

Determination of Percent Composition of Components of a Mixture using Refractometry

#144

Chemistry BC 3328

Monday Section

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ABSTRACT: A mixture of 1-butanol and ethyl acetate (**R-132**) of unknown composition was analysed using refractometry.

INTRODUCTION

In this experiment, the percent composition of a mixture was determined by comparing the mixture's refractive index to a standard curve. Refractive index of the mixture was determined using refractometry.

Refractometry is a technique that measures how light is refracted when it passes through a given substance¹. A refractometer measures the extent to which light is bent (i.e. refracted) when it moves from air into a sample and is used to determine the refractive index or index of refraction (n) of a liquid sample. The ratio of the speed of light in vacuum to the speed of light in another medium is defined as the refractive index for the substance.

The refractive index depends on both the temperature of the sample and the wavelength of light used. Hence, these are both indicated when reporting the refractive index, e.g., n^{20}_D 1.3742. The superscript indicates the temperature in degrees Celsius, and the subscript denotes the wavelength of light (in this case the letter D indicates D line of sodium at 589 nm).

Refractive index is routinely determined as part of the characterization of liquid samples, similar to the determination of melting points to characterize solid compounds². It is also used to:

1. Help identify a sample by comparing its refractive index to known literature values.
2. Assess the purity of a sample by comparing its refractive index to the literature value for the pure substance. The closer the refractive index is to the literature values, the purer the sample.

3. Determine the concentration of a solute in a solution by comparing the solution's refractive index to a standard curve.

RESULTS AND DISCUSSION

In this experiment, refractive index of a mixture (**R-132**) of 1-butanol and ethyl acetate of unknown composition was determined. The experimentally determined value is 1.3795 at 25 °C. The literature values of refractive indices (n_D^{20}) for pure 1-butanol and ethyl acetate are 1.3993 and 1.3722 respectively³.

Refractive index is temperature dependent. To adjust for temperatures other than 20 °C, the following formula was used:

$$n_D^{20} = n_D^T + 0.00045 (T - 20^\circ\text{C}), \text{ where } T = 25^\circ\text{C}.$$

The corrected refractive index of the mixture was found to be 1.3817 at 20 °C.

By comparing the experimental and corrected values of refractive index (n_D^{25} v/s n_D^{20}), we could infer that refractive index of a substance increases with decrease in temperature. Additionally, on comparing the corrected value to the literature values of 1-butanol and ethyl acetate, one could hypothesize that the mixture may contain more percentage of 1-butanol.

A standard curve showing the relationship between refractive indices and concentration of 1-butanol in ethyl acetate was provided. Using this curve, percent composition of 1-butanol corresponding to the experimental refractive index, 1.3795 was determined to be 42.5%. Hence, the percent composition of ethyl acetate in the given mixture is 57.5%.

CONCLUSION

Percent compositions of 1-butanol and ethyl acetate in a mixture of unknown composition was successfully determined to be 42.5% and 57.5% respectively using refractometry. Experimentally determined refractive index of the mixture is 1.3993 at 25 °C and the corresponding corrected refractive index of the mixture at 20 °C is 1.3817.

EXPERIMENTAL SECTION

General Methods. Refractive Index was measured on an Abbey Refractometer at 25°C using D-line (nm) of Sodium lamp. Temperature was recorded in degree celsius.

Procedure. A mixture (**R-132**) of unknown percent compositions of 1-butanol and ethyl acetate was used for analysis. The mixture was a clear, colorless liquid with strong odor. The prism of the refractometer was lifted. The top and bottom surfaces were cleaned with 95% ethanol. Once both surfaces were dry, 1-2 drops of the undiluted mixture were placed onto the bottom prism until the entire surface was covered, using a disposable pipette. The prism was closed, and the refractive index of the mixture was determined immediately as per the instructions provided. Temperature was noted. Experimentally determined refractive Index: $n_D^{25} = 1.3993$. Corrected $n_D^{20} = 1.3817$. Percent Composition of the mixture (**R-132**): 42.5% 1- butanol, 57.5% ethyl acetate.

SUPPORTING INFORMATION

The materials included with this report are copy of standard curve, marked and labeled with corrected value of refractive index and corresponding percent compositions of 1-butanol and ethyl acetate, copies of the laboratory note-book pages containing table of physical constants, data table and result table with experimental and corrected refractive indices.

REFERENCES

1. BC3328 Introductory Organic Chemistry Laboratory Manual Barnard College; New York, 2019; pp 145–150.
2. Zubrick, J.W. *The Organic Chem Lab Survival Manual*, 9th ed.; Wiley: New York, 2009.
3. Rumble, J. R. CRC Handbook of Chemistry and Physics, 100th ed.; Taylor and Francis: Oxford 2019–2020 (<http://hbcponline.com/>, accessed on January 12, 2020).