number of pupils in the class is high, implementation of the module method is possible with the introduction of certain modifications, e.g. devoting a two-hour session to it, preparing identical stations (with the same tasks), increasing the number of group participants (which is not recommended, but is used from time to time), decreasing the number of "mandatory" stations.

If there is a group of talented pupils in the class, it is possible to prepare additional stations for them in order to make them use their potential.

The method may be characterised:

- by a closed structure, strictly planned by the teacher – change of work stations takes place upon the teacher's signal, each group has to "pass" each station;
- by a semi-open structure: the pupils decide for themselves when and how they are going to change stations. They might decide how many of the stations they must pass through, e.g. five out of eight;
- by an open structure (not encountered in chemistry teaching): the pupils choose stations and their number on their own.

USE OF CIRCUS METHOD ON THE CHEMISTRY LESSON

A lesson devoted to food and its preservation is presented below. It consists of seven experimental stations and two theoretical stations:

(1) Theoretical station - Chemical Methods of Food Preservation
(2) Theoretical station - Physical Methods of Food Preservation
(3) Experimental station - the label
(4) Experimental station - the container, i.e. the can
(5) Experimental station - metal layer
(6) Experimental station - inner layer
(7) Experimental station - tomato sauce
(8) Experimental station - the noodles
(9) Experimental station - the meat

The groups perform their tasks and record the results on the worksheets.

Comments

The teacher will decide which experiments she/he prefers to offer to particular group of students (experimental stations 3-9). The experimental instructions can be found on the CITIES project website too. It depends on: laboratory conditions, time scale, students' skills and knowledge etc; the teacher may modify the list, dependent on these factors.

Introduction

Preservatives have become a cause for concern in the western world. It is probable that starving people in Africa or Asia do not give them a second thought. American and European producers compete in their offers of natural food /organic i.e. without chemical additives, which means without the notorious E-numbers - flavourings, thickeners, antioxidants, fillers, as well as preservatives. On the other hand, at the beginning of the last century the diseases connected with the digestive system, including poisoning caused by such bacteria as botulinus toxin *Clostridium Botulinum* were the main reason of deaths (not brought about by wars, crimes or injuries). Botulinum is the strongest contemporary known poison, much stronger than cyanides and arsenic, not mention potassium nitrate used for preservation.

One of the oldest methods of the food preservation was **drying** - mushrooms, fruits and meat were treated in this way. During drying, water was evaporated from the product which could be then stored for a long time. The next stage was

the **thermal treatment** of food - grilling and boiling, which caused the denaturation of protein, which is contained in meat as well as that forming bacterium cells. In the regions with a cold or Arctic climate the preservative properties of **low temperatures** were used. Nowadays we apply these properties in refrigerators and freezers. To ensure an oxygen-free atmosphere, light absence and a low temperature, which slow down decomposition processes, food was buried e.g. eggs (China) and butter (Ireland and Great Britain).

THEORETICAL STATION 1 – WORKSHEET

Chemical Methods of Food Preservation

Read the text and do exercises afterwards.

Besides grilling, **smoking** was used to preserve meat, fish and cheese. At properly controlled temperatures, smoke dries food and certain smoke components, e.g. cresols destroy bacteria and fungi, prolonging food utility.

New solutions had been looked for until the preservative properties of rock **salt** (table salt, sodium chloride) were discovered. The preservation with salt is based on the osmosis process. Salt "dries" meat protein, as well as bacterium protein destroying their structures. **Sugar** acts in the same way, the results????– fruit preserves, stored in cellars, are edible for years.

In the early days, a little bit of **salicyl** – salicylic acid occurring in the bark of white willow *Salix alba*, was added to preserves. With regard to its relatively toxic properties - it badly affected not only bacteria but also human health, nowadays, its use is forbidden and it has been substituted with benzoic acid (or sodium benzoate with bacteriostatic properties). Benzoic acid is present, among others, in blue berries and protects their preserves against spoilage.

The specific methods are the **alcohol fermentation** – the method of obtaining wine and beer and the fermentation used in cheese production as well as cucumber and cabbage preserve preparation - **lactic fermentation,** which results in forming lactic acid from carbohydrates. Due to the beneficial microorganisms (e.g. yeast, lactic bacteria) the chemical compounds are formed which are destructive to other microorganisms.

Finally, the method known by our grandmothers and mothers – the low temperature meat preservation with the mixture of NaCl and KNO_2 called **pickling**. This method causes a colour and taste change (pink ham) and extends food use. **Sulfur dioxide** is another chemical preservative; already Homer mentioned it in „Odyssey". SO_2, with the symbol E220, is used in the wine industry and for fruit preservation. Because of its reducing properties, sulfur dioxide protects food against oxidation.

Exercises

1. Explain, in one sentence, why people used to store butter under water to protect it against spoilage.

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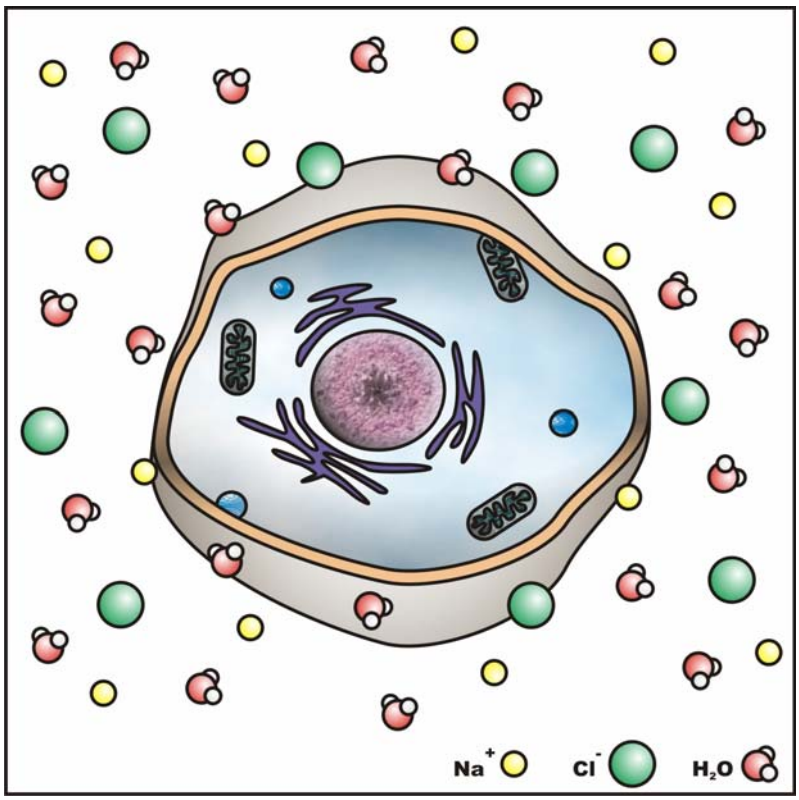
2. Choose the kinds of compounds, from those shown below, which formed during the fermentation process of food preservation.

(a) hydrocarbons

(b) alcohols
(c) acids
(d) carbohydrates
(e) proteins
(f) two answers are correct

3. Show (draw), in the diagram, the direction of H_2O molecules' flow when meat is submerged in salt water (cell – environment)



Graphical work by Agnieszka Węgrzyn.

THEORETICAL STATION 2 – WORKSHEET

Physical Methods of Food Preservation

Read the text and do the exercises afterwards.

During the Napoleonic Wars (1798 - 1815) there was a need to supply food for huge number of soldiers. The French journal Le Monde offered 12 000 francs for the daredevil who could fulfil this need. In 1809 Nicolas Francois Appert provided his service. He observed that if food was boiled in a closed glass jar, it did not spoil if it was tightly closed. That was it! At that time the reasons for this phenomenon were not known (Louis Pasteur was not born until some years later). That process was called **appertisation.**
However, bottles were inconvenient because of their weight and glass fragility. Basing on the Appert's method Peter Durand patented the process of the food preservation in hermetic iron cans (1810). Over a period of time, the cans became common. There were technological problems, and soldiers had to open them with bayonets or smashing them with stones. Such preserved food also caused health problems because lead was used as the soldering agent connecting the iron sheets. In the next stage the iron sheets were covered with tin or lacquer to limit the contact of the food with the metal and this resulted in a significant improvement in the quality of the preserves.
Similar to appertisation, canning is still used at some houses. It is a kind of pasteurisation – destroying microorganisms by means of a high temperature. Food is boiled in glass jars (with a glass cover and a clamp or a metal twisted cover) with an addition of sugar or organic acids.
Irradiation belongs to the more sophisticated methods of food preservation. One of the sources of radiation can be the isotopes of cobalt ^{60}Co or caesium ^{137}Cs emitting γ-radiation. This radiation destroys bacteria, moulds and vermin, and retards ripening and spoilage. Irradiation does not kill viruses or toxins produced by bacteria.
Lowered pressure also preserves food. For example peanuts are packed in vacuum bags. Often in such a bag an additional bag (with a substance which absorbs oxygen) is placed, thus bacteria are deprived of the life-supporting element. Technologists recommend also the **preservation with modified atmosphere.** Nitrogen and carbon dioxide are the most often applied gases in this process. In the latter case, bars of solid carbon dioxide are used from which (by sublimation) gaseous CO2 is emitted destroying bacteria due to the processes called hypoxia and hypercarbia. The bacteria suffocate.
In the preservation of fruits, vegetables, sauces and ready-made meat products, the **techniques of high pressure** are applied. To a steel container containing food, water under the pressure of 5000 atm is pumped. The whole process lasts about 6 minutes, cellular structures are destroyed as a result of high pressure exposure. The benefits of this procedure are: it only takes a short time, there are no changes to the taste or smell and the food retains its fresh appearance.
Freeze-drying (lyophilisation) is an interesting method of food preservation from Southern America. A few hundred years ago, the Incas (Peru) stored food in the

mountains, where it froze and then underwent drying during the ice sublimation under the low pressure present at that altitude. Nowadays, in this process food is placed in special containers, frozen and pressure is lowered artificially. Food preserved in this way can be stored for very long periods of time because during lyophilisation water is removed from the environment as well from the cells of microorganisms.
Finally, one can mention the application of so-called **pulsating electric field PEF** to juice, milk, kefir, yoghurt, soups, as well as liquid egg mass preservation. In this process, taking place at ambient temperature, liquid is passed between two electrodes and exposed for a short time (microseconds) to impulses of the electric field with voltage 20-80kV. Microorganisms and microbes are destroyed. After high voltage treatment the food is chilled. Taste and flavour are retained.

Exercises

1. You live in the 21 century and know of Louis Pasteur's achievements. Write a short „virtual" letter (2-3 sentences) to Mr. Nicolas Francois Appert explaining the scientific basis of his method, i.e. why „ if food is boiled in a closed glass pot, it does not spoil if it is tightly closed".

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2. Check in MSDS cards which properties are characteristic of lead compounds (choose one of soluble salts). Give reasons for the statement that „canned food caused health problems because lead was used as the soldering agent connecting iron sheets".

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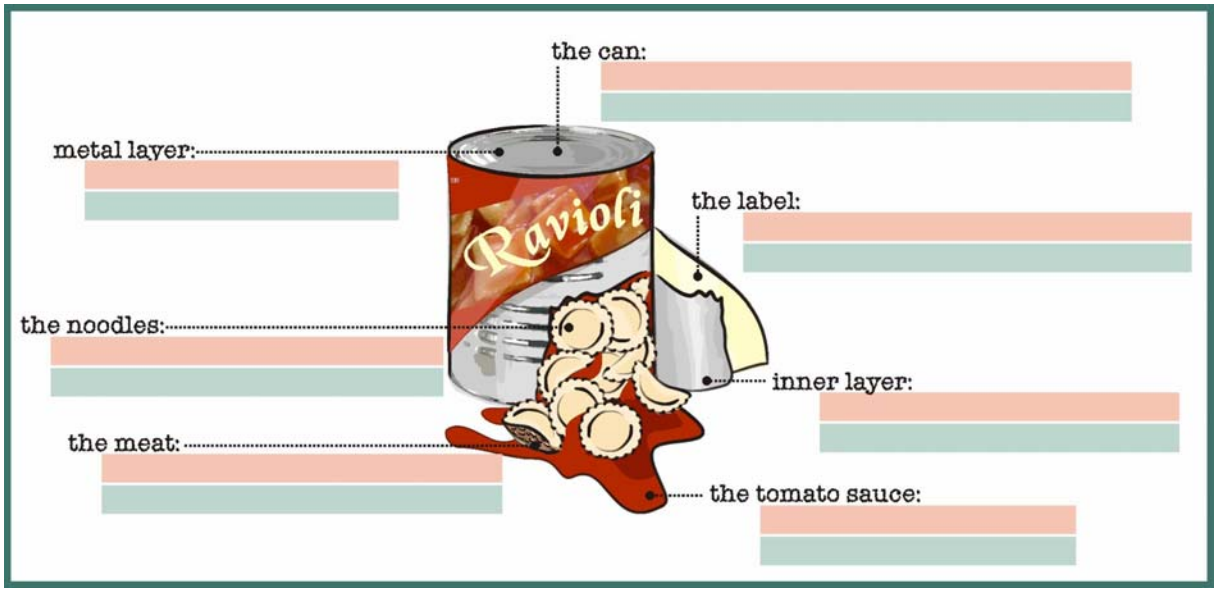
3. Which of the bacteria listed below should be destroyed during low pressure or modified atmosphere food preservation? Ascribe them to the proper group in the table.

   a) *Mycobacterium tuberculosis* (tubercle bacillus, aerobic bacterium)
   b) *Clostridium tetani* (tetanus bacillus, anaerobic bacterium)
   c) *Clostridium botulinum (*botulinus bacillus, anaerobic bacterium)
   d) *Mycobacterium leprae* (leprosy bacillus, aerobic bacterium)
   e) *Streptococcus pneumoniae (pneumococcus*, aerobic bacterium)

Should be destroyed	Should not be destroyed

SUMMARY – WORKSHEET

You have to complete the names of substances and names/descriptions of methods which you used to analyse them.



Graphical work by Agnieszka Węgrzyn.