[O28] Industry-supported context-based chemistry practicals

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ABSTRACT

Two industry-supported context-based undergraduate chemistry practicals are described. The extent of the industrial involvement is primarily through in-kind support and this is explained for each practical. One experiment is concerned with spectro-photometric and kinetic analysis of commercial photochromic dyes, whilst the other is concerned with UV absorption spectroscopy and Beer-Lambert analysis of commercial UV sunscreens. Both experiments involve the students carrying out measurements that would be routinely undertaken by the industrial partner and they are able to make direct comparisons of their data with the company's published data. Both experiments are supported by pre-lab and post-lab activities and extensive on-line resources.

INTRODUCTION

> *'Wow, why don't textbooks and lab manuals do a better job of communicating what these real-world chemists do?'* (1)

This is a quote from the preface to '*an industry-based laboratory manual*' by John Kenkel and is an appropriate pre-text to the work described here.

In recent years the author has been active in the development of problem-based practical work for undergraduate chemistry students and some of this work has been disseminated via the LTSN and elsewhere (2). The work reported here focuses on the development of context-based undergraduate chemistry laboratory experiments that owe their inception to liaison with industrial partners. To place the industrial involvement in perspective, the author has secured in-kind support in the form of commercial samples as well as technical advice and electronic materials (articles/ brochures). The practicals involve topical contemporary industrial contexts that require knowledge and understanding of practical and theoretical aspects of core chemistry topics.

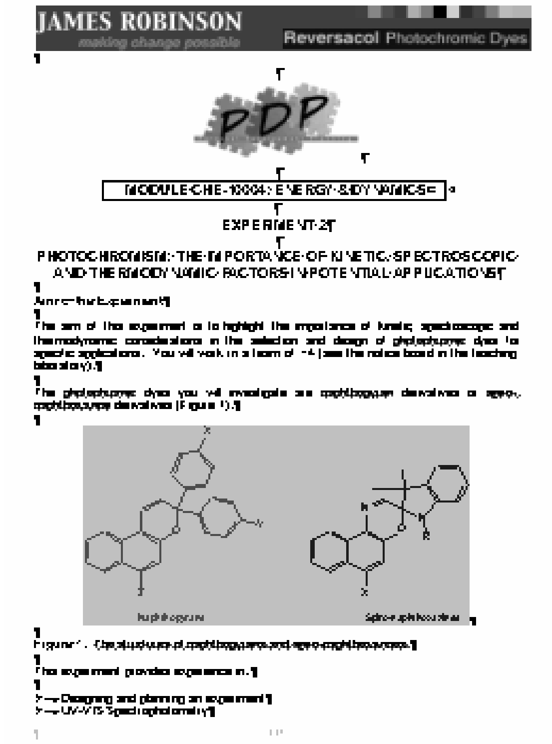
Context-based practical work clearly has the potential to show '*purpose', 'relevance*' and '*application*', provided the context is valid and credible. This work reported here is concerned with the use of tangible industrial/commercial contexts that draw upon specific core topics in chemistry to form the basis for undergraduate chemistry practicals. In addition, a particular (although not pre-requisite) aspect of these practicals is that there is some form of industrial support/sponsorship, even if this is just in-kind support through the supply of materials and/or resources. The educational aim of the work is to enrich the student learning experience in the laboratory through provision of contemporary and topical industrial contexts within which they can learn and apply theoretical and practical aspects of core topics in chemistry. The approach described is flexible and adaptable to other laboratory-based sciences.

DESCRIPTION OF THE PRACTICALS

1. Photochromism: The Importance of Kinetic, Spectroscopic and Thermodynamic Factors in Potential Applications

'*Photochromism*' is an example of a photochemical phenomenon with tangible and recognisable applications in products such as photochromic sunglasses. Moreover, the kinetic, thermodynamic and spectroscopic properties of such dyes are important considerations when selecting a dye for a particular application.

For this practical the industrial partner is James Robinson Ltd (3-5), who have kindly supplied free samples of various organic photochromic dyes (Reversacol product range). The experiment forms part of the level 1 physical chemistry module, CHE-10004 'Energy and Dynamics', at Keele University. The first page of the script and an image of the relevant website are shown on the right.



The experiment involves:

(i) Acquisition of UV-VIS absorption spectra of the colourless and coloured forms of the dyes,

(ii) Measurement of the rate constants and half-lives for the fading of the coloured forms of the dyes

(iii) Investigation of the temperature dependence of the fade rate and measurement of the activation energy for the fading process of one of the dyes

(iv) Chemical structure drawing and

(v) Use of online resources available on the James Robinson website.

In tasks (i)-(ii) students carry out measurements that would be undertaken by James Robinson Ltd and other manufacturers of photochromic dyes.

In the process of carrying out the experiment students learn about first order kinetic data analysis, the variety of chemical structures used for organic photochromics, their spectroscopic and chemical properties, how they work, their applications and how kinetic, spectroscopic and thermodynamic considerations are important for these. They also learn about some of the technical jargon/terminology used in the industry. The experiment is supported by a number of informative pdf articles/brochures/data sheets freely available from the James Robinson website and relating to spectroscopic and kinetic data on the individual molecules as well as more general articles on photochromism. The students compare their data with the spectroscopic and kinetic data published by James Robinson. The practical shows how an understanding of 1st order kinetics and spectrophotometry are important within an industrial context and also how this understanding aids interpretation of technical product data.

2. An Investigation of the UV Absorbing Properties of Commercial Organic Sunscreens.

For this practical the industrial partner is DSM Nutritional Products (6), who have kindly supplied free samples of three organic UV sunscreens (Parsol 5000, Parsol MCX and Parsol 340). The experiment has been piloted with trainee chemistry teachers on a TTA Chemistry Enhancement Course and will form part of the level 1 physical chemistry module, CHE-10004 ‘Energy and Dynamics’, at Keele University from 2005-2006. The experiment involves:

(i) Measurement of the UV absorption spectra of the three sunscreens

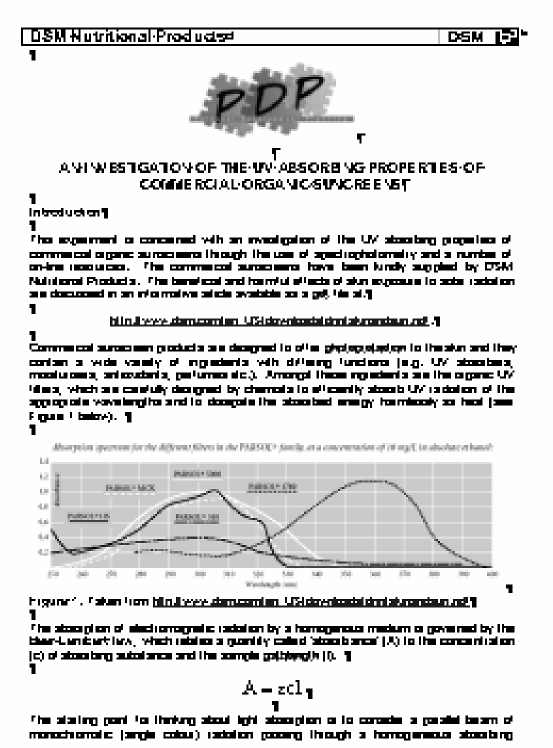
(ii) Application of the Beer-Lambert law for the determination of the molar absorption coefficients of the three sunscreens,

(iii) Investigation of any modifications to the UV absorption profile of the sunscreens as a result of exposure to UV light inducing photoisomerisation

(iv) Use of an on-line sunscreen simulator (provided by Ciba (7) and requires registration before use) to formulate a sunscreen and obtain SPF and UVA protection factor information in addition to spectral data.

Tasks (i) – (iii) involve the students carrying out measurements that would be undertaken by DSM and other sunscreen manufacturers when developing new sunscreens, and in this respect the industrial context is tangible. For (iv), the students are required to include one of the sunscreens they have studied in their formulation and individual results can be saved as a pdf file for submission with their laboratory reports.

In the process of carrying out the experiment students learn about the variety of chemical structures that form the basis of organic UV sunscreens, their physical, spectroscopic and chemical properties, how they work, some of the technical jargon/terminology associated with the industry and the wide range of companies involved in their manufacture. The students also learn about the beneficial and harmful effects of exposure to solar radiation as well as the background to sunscreen testing and formulation. The experiment is supported by a number of informative pdf articles/brochures freely available from the DSM website and relating to technical data on the individual molecules as well as more general articles on suncare. The students compare their data with the data published by DSM and this requires students to work between different types of units for molar absorption coefficients. The practical helps students to appreciate the importance of the value of the molar absorption coefficient as a key parameter for organic sunscreens and shows where the Beer-Lambert law is used directly within an industrial context. The students also acquire a sense of scale in relation to what the values of molar absorption coefficients for UV absorption bands of organic molecules.



DSM Nutritional Products | DSM

AN INVESTIGATION OF THE UV-ABSORBING PROPERTIES OF COMMERCIAL ORGANIC SUNSCREENS

Introduction

This experiment is concerned with an investigation of the UV absorbing properties of commercial organic sunscreens through the use of spectrophotometry and a number of on-line resources. The commercial sunscreens have been kindly supplied by DSM Nutritional Products. The beneficial and harmful effects of skin exposure to solar radiation are discussed in an informative article available as a pdf file at:

[illegible]

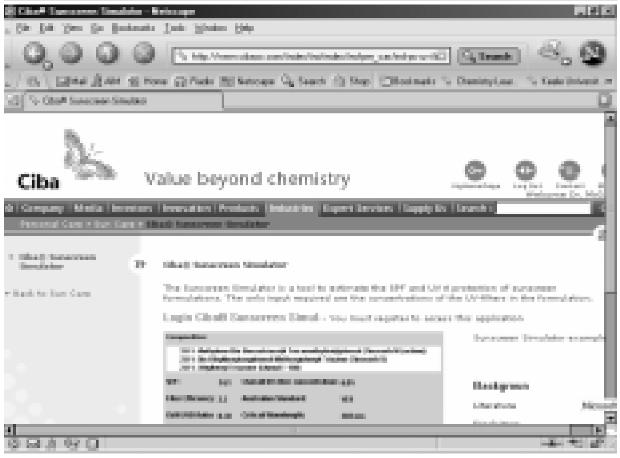
Commercial sunscreen products are designed to offer photoprotection to the skin and they contain a wide variety of ingredients with differing functions (e.g. UV absorbers, moisturisers, antioxidants, perfumes etc.). Amongst these ingredients are the organic UV filters, which are carefully designed by chemists to efficiently absorb UV radiation of the appropriate wavelengths and to dissipate the absorbed energy harmlessly as heat (see Figure 1 below).

Figure 1. Taken from [illegible]

The absorption of electromagnetic radiation by a homogeneous medium is governed by the Beer-Lambert law, which relates a quantity called 'absorbance' (A) to the concentration (c) of absorbing substance and the sample pathlength (l).

$$A = \varepsilon c l$$

The starting point for thinking about light absorption is to consider a parallel beam of monochromatic (single colour) radiation passing through a homogeneous absorbing



The first page of the script and images of the relevant websites are shown above and right.

CONCLUSION

Two industry-supported context-based chemistry practicals have been described. A distinctive feature of the practicals is the use of actual commercial samples by the students to carry out practical activities that mirror what is actually undertaken by the industrial partners. Students acquire data that they can compare directly with that published by the company. In addition to learning core chemistry topics, students also learn about the chemistry behind the products and some of the key issues for the design and marketing of these products.

ACKNOWLEDGEMENTS

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