EDUCATIONAL ACTIVITIES FOR PHYSICAL PHARMACY CLASSES ON COLLOIDS

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ABSTRACT

Colloids are an important component of physical chemistry and physical pharmacy curricula. In pharmacy, colloidal systems and concepts are encountered in dosage forms (e.g., suspensions, emulsions) and many drug delivery systems (e.g., nanoparticles). Since colloids may appear rather theoretical in nature and may be difficult to grasp when taught to students for the first time, practical activities are invaluable in teaching this topic. This paper presents some useful activities for classes on colloids that may be incorporated in physical pharmacy and physical chemistry courses. *[African Journal of Chemical Education—AJCE 11(1), January 2021]*

INTRODUCTION

Colloids are systems comprised of at least two distinct phases – a dispersed phase and a continuous dispersion medium. They are distinguished from solutions and coarse dispersions by the size of their dispersed phase which is predominantly in the range of 1 – 1000 nanometers. A classic example of a colloidal system is a dispersion of oil in water, i.e., an emulsion. Colloids are important in physical chemistry due to their broad applications in numerous fields including biology, foods, paints, agriculture, water treatment and the environment. In physical pharmacy, they are an integral part of teaching curricula as they form the basis of many formulations and drug delivery systems such as suspensions, creams and nanoparticulate drug carriers. The study of colloids also helps convey a deeper understanding of other important concepts in physical chemistry such as particle size and interfacial phenomena. This paper presents some concepts and simple activities that the author has found to be helpful while teaching colloids as part of a physical pharmacy course to pharmacy students.

METHODOLOGY/EXPERIMENTAL

The teaching activities were incorporated into lectures on colloids for pharmacy students. For the activity on the preparation of butter, heavy whipping cream was obtained from a local supermarket and used with a 150 mL polypropylene plastic container with a screw-top type closure. The container is partially filled (e.g., 1/3 to 1/2 of capacity) with the cream at the beginning of the activity.

RESULTS AND DISCUSSION

The goal of these activities is to make the concepts relatable to products and systems that students are already familiar with or encounter on a regular basis. Table 1 is used in the first slides of an introductory lecture to show that colloids are present in many tangible areas. Showing that colloids are all around us illustrates that the topic is not an esoteric one and is important in day to day life. This helps the learner appreciate the value of understanding the basics of colloids. Students can be asked to name the type of colloid as well as the dispersed and continuous phases in the examples given.

TABLE 1. COMMON EXAMPLES OF COLLOIDAL SYSTEMS

Field	**Examples**
Foods	Milk, cream, butter, ice-cream
Environment	Clouds, river water (with silt), dust, motor vehicle headlight beams at night (Tyndall effect), air quality (particulate matter – PM 2.5 and PM 10)[†]
Pharmaceuticals	Antibiotic suspensions, powders for reconstituion, Scott's emulsion, aerosols
Cosmetics	Creams, lotions

[†] fraction of particulate matter (PM) of a particle size less than the specific numerical (μm) value

Puzzles are an activity that many students find interesting and they can be used as practice exercises on key scientific terms that students have not previously encountered. They can be easily prepared using various free online crossword makers and customized to the specific material that has been taught. An example of a crossword puzzle based on introductory lectures in colloids is shown in Figure 1. In addition to being appealing as a problem-solving activity, crosswords can be used as a group activity. They are also a useful teaching tool in helping students to recall key terms and definitions. A number of studies have reported the utility of crosswords in enhancing learning and revision in chemistry courses [1, 2] as well as in other fields [3–6].

Environmental air pollution is an aspect of modern life, especially in large cities, that everyone can relate to. This pollution arises from activities that involve combustion such as the burning of firewood, coal, fuels as well as motor vehicle emissions. Air pollution to a large extent comprises of solid and liquid particles from combustion processes that are suspended in air, thereby forming a colloidal system. Using internet-based sites that monitor air quality, students can observe the air quality at various locations in their country or around the globe [7]. Some air quality monitoring sites also indicate quality parameters as a function of time (e.g., on an hourly basis) which may be observed to vary at various times throughout the day. Students can be asked why this occurs. For example, it may coincide with times of increased or decreased man-made emission producing activities (e.g., peak rush hour, factory work shifts).

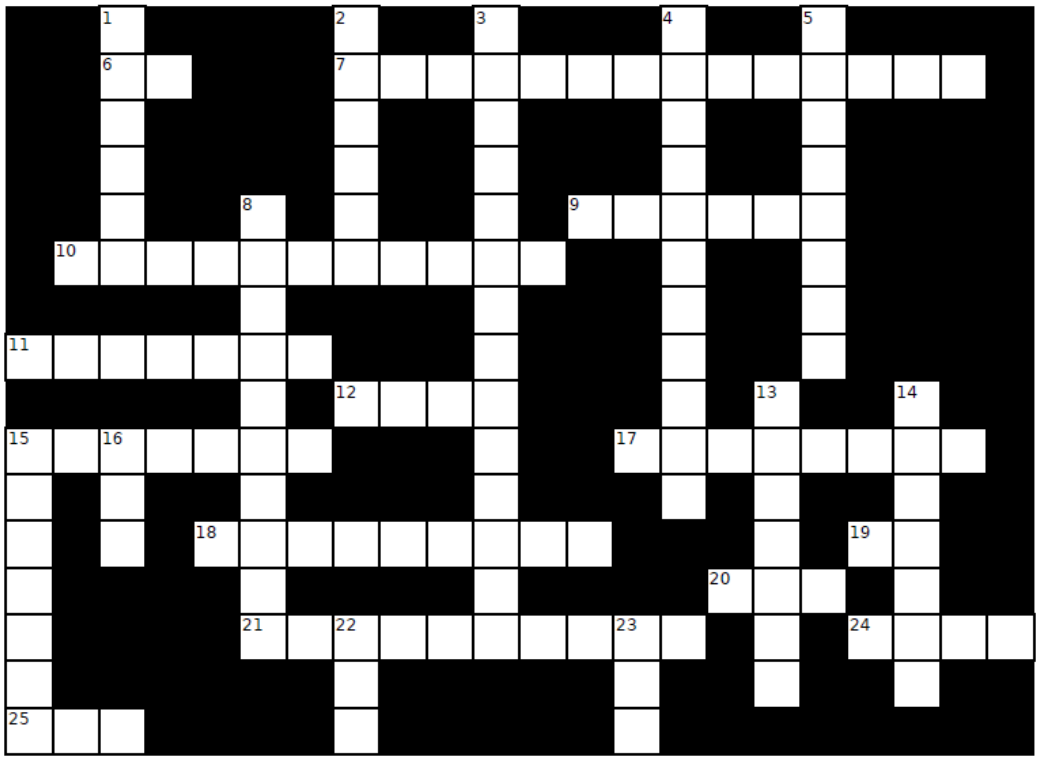
The final activity is a practical demonstration that can be conducted in class with the use of a container (preferably plastic) and some heavy whipping cream. The whipping cream is placed in the container which is closed and then vigorously shaken for a few minutes. This causes it to change in consistency from a thick liquid to a thick foam. Shaking the foam vigorously for a few more minutes then results in phase separation with the formation of a semi-solid (butter) and a liquid (water) (Figure 2). It is probably useful (more challenging) not to initially reveal to the students that they are making butter – rather they should be asked what the final product (Figure 2b) is, given that the starting material is cream.

As the product goes from a cream to a foam and finally to butter (each is a different colloidal system) there is noticeable difference in the sound made by the shaking of the container. The students can be asked to describe the differences in the material as it undergoes the physical

changes (e.g., the dispersed and continuous phases for each product) and the reasons why these changes occur.

CONCLUSIONS

The article has presented a number of simple yet practical activities that can be easily incorporated into classes on colloids as part of a physical chemistry or physical pharmacy class. By providing practical and hands-on activities, students are better able to understand and appreciate a topic that many may otherwise find to be highly theoretical and sometimes challenging to comprehend.



Across

6 Unit of size measurement of colloidal particles
7 Determines the stability of colloids
9 Look out the window and you might see this colloid
10 This colloid loves water
11 Force which causes particles to settle
12 Gas dispersed in a liquid
15 Micrometers
17 Association colloids
18 A type of interaction between a dispersed phase and a dispersion medium
19 Increases with decreasing particle size (initials)
20 Surface area per unit weight or volume (abbreviation)
21 Solid dispersed in a liquid
24 This colloid goes well with tea
25 Viscous polymeric colloidal solution

Down

1 Requirement to increase surface area
2 Forms a colloid when dispersed in water; present in maize, rice, wheat
3 Random movement of colloidal particles (two words)
4 Thermodynamically unstable colloid
5 A liquid dispersed in a immiscible liquid
8 Dispersion medium = _____ phase
13 Colloid for inhalation
14 Forms a colloidal solution in water; may be used to make capsules
15 Method to prepare colloids
16 Concentration at which amphiphilic molecules form colloids (abbreviation)
22 A solid dispersed in a gas or a liquid
23 A type of liquid that is very difficult to disperse in water

Figure 1. An example of a crossword based on an introductory lecture on colloids

Figure 2(a) foam formed after shaking heavy cream for a few minutes; **(b)** butter formed after shaking the foam for a few more minutes.

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