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RESEARCH NOTE

Refractometric determination of ethanol concentration

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The refractive indices of various ethanol concentrations with and without dyes (Methylene Blue and Crystal Violet) have been determined using a refractometer. In general, the refractive index increases with ethanol concentration but, in the particular cases where Crystal Violet or a mixture of Crystal Violet and Methylene Blue were used, the variation of the refractive index with ethanol concentration is linear.

INTRODUCTION

The present methods for determining ethanol concentration include, for example, distillation at 78°C (Hart & Fischer, 1971) or use of gas–liquid chromatography (GC) (Afschar & Schaugerl, 1986). The use of a GC method is usually impossible, expensive or hampered in many laboratories in the underdeveloped or developing countries because of lack of equipment and/or unavailability of the gas required for its use. On the other hand, the distillation process is usually time-consuming and requires a strict temperature control. It has been observed that commercially available absolute ethanol is sometimes impure. It is suspected that some vendors for commercial laboratories may be diluting the product in order to maximise profit. This work was therefore undertaken to develop a rapid and accurate method for determining the concentration of distilled and commercially available ethanol.

MATERIALS AND METHODS

Materials

Absolute ethanol was obtained from James Borough Ltd, London; Crystal Violet and Methylene Blue were from Merck, Darmstadt, Germany and the 60/70 Abbé refractometer was supplied by Bellingham & Stanley Ltd, UK.

Method

Preparations of 10, 20, 30, 40, 50, 60, 70, 80 and 90% ethanol were made by mixing appropriate volumes of absolute ethanol and distilled water. Solutions of Methylene Blue and Crystal Violet, each at a concentration of 0·025% (w/v), were prepared with distilled water. The Methylene Blue solution was then mixed with an equal volume of the Crystal Violet solution, and 1 ml of this dye mixture was then mixed thoroughly with 1 ml of each of the ethanol preparations. The refractive index of each of the ethanol/dye-mixture solutions was then determined as described by Connors (1975). A 0·0125% (w/v) solution of each dye was also mixed with an equal volume of the different ethanol concentrations and the refractive index of each of the ethanol/dye solutions determined.

RESULTS AND DISCUSSION

The recorded refractive indices are averages of three readings. The refractive index of the mixture of Methylene Blue and Crystal Violet was 1·3317, which was lower than that of either of the dyes (1·3327 for Methy-

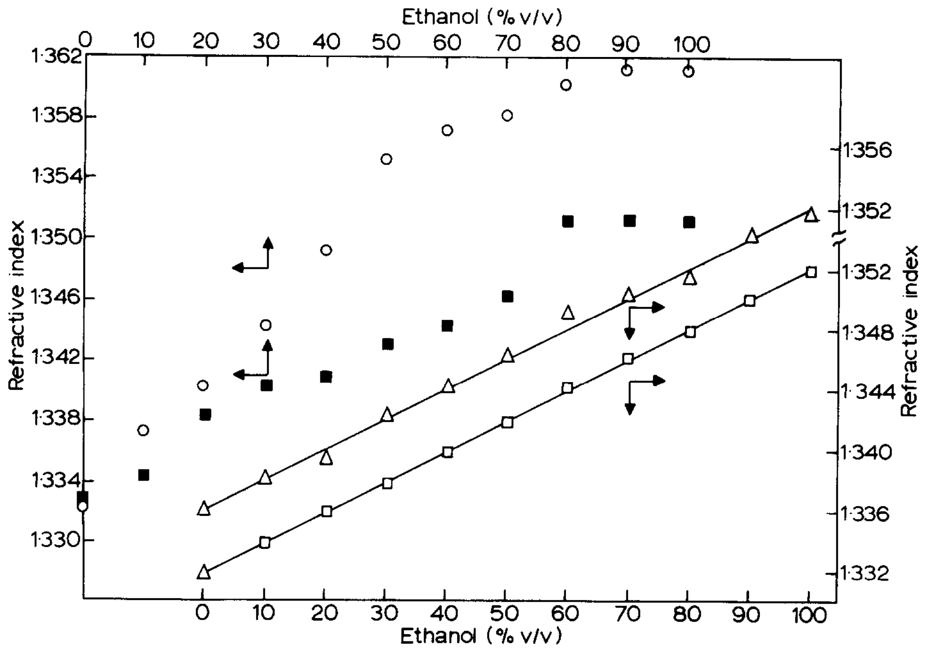

Fig. 1. Variation of refractive indices with ethanol concentration of the various mixtures: □, Crystal Violet + Methylene Blue; Δ, Crystal Violet; ■, Methylene Blue; ○, without any dye.

lene Blue and 1·3320 for Crystal Violet). This suggests an interaction between the molecules of the two dyes. The refractive indices of various ethanol concentrations without any dye were observed to increase with an increase in the percentage of ethanol but only up to about 90% (v/v), after which it remained unchanged. The results also show that the refractive indices of a mixture of a solution of either of the dyes (Methylene Blue or Crystal Violet) or of the dye mixture (Crystal Violet + Methylene Blue) with the various ethanol concentrations increased with an increase in the ethanol concentration (Table 1), although, for Methylene Blue, the increase was only up to about 80% (v/v). These observations seem to agree with the report that the refractivity of a liquid is an average effect determined by the contributions of molecules variously oriented relative to one another and to the field of incident radiation (Raman & Krishnan, 1988).

A graph of the refractive indices versus ethanol concentrations of the various mixtures is shown in Fig. 1. It was observed that only mixtures of ethanol with either Crystal Violet or a combination of Crystal Violet and Methylene Blue gave a linear variation of refractive index with ethanol concentration. In these cases the variation can be represented by the equation

$$\eta_c = \eta_0 + aC$$

where η_c is the refractive index of a given alcohol concentration; C, η_0 and a are constants. For Crystal Violet alone $\eta_0 = 1{\cdot}3322$, $a = 1{\cdot}96 \times 10^{-4}$ with a correlation coefficient of 0·9971, while for the combination of Crystal Violet and Methylene Blue $\eta_0 = 1{\cdot}3318$, $a = 2{\cdot}02 \times 10^{-4}$ with a correlation coefficent of 0·9998. Thus the use of a combination of Crystal Violet and Methylene Blue gives a better linear variation.

In both cases $a = 2 \times 10^{-4}$ and η_0 is very close to the refractive index of water (1·3322), as expected. Thus $c = 5 \times 10^{-3} (\eta_c - 1{\cdot}3320)$.

Alternatively, the refractive index of the ethanol concentration can be read off a standard curve of the refractive indices of various ethanol/dye-mixture solutions against ethanol concentration.

The refractometric method of determining alcohol concentration is both relatively rapid and easy to use and can determine ethanol concentration to an accuracy of about 0·5%.

Table 1. Refractive indices of the solutions of dyes and various ethanol concentrations at 30°C

Ethanol (%)	Refractive index: Without dye	With Methylene Blue	With Crystal Violet	With Crystal Violet/ Methylene Blue
100	1·361 2	1·351 2	1·351 7	1·351 9
90	1·361 2	1·351 2	1·349 2	1·349 9
80	1·360 2	1·351 2	1·347 4	1·347 9
70	1·358 2	1·346 2	1·346 2	1·346 1
60	1·357 2	1·344 2	1·345 0	1·344 2
50	1·355 2	1·343 0	1·342 2	1·341 8
40	1·349 2	1·340 7	1·340 2	1·339 8
30	1·344 2	1·340 2	1·338 2	1·337 7
20	1·340 2	1·338 2	1·335 4	1·335 9
10	1·337 2	1·334 2	1·334 2	1·333 9
0	1·332 2	1·332 7	1·332 0	1·331 7

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