Determination of the acidity of nutritional supplements in the secondary school science-laboratory: an interdisciplinary experimental approach for effective classroom discussions

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ABSTRACT

In this paper we propose a very simple laboratory exercise for measuring the acidity of aqueous solutions of nutritional supplements in the secondary school science-laboratory, which can give rise to interdisciplinary discussions in classroom for removing students' misconceptions related to nutritional supplements.

KEYWORDS: acid-base chemistry, human biology, nutrition education

Objectives of the Study

In the modern pedagogical practices the use of interdisciplinary didactic scenarios and discussions based on laboratory exercises is frequent. The present study proposes an experimental approach for secondary schools which could be used: a) with an emphasis on understanding the concept of pH in junior classes (in accordance with the analytical curriculum of chemistry), b) as a motivation for effective discussions-debates regarding nutritional supplements in senior classes of biology or biochemistry.

Secondary school students' misconceptions about pH

It has been shown that secondary school students present considerable difficulty with acid-base chemistry, and they are unable to describe accurately acid-base concepts, such as pH or the theoretical descriptions of acids and bases (Sheppard K, 2006). A number of factors were identified as contributing to these difficulties, including the overstuffed nature of introductory chemistry itself, the emphasis during instruction on solving numerical problems, and the dominant role played by the textbook (Sheppard K, 2006). A descriptive study in Germany indicated that senior high school students have misconceptions about conjugate acid-base pairs (Schmidt HJ, & Chemie F, 1995): a) they confuse non-conjugate and conjugate acid-base pairs, and b) students regard pairs of positively and negatively charged ions as conjugate acid-base pairs as if they somehow neutralized each other. Students use chemical terminology, but misconceptions occur because the terminology is misleading (Schmidt HJ, & Chemie F, 1995). However, examination of student explanations and analyses of semi-structured interviews conducted with students in a Turkish high-school suggested that laboratory activities: a) enhanced student understanding of acid-base chemistry, b) were enjoyable, c) helped students link concepts, and d) reduced their alternative conceptions (Özmen H, Demircioglu G , & Coll RK, 2009).

Secondary school students' misconceptions about nutritional supplements

Marketing claims for sports supplements generally lack consistent double- blind animal and human studies showing either performance gains or freedom from adverse side effects and long-term health consequences (Bartee RT *et.al*., 2004). Medical evidence suggests only certain subgroups of people need nutritional supplements, however may people self-prescribe them (Perko MA, 1999). Users attribute advantages to performance-enhancing drugs and are inclined to overlook the risks of using them (Wiefferink CH, 2008). It is a fact that many nutritional supplements fall within the spectrum of adolescent use, and this use may be driven by misguided beliefs in their performance-enhancing abilities. Groups at particular risk are students involved in physical activity to a high degree (Bell A *et.al*., 2004). Currently, there exists little data on safety and efficacy of supplements, and there is virtually no data regarding safety and efficacy of supplements in individuals under the age of 18 years. Sales indices suggest sports supplement consumption continues to increase among young athletes, and research indicates young athletes have become the key target for marketing (Housman JM, 2006). Additionally, pressures to achieve greater athletic performance or an ideal body image are strong motivators for young athletes. These factors create an environment in which adolescents are likely to consume dangerous sports supplements without being aware of risks associated with supplements (Housman JM, 2006). A wide range of dietary supplements have been found to be contaminated with toxic plant material, heavy metals, or bacteria (Cohen PA, 2009). Of particular concern are dietary supplements that are contaminated with prescription medications, controlled substances, experimental compounds, or drugs rejected by the FDA because of safety concerns (Cohen PA, 2009). Some dietary supplements can cause death or disability as a result of improper use, such as consuming more of the product than is recommended (Crowder, T *et.al*., 2008, Dunn MS *et.al*., 2001). Many contaminated dietary supplements are sold over the Internet, but they have also been found in mainstream retail stores (Cohen PA, 2009).

Experimental design

The laboratory exercise is designed to be carried out by students of Gymnasium (middle-high school) using cheap, simple and safe materials, that are easy to be found. Chemical balance, magnetic stirrer/mixer or pH meter are not required for the experiment, because the nutritional supplements are in the form of effervescent uncoated tablets (obtained by a pharmacy store) and they are dissolved easily into water as it is shown in Figure 1.

Effervescent uncoated tablets are designed to break in contact with water or another liquid, releasing carbon dioxide in water (usually due to interaction between tartaric acid and citric acid with alkali metal carbonates or bicarbonates in presence of water) (Srinath KR, 2011). Rapid breakdown often may cause the tablet to dissolve into a solution, and is also often followed by a froth. Effervescent tablets are being used as products of pharmaceutical and dietary industry (Srinath KR, 2011). The pH of the solution is an important characterization of the effervescent tablets. The nature of the ingredients of the effervescent tablets leads to formation of a buffer system. The pH of the solution can be measured at standard volume and temperature.

The measurement of the pH should be done at specific time since the effervescent tablets have a tendency to change the pH on standing. The pH change occurs due to constant breakdown of carbonic acid to carbon dioxide and water and due to the presence of slowly soluble materials which require time for complete dissolution.

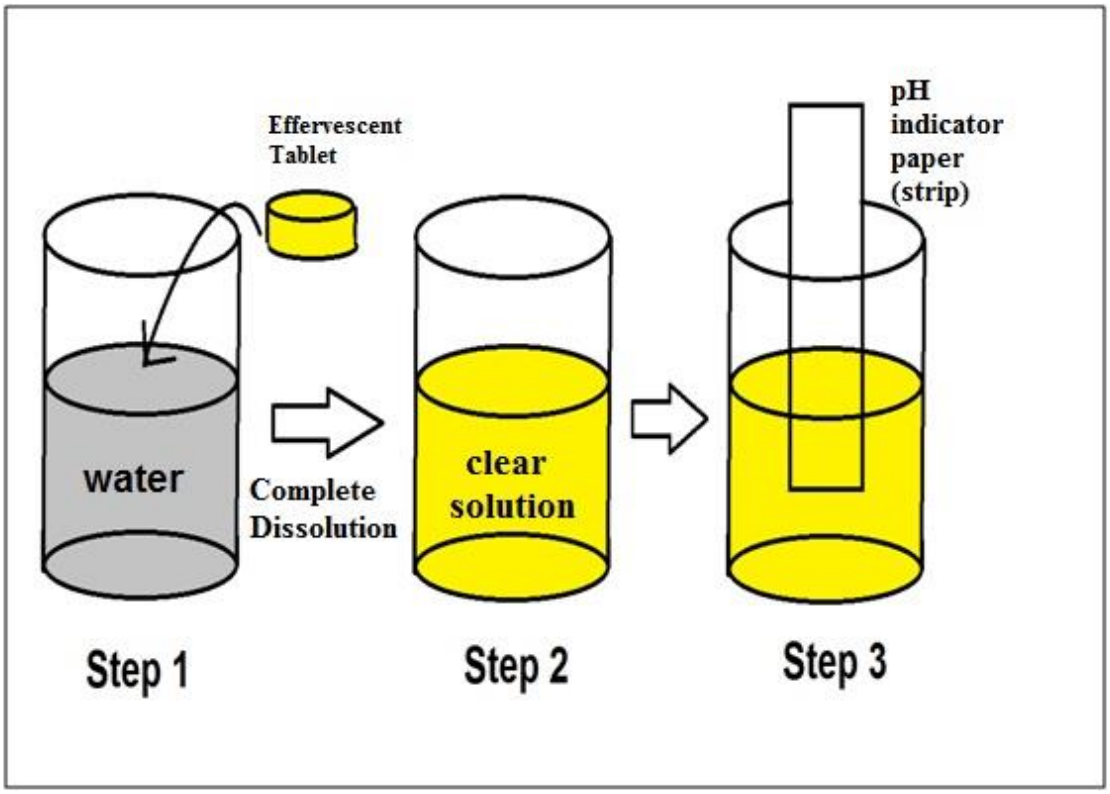

Figure 1: Experimental design: a) the effervescent tablet is disintegrated and dissolved into water to form a clear solution, b) the determination of acidity is performed using a pH indicator paper (strip).

A well-formulated effervescent tablet will disintegrate and dissolve within 1–2 min to form a clear solution. Consequently, the residue of undissolved drug must be minimal. The temperature of the water influences the dissolution time. It is, therefore, important to choose a water temperature that is actually used by consumers (e.g., a general requirement on disintegration time of 5 min in water 15–25 C).

Conclusions

The exploratory and discovery learning by performing laboratory experiments is an important strategy for teaching science, because the student is encouraged to observe, assume, test cases and produce scientifically accepted conclusions. Furthermore, experimental teaching stimulates student interest, promotes self-motivation, and builts new knowledge. The proposed laboratory exercise serves the interdisciplinary teaching model by linking concepts of chemistry with issues of biology-nutrition, and therefore it could be useful for attempting to overcome secondary school students' misconceptions about the concept of pH or to trigger discussions about the hidden dangers of nutritional supplements in school-aged children.

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