Chemistry Chat

Keeping Up with Changes in Senior High School Chemistry

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1. Introduction

In a previous report,[1] I described how I encountered difficulties in conducting experiments in senior high school chemistry classes. In this article, I introduce the challenges of keeping up-to-date with the latest content in senior high school chemistry, which changes occasionally.

2. Changes in Terminology

Terminology changes over time. Based on the revisions in the *Curriculum Guidelines* in Japan announced in 2018,[2] the terms used in Japanese textbooks have been significantly revised.[3,4] Teachers must pay close attention to these changes to ensure they do not overlook them when revising the guidelines.

Table 1. Changes in terminology around 2022

	Old Term	New Term
Alkali earth metals	Group 2 elements including Be and Mg	Group 2 elements including Be and Mg
Transition elements	Groups 3−11	Groups 3−12
18 Group	Inert gases	Noble gases
Reverse sublimation	(Sublimation)	Deposition
Enantiomer	Optical isomer	Enantiomer
Isomer based on double bond	Geometric isomer	*cis*-*trans* isomer

The teaching contents in schools are constantly changing. Hence, when I talk with people of different generations, It is interesting for me to note that they used outdated terms. For example, the terms "gram equivalent" and “normamality”: sound nostalgic.[4,5]

3. Thermochemistry

Japanese senior high school textbooks have historically described reactions involving heat exchange using thermochemical equations with an equals sign.[6] For example, the reaction for the formation of water is expressed as:

$$H_2\,(g) + \frac{1}{2}O_2\,(g) = H_2O\,(l) + 286\ \text{kJ}$$

However, from the fiscal year 2023, the textbooks have switched to thermochemical reactions that include enthalpy changes, and thus Japanese thermochemical equations are at last complied with international standards.[7] The reaction of the formation of water is now expressed as:

$$H_2\,(g) + \frac{1}{2}O_2\,(g) \rightarrow H_2O\,(l) \quad \Delta H = -286\ \text{kJ}$$

This is one of the revisions of Japanese "Galápagosized" chemical education. The previous thermochemical equations focused on energy exchange viewing from an external system, whereas the new approach describes energy exchanges from internal system.

4. Experiment: Regulations of Chemicals

Several substances have become regulated in recent years because their hazards to humans and the environment have been revealed. Examples related to senior high school classes are given below.

4.1 Mercury

After the Minamata Convention on Mercury in 2013 came into effect, schools disposed of unnecessary equipment and reagents containing mercury.[8] However, metallic mercury is indispensable for understanding the concept of pressure. The standard atmospheric pressure is described in textbooks as:

$$1.013 \times 10^5 \text{ Pa} = 760 \text{ mmHg} = 1 \text{ atm}$$

Unfortunately, many schools do not have sufficient quantities of metallic mercury, so students have to understand the relationship between atmospheric pressure and mercury in textbook only. Many students who graduated school without watching a Torricellian vacuum with their own eyes, which is a pity.

Other than metallic mercury, two mercury compounds appear in current textbooks in the following reactions:[7]

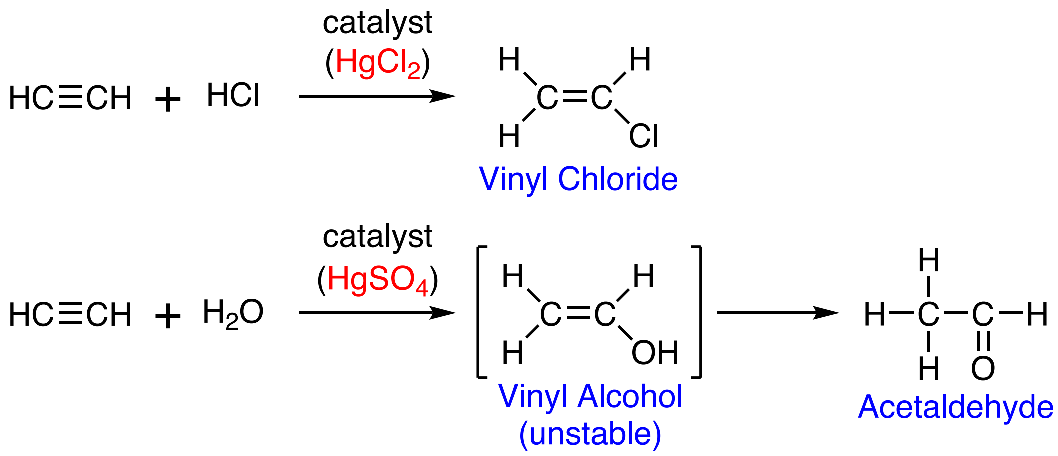

Figure 1. Mercury compounds appeared in the textbooks

Mercury compounds play important roles as catalysts for addition reactions involving triple bonds, but these compounds can cause Minamata Disease, also called "methylmercury poisoning." It is quite difficult to make students understand the harmfulness of mercury-containing substances because we cannot show these reactions or demonstrate biological toxicity directly to them.

4.2 Benzene

Benzene is carcinogenic.[9] The classic experiment "Nitration of Benzene" was removed from textbooks revised in 2017. Although "Synthesis of Azo Dyes" remains, benzene is replaced by nitrobenzene as the starting material in the laboratory. It is a pity that students cannot directly handle the basic skeleton of aromatic compounds.

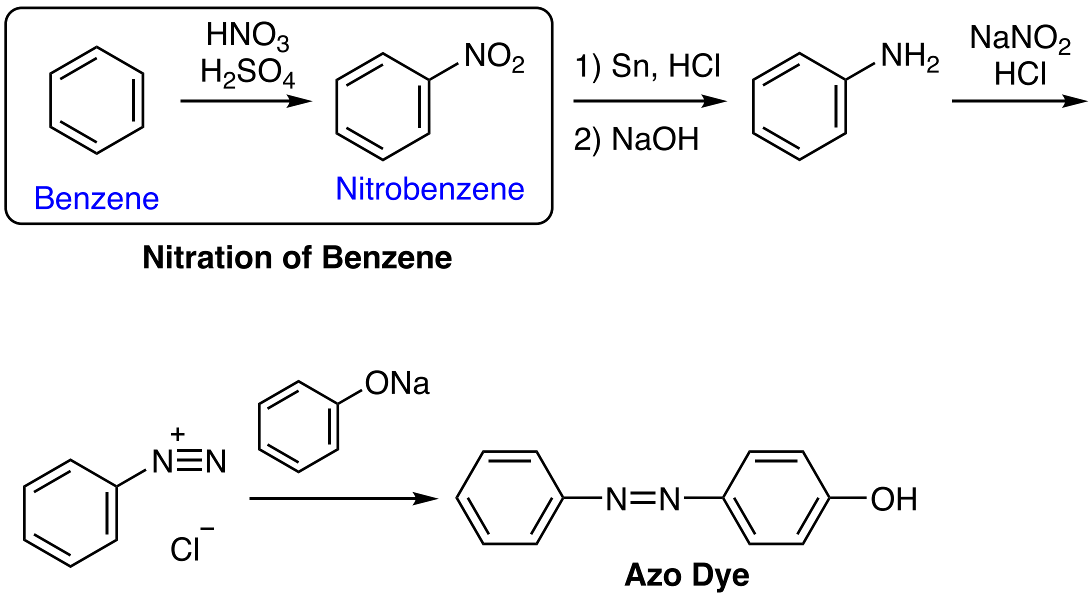

Figure 2. Synthetic route to an azo dye from benzene

4.3 Carbon Tetrachloride

As an ozone-depleting substance,[10] the use of carbon tetrachloride is limited. Students learn that its structure has a tetrahedral shape; four chloride atoms are arranged around the center carbon atom. Methane is introduced as a typical non-polar compound when studying molecular shapes and polarity. However, it is quite difficult to experimentally demonstrate that methane is non-polar because it is a gas at room temperature. Unlike methane, carbon tetrachloride is a liquid at room temperature, allowing students to visualize its non-polar properties through interactions with static electricity.[11] The following is a demonstration of polarity:

Experiment: Produce a flow of water or carbon tetrachloride from a burette, and bring an electrically charged rod close to the flow.

Result: The polar water flow is bent by the electric charge, but the non-polar carbon tetrachloride flow is not.

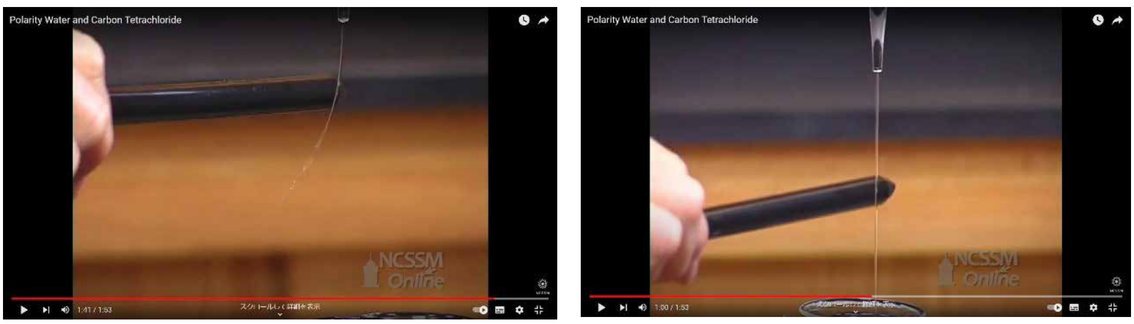

Figure 3. Flow of water (left) and carbon tetrachloride (right) near a charged rod

5. Conclusion

Due to occasional changes in content and terminology definitions in senior high school chemistry, teachers must always keep up with the latest information. Also, we have to comply the legal regulation of substances handled and their effects on the environment. Furthermore, we should not forget to update our handouts/practice problems in classrooms and experimental procedures in laboratories.

References and Notes

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2. Ministry of Education, Culture, Sports, Science and Technology, Commentary on the Curriculum Guidelines for Senior high schools, Science Edition, Math and Science Edition 2018, p. 103. (Japanese)
3. Chemical Society of Japan, Subcommittee on Chemical Terminology, *Chemistry and Education* **2015**, *63*, 204; Chemical Society of Japan, Subcommittee on Chemical Terminology, *Chemistry and Education* **2016**, *64*, 92. (Japanese)
4. Compendium of Terminology in Analytical Chemistry, IUPAC Orange Book, D. B. Hibbert ed., The Royal Society of Chemistry, **2022**, Chapter 6.
5. One gram equivalent is an acid (or base) mass that can produce 1 mol of hydrogen ions (hydroxide ions) in a neutralization reaction. The number of gram equivalents of acid or base dissolved in 1 L of solution is called that solution's normality (symbol N). For example, one gram equivalent of sulfuric acid (molecular weight 98) is 49 g, and concentrated sulfuric acid (36 mol/L) is 18 N. This appeared in senior high school textbooks at least until 1983.
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Author Information

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