Two simplified experiments for an estimation of surface tension

O R Battaglia, G Termini, A Agliolo Gallitto and C Fazio

Dipartimento di Fisica e Chimica – Emilio Segré, Università degli Studi di Palermo, Palermo, Italy

Abstract. We present here two different experimental apparatuses for measures in the field of surface phenomena. Set-ups are low budget, using materials and experimental apparatuses available in ordinary didactic laboratories. The first one allows us to estimate the surface tension of soap bubbles and verify the Young – Laplace law. The second apparatus is a simplified version of the well-known Du Noüy ring and allows us to measure the surface tension of generic liquids.

1 Introduction

Although the comprehension of surface phenomena is relevant not only in physics but also in disciplines such as engineering, chemistry and biology, the traditional approaches used to introduce the basic concepts related to this topic often prove to be ineffective in fostering students' understanding. Consequently, it often becomes difficult to make this topic interesting for both high school and undergraduate students [1]. Our research aims to build and test alternative strategies to improve the teaching-learning process related to surface phenomena with a focus on surface tension, also introducing hands-on and minds-on experimental activities and interactive lessons based on active learning strategies. This approach may help to promote students' interest and authentic understanding of physical phenomena.

Here we present two different experiments to study and estimate surface tension. The equipment required for the experiments is readily accessible and very cheap.

2 The experiments

The first apparatus [2] allows us to measure surface tension of a soap bubble and verify the Young-Laplace law. A fundamental quantity is the overpressure $\Delta p = p_{int} - p_{ext}$ inside a soap bubble, which is the difference between the pressure inside the bubble p_{int} and the pressure outside the bubble p_{ext}. This overpressure acts against the force due to surface tension γ of the soap film. In the case of a spherical bubble, the overpressure Δp can be obtained by the Young – Laplace equation

$$\Delta p = \frac{4\gamma}{r} \qquad (1)$$

where r is the radius of the soap bubble. The experimental apparatus allows us to measure both the overpressure and the radius, necessary to estimate del surface tension.

In the du Noüy ring method [3] one slowly lifts a metallic ring from the surface of a liquid. The force F required to raise the ring from the liquid's surface is related to the surface tension as follows

$$F = F_{ring} + 4\pi R\gamma \qquad (2)$$

where F_{ring} is the weight of the ring and R is the inner radius of the ring. Thus, measuring F when the ring detaches from the liquid surface, we can determine γ.

3 Results and conclusions

The surface tension values obtained by using the two experimental set-ups are consistent with the results reported in the literature, but the experimental apparatuses cost only a fraction of the professional ones commonly available. Reconstructing and trialling experimental set-ups for educational purposes by using inexpensive materials can be very important, as schools often do not have the budget needed to buy sophisticated, and often very expensive, professional laboratory equipment.

The experimental activities we propose here are part of a teaching/learning sequence. It also includes computer simulations and interactive lessons that will be trialled with a specific sample of high school students. Specific aspects of the teaching/learning sequence include students' active engagement in planning experiments, focus on important aspects of the observed phenomena and the use of models to predict results starting from testable hypotheses.

References

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