Chemistry made accessible for children

*Christer Gruvberg**

Abstract

A couple of experiments designed for children "to do chemistry" are presented. Both can be developed using microscale equipment with clear and colourful results. We conclude that if we want to increase interest in chemistry then it is important to start early.

Many international studies show that chemistry is not catching the students' interest and there is a drop in the number of students choosing chemistry for their future career. A common opinion is that we must interest children for chemistry at an age when they still decide to like/dislike a subject without being influenced by the opinions of their friends.

When my children were small, their classes would visit my work and I was asked to explain to them what chemistry is and what a chemist does. I realized I had a communication problem. Using technical words would not at all help the children understand what chemistry is or what a chemist does so I decided that the most effective method would be to let the children experience chemistry by doing it themselves. It is easy to develop experiments in microscale that use simple equipment and give clear and colourful results so I developed two exercises, one qualitative and one quantitative analysis.

The responses from the children were very positive. Some of the comments they gave agreed with some of the main objectives I had in mind. They used words and expressions like "detective work", "exciting", "May we add solution C [*di-methyl-glyoxime*] to this orange juice to check if there is any nickel in it?", "May we come back another time to do some more chemistry?" In my opinion the exercises did not make them learn any specific chemistry, but they developed an understandable, positive picture of chemistry and chemists. They experienced what it looks like to work with chemistry, and that chemists learn about the world by doing laboratory experiments, a method similar to the way children interact with the world when they are playing. The children worked in small groups and recorded their results on a simple report sheet which they showed to me. After I had checked their results and written "Approved" and signed it, they carried the report sheet back to their seats looking like Nobel prize winners do when they have received their awards from the hand of the Swedish king. With memories like this, I am sure that students in upper classes will start their chemistry studies with optimistic attitudes which can help them maintain their interest while adjusting to the more abstract topics of lectures and laboratory exercises in formal chemistry courses.

Qualitative analysis: Which bottle contains which substance?

Materials

- 0.1M solutions of $Fe(NO_3)_3$, $NiCl_2$ and $CuSO_4$ in bottles labelled 1, 2 and 3 and in cut off standard Beral pipettes labelled Iron, Nickel and Copper.
- 0.1M solutions of KSCN, di-methyl-glyoxime, NH_4Cl in cut off standard Beral pipettes labelled A, B and C.
- 24-well plates.

Procedure

The class is told that I was preparing the solutions in the bottles so I could use them to show them some chemistry. Unfortunately I forgot to label the bottles so I do not know which bottle is which. With the children's help I will have the chance to find out the content in the different bottles. Working in groups of three they will use chemistry to find out what is in the bottles. First they need some safety instructions. They are not allowed to eat or drink anything in the laboratory. They need to wash their hands when they have finished each experiment and when they leave the laboratory. They must wear safety goggles, lab coat and plastic gloves for their protection (this is increasing the feeling that they are treated seriously as well). Some of the pupils had problems when using the gloves in their work and were permitted to work without gloves if they washed their hands extra carefully afterwards.

The written lab sheets contained simple instructions to add a few drops of iron solution to three wells in the first row of the 24-well plate followed by nickel solution on to the second row and finally copper to the third row. Then they were supposed to add a few drops of solution A to the first three wells in the first column of the plate, followed by solution B to the second column and C to the third column.

* Gothenburg University, Department of Chemistry. Box 823, SE-412 96 Gothenburg, Sweden.
Correo electrónico: gruvberg@kreativkemi.se

The plate was placed on a white paper sheet and the pupils were supposed to describe what colour observations could be used to identify the three elements. They repeated the mixing procedure on a second 24-well plate but this time they used solution 1, 2 and 3 instead of iron, nickel and copper.

When all the mixing work was done, the instructions asked the pupils to compare the mixtures to see if they found any matches between the pattern on the two plates. They discussed the patterns and wrote down their conclusions by writing iron, nickel or copper beside the printed words Solution1: Solution2: and Solution 3: according to their experiment observations.

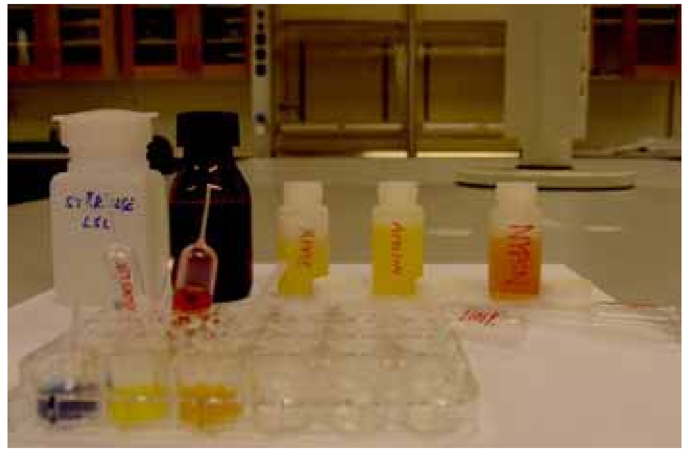

Figure 1. This picture shows all the equipment for the titration, including storage bottles.

Which table drink has the highest content of C-vitamins?

Materials

- 6 labelled, cut off standard Beral-pipettes containing iodine solution, starch solution, water, orange juice, apple juice, rosehip cream (usual in Sweden, but can be replaced by any juice or table drink familiar to the children).
- tooth picks for stirring.

The starch solution is prepared by making a suspension of 0.1g starch flour in a few millilitres of deionised water. Heat 50 mL deionised water to boiling in a small beaker then add the suspension during stirring the boiling water. Continue stirring until the mix is becoming thicker and looking clearer. Remove the beaker from the hot plate and let it cool. When at room temperature dilute the starch solution to 100 mL with water.

The iodine solution is a saturated aqueous iodine solution, prepared by storing some iodine crystals in deionised water for at least 24 hours. The saturated solution has a yellow colour.

Because the solubility of iodine in water is temperature dependent the saturated solution can differ between a colder place like Sweden and places with warmer climate. Depending on what beverages used for the investigation there will different C-vitamin contents found.

Before doing laboratory work with the children, I recommend that the method is adjusted by testing it ahead of using it in class.

Use 20 drops of an orange juice sample; add two drops of starch solution and stir the mixture with a toothpick. Add iodine drops to the sample until it has a remaining somewhat blue blackish colour change after stirring. It is ideal if it takes some ten drops to reach the end-point. If less than 10 drops of Iodine solution is required then dilute the iodine solution to half the concentration. If the number of drops is larger than ten, then dilute the beverage stock solution; for instance, if 20 drops of iodine solution were used, dilute 50 mL of the beverage to 100 mL using deionised water; if 50 drops were used, dilute 20 mL of the beverage to 100 mL using deionised water. When the right dilution is achieved then dilute the other beverages in the same way so the results obtained from the investigations on the different beverages will be comparable. The beverages I use give the following number of iodine drops for the endpoints: Apple juice 1 drop, Orange juice 10 drops and Rosehip cream 12 drops. These results are consistent with the information from the beverage producers. Each drop of Iodine solution indicates close to 2.5 mg C-vitamin per 100 mL of beverage, when adjusted to 1 drops Iodine solution per 20 drops Orange juice.

Procedure

Prelab

The class was told that vitamin C is important to intake daily. A few hundred years ago when ships were crossing the oceans, ships spent several weeks on the sea and it was not possible to have fresh food for the sailors. Because their food did not contain C-vitamins the sailors got sick and lost their teeth and hair. For children it is even more important to intake C-vitamins while they are growing! In order to see if the pupils receive enough C-vitamins from their table beverages, they were told that they could compare the C-vitamin contents in some familiar beverages with the help of chemistry.

To help them understand the chemical reaction strategy, I told them the story of the giant named Starch and the small gnomes called C:s. Both Starch and C:s liked to eat some small nuts called Iodine which only could be bought in the

Figure 2. This second figure shows three stages of the titration, the left well is a titrated sample, in the middle a sample during titration and the right one is an untitrated sample.

grocery store. The Iodine had a wonderful taste but, whether you were Starch or a C, as soon as you ate only one Iodine, you would feel completely full and could not eat any more. Starch had the problem that the C:s were very fast runners and they were so many that each time the grocery store announced that they were selling Iodine then the C:s always were the first to eat one iodine each. Starch did not have the chance to eat his Iodine until each of the C:s had had one Iodine to eat. When Starch finally ate his Iodine he got so happy that he turned almost black.

Lab

After the story, the pupils worked together in groups of three, using simple instructions like:

Well #1: 20 drops WATER and 1 drop STARCH and 1 drop IODINE = ……

Well #2: 20 drops ORANGE and 1 drop STARCH. Starch got happy after……drops IODINE.

The first instruction shows the pupils what the colour reaction looks like! The second instruction was repeated for each beverage.

Before the groups started their work they were shown each item of their equipment; they were shown how to add drops and how to stir and they were reminded about the safety rules. One advantage with microscale is that each group has all the equipment they need in front of them and as they need not pick up any missing equipment they work in an environment that is as peaceful as it can get with children in this age. I recently told a class that they should try to work with low voices or else they might disturb Starch so he would not become black after his meal, it decreased the noise at that event. After the work was finished the pupils washed their hands.

Postlab

The pupils were asked if they had had fun and if they had any questions they wanted to discuss.

My first question to them was, when was Starch having his Iodine in each case?

The answer was "When all the C:s had had one Iodine each!"

"Please tell me which well you think had the largest number of C:s!" "Rosehip cream!" "Why?" "Because Starch had to wait 12 drops before he had his meal!" "Which well had the fewest C:s?" "The first one because Starch got happy right away!" After we had discussed the different wells and the results I told them that our story was only a way of making the work easy to understand. The truth is that there is no giant and there are no gnomes instead there are small particles that we cannot see and they act in a way that is very similar to the story. The particles called Iodine are interacting with all the particles called C-vitamins (one iodine for each C vitamin) before the last Iodine particle pairs with a particle called Starch and this pair together turns black-bluish.

"So what you did was use chemistry the way chemists do when they want to know which beverage has the highest content of C vitamins! When chemists have produced results they often make a report which they publish for others to read. When you go back to your classroom I want you to make a poster which shows how much C-vitamins the different beverages contain, then publish it by hanging it on the wall in school so others can see your results and learn from it!"

"If you want to continue working like real scientists, then look for books in the library to find out why C-vitamins are important for your health!"

In conclusion, if we want to increase interest in chemistry then it is important to start early. The two exercises I describe are simple, quite harmless, cheap, very close to reality, and generate colourful experiences and successful results. By avoiding theory and complicated words, young children can be given clear and memorable impressions of Chemists and the World of Chemistry that can be positive influences on their attitudes when they make choices in their later studies.