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A Demonstration of the Sublimation Process and its Effect on Students' Conceptual Understanding of the Sublimation Concept

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Abstract: In this paper, we present a demonstration for sublimation and we investigated the demonstration efficiency on students' conceptual understanding of sublimation. Demonstration is considered an effective strategy to teach intangible concepts and a way to increase students' enthusiasm for learning. We prepared a solution in which the surface tension was decreased using soap. This facilitated the formation of bubbles when dry ice was added. This provides a good environment for students to observation of sublimation. The demonstration improved students' understanding of sublimation.

Keywords: Phase transitions; sublimation; demonstration; chemistry.

Süblimleşme Kavramı Üzerine bir Gösteri Deneyi ve bu Gösteri Deneyinin Öğrencilerin Süblimleşme Kavramını Anlamalarına Etkisi

Öz: Bu çalışmada süblimleşme kavramı için bir gösteri deneyi hazırlandı ve bu gösteri deneyinin öğrencilerin kavramsal anlamaları üzerine etkileri araştırıldı. Gösteri deneyleri öğrenciler için anlaşılır olmayan, soyut kavramların öğretilmesinde ve öğrenci istekliliğinin artırılmasında etkin yollardan biri olarak görülmektedir. Yapılan deneyde, çözeltinin yüzey gerilimi surfaktant kullanılarak düşürülmek suretiyle katı CO_2'in süblimleşmesi esnasında etkin baloncuk oluşumu sağlanmıştır. Bu sayede öğrencilere süblimleşme olayını etkin gözlemleme imkânı sunulmuştur. Çalışma sonunda, bu gösteri deneyinin öğrencilerin süblimleşme kavramını anlamada yardımcı olabileceği düşünülmüştür.

Anahtar kelimeler: Faz değişimleri; süblimleşme; gösteri deneyi; kimya.

INTRODUCTION

The use of demonstrations as an educational tool is a promising method in general chemistry courses (Price and Brooks, 2012). Demonstrations enable lecturers to increase students' motivation and inspiration in chemistry classes, especially at introductory levels, where students have had little or no conceptual introduction to chemical phenomena. Students enjoy watching demonstrations and, in general, pay remarkable attention to them (Pierce. D & Pierce. T, 2007). Therefore, well-planned and effectively presented classroom demonstrations encourage active, visual, and conceptual learning (Meyer *et al.* 2003).

Phase, phase equilibrium, and phase transitions are basic concepts of chemistry. The process of sublimation is defined in the International Union of Pure and Applied Chemistry (IUPAC) terminology as "the direct transition of a solid to a vapor without passing through a liquid phase." Azizoğlu *et al.* (2006) reported students' misconceptions about the phase changes of matter. They provide examples of students' definitions of sublimation such as "sublimation is a change of state from a gas to a solid (gas→ solid)" and "vaporization is a state change from a solid to a gas." In a study which set out to determine prospective elementary school teachers' misconceptions about phase changes, Demircioğlu *et al.* (2004) found that students confuse the concepts of condensation, evaporation, and sublimation. In another major study, Harman (2012) reported that prospective pre-service science teachers thought that sublimation is a chemical process, that naphthalene reacts with air and that matter's chemical properties change when it undergoes sublimation.

The sublimation process is commonly explained in general chemistry classes using examples with dry ice, iodine, and naphthalene. In the literature, Goldsmith (1995) was the first to present a demonstration of sublimation using iodine. However, Petruševski *et al*. (2012) have suggested that iodine and naphthalene cannot be considered to sublimate; at atmospheric pressure (≈ 1 bar), they would first melt (at ≈ 114 °C and at ≈ 80 °C, respectively) and then boil (Figure 1).

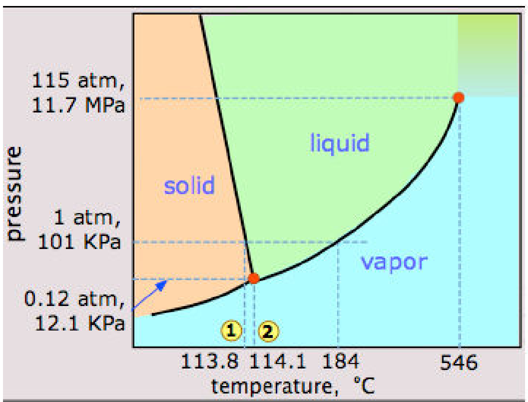

Figure 1. Phase diagram of iodine (retrieved from http://chemwiki.ucdavis.edu/Textbook).

At a temperature below −78 °C, carbon dioxide condenses into a white solid called dry ice. In daily life, it is frequently used as a cooling agent. Liquid carbon dioxide can only form at atmospheric pressures above 5.1 atm. At lower pressures, it will go directly from a solid to a gas phase (see Figure 2).

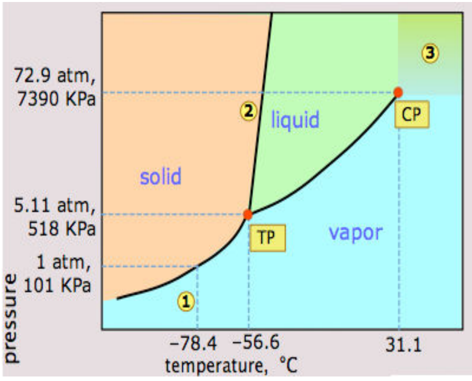

Figure 2. Phase diagram of dry ice (retrieved from http://chemwiki.ucdavis.edu/Textbook)

As mentioned above, students have many misconceptions about sublimation. However, to the best of our knowledge, no work has attempted to demonstrate sublimation using dry ice or tested its efficiency on undergraduate students' learning of the concept.

Purpose of study: This study presents a demonstration of the sublimation process and investigates the effect of this demonstration on students' conceptual understanding of sublimation.

METHODOLOGY

The pre-experimental research model was a one-group pretest-posttest design in which the students' understanding of sublimation before the application of the demonstration was compared with these students' understanding after the application.

Participants: The target population of the study was all students taking undergraduate-level chemistry at a state university in Turkey. The study participants were 47 first-grade elementary teacher-training students who took general chemistry courses at the time of the study.

Data collection tools: Two experts with a Ph.D. degree in chemistry prepared open-ended questions to determine the students' understanding of sublimation (*e.g.* 1. What is sublimation? Please explain the process. 2. Is sublimation a chemical or physical change? Why? 3. Please give examples of sublimation. Explain why you gave this example.). Further, focused group interviews were conducted with five participants to examine their feelings about the demonstration.

Data Analyses and Results: In order to identify the students' misconceptions a coding and classifying approach (Gay, Mills & Airasian, 2009) was used for the qualitative data analysis. First, response phrases were categorized and then analyzed according to recurring themes by two experts in chemistry. The codes were determined by words which are repeated in pretest and posttest. To understand the demonstration efficiency same data analyses approach also was used in posttest. The results of the qualitative data analysis are presented in Table 1.

Table 1. Misconception themes, codes, students' frequency and percentage.

Misconceptions		**Pretest**		**Posttest**	
Themes	**Codes**	**Frequency**	**%**	**Frequency**	**%**
Confused sublimation with evaporation	Can be done at every temperature	2	4	0	0
	Giving an example related to evaporation	21	37	4	67
Sublimation is a chemical change	Chemical structure changed	16	28	0	0
	It is not reversible	11	19	2	33
	It is a chemical change (there is no explanation)	7	12	0	0

The differences between pretest and posttest results in terms of students' misconceptions about sublimation in Table 1. As the table shows, there is a clear decrease of students' misconceptions frequency in posttest. Table 1 also shows that approximately half of the respondents gave an example of sublimation related to evaporation in pretest (37%) after the demonstration, a few respondents gave an example of sublimation related to evaporation. A few respondents said that sublimation occurs at every temperature (4%) in pretest. Less than half of the respondents said that in the sublimation process the chemical structure changes (28%) no misconceptions was recorded in posttest related to this misconception. A small number of respondents said that sublimation is a reversible process and a few students in posttest. Furthermore, a small number of respondents said that sublimation is a chemical change, but they did not explain why (12%) in pretest.

The focus group interview students generally said that the demonstration of sublimation was enjoyable and aided learning. Some excerpts from the interview are below:

"It is enjoyable to learn with demonstration." [Student A]

"Demonstrations help us to understand that sublimation is transfer of matter from solid state to gaseous state without passing through liquid state." [Student B]

"I understood from the demonstration that sublimation is different from evaporation." [Student C]

Performing the demonstration: A 200 mL solution was prepared using a surfactant (common liquid soap). The surfactant was used to reduce the surface tension of the solution to produce bubbles. The solution was heated to 40-50 ^{0}C to accelerate the process. A piece of dry ice was added to this mixture. Dry ice changes its phase from solid to gas by forming a bubble on the top of the beaker. When the pressure of CO_2 (g) exceeds the surface tension of the surfactant, the bubble bursts (Fig. 3). In our demonstration, we used dry ice that had been produced in our laboratory. The demonstration lasted in approximately 3 minutes.

Figure 3. Pictures of the demonstration.

Safety precautions:

Do not touch dry ice; it is dangerous to handle due to its extremely low temperature. In general, the demonstration is safe to perform in the classroom.

DISCUSSION

This study assessed the importance of using a demonstration to teach the sublimation concept. It found that students have many misconceptions about sublimation, which supports prior research into teaching sublimation (Azizoğlu, Alkan & Geban, 2006; Demircioğlu. H, Demircioğlu. G, Ayas, 2004; Harman, 2012). This study shows that half of the students provide examples of sublimation related to evaporation. It is likely that this is due to the lack of examples given on the subject. The observed lack of understanding of the concept decreases after a demonstration, suggesting that these students benefited from the demonstration. In our demonstration, students were given the opportunity to distinguish between the two processes (evaporation and sublimation) by personally observing the transition from a solid to a gas state.

The most interesting finding was that students thought that sublimation is an irreversible change (Harman, 2012). A possible explanation for this result may be the lack of adequate understanding that all phase changes are reversible processes. Students have difficulty understanding that sublimation is reversible due to a lack of understanding of the effect of pressure. Our demonstration did not show the transition from CO_2 (g) to CO_2 (s). After the demonstration, a few students still provided an example related to evaporation. This result may be explained by the fact that students resist changing their misconceptions (Çayan & Karslı 2015).

It is surprising that students believed that the chemical structure changes in the sublimation process before the demonstration, but not after the demonstration. It is difficult to explain this result, but it could be that students thought that sublimation is different from other phase changes. In the demonstration, students may have seen that there is no chemical change in sublimation (Table 1).

The observed differences between students' responses in the pretest and in the posttest is significant in terms of decreased misconception. Based on these results, it can be argued that the demonstration has enabled students to learn the concept of sublimation. Moreover, they found our demonstration an easy way to learn the sublimation concept. This finding, while preliminary, suggests that before learning about sublimation phase changes, students should understand other common phase changes.

CONCLUSION

The current study has presented a demonstration of the sublimation process. The results are significant in at least two major respects: the demonstration helps students to learn the concept of sublimation and students find it easier and more enjoyable to learn by demonstration. The findings suggest that this approach could be useful for lecturers who are teaching the sublimation concept in chemistry class.

REFERENCES

Azizoglu, N.; Alkan, M.; Geban, O., Undergraduate pre-service teachers' understandings and misconceptions of phase equilibrium. Journal of Chemical Education 2006, 83 (6), 947-953.

Çayan, Y. & Karsli, F., Fiziksel Ve Kimyasal Değişim Konusundaki Kavram Yanilgilarinin Giderilmesinde Probleme Dayali Öğrenme Yaklaşiminin Etkisi. Kastamonu Eğitim Dergisi 2015, 23(4).

Demircioğlu, H., Demircioğlu, G. & Ayas, A., Sınıf öğretmeni adaylarının bazı temel kimya kavramlarını anlama düzeyleri ve karşılaşılan yanılgılar Hasan Ali Yücel Eğitim Fakültesi Dergisi, 2004, 1(1).

Digital image. Chemwiki. Ucdavis.edu, n.d. Web. 16 Oct. 2015.

Gay, L.R., Mills, G. E., & Airasian, P. (2009). Educational Research: Competencies for Analysis and Applications (9th ed.). Upper Saddle River, NJ: Pearson Education Inc.

Goldsmith, R. H., Overhead projector demonstrations - Iodine demonstration of sublimation. Journal of Chemical Education 1995, 72 (12), 1132-1132.

Harman, G., Fen Bilgisi Öğretmen Adaylarinin Fiziksel ve Kimyasal Değişme Hakkindaki Bilgileri ve Kavram Yanilgilari. Eğitim ve Öğretim Araştırmaları Dergisi 2012, 1 (3) ISSN: 2146-9199

Meyer, L. S.; Schmidt, S.; Nozawa, F.; Panee, D., Using demonstrations to promote student comprehension in chemistry. Journal of Chemical Education 2003, 80 (4), 431-435.

Petruševski, V. S., Marina. Šoptrajanov, Bojan., Are All Types of Sublimation Equivalent? Chem. Educator: 2012; pp 98-99.

Pierce, D. T.; Pierce, T. W., Effective use of demonstration assessments in the classroom relative to laboratory topics. Journal of Chemical Education 2007, 84 (7), 1150-1155.

Price, D. S.; Brooks, D. W., Extensiveness and perceptions of lecture demonstrations in the high school chemistry classroom. Chemistry Education Research and Practice 2012, 13 (4), 420-427.