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Determination of the Chemical Composition of Alcoholic Products Using the Photoelectric Colorimetric Method

Botirova Sabina Metin qizi

Teacher of the Department of General Sciences Asia International University Bukhara, Uzbekistan

sabinabotirova498@gmail.com

Abstract. This article discusses the theoretical foundations, practical applications and analytical capabilities of the photoelectric colorimetric method in determining the chemical composition of alcoholic products. The study explains the relationship between optical density and concentration in the process of determining the amount of ethanol, fusel oils, aldehydes and other impurities based on the Beer–Lambert law developed by August Beer and Johann Heinrich Lambert. The results obtained using a photoelectric colorimetric method are of great importance in quality control of alcoholic beverages, sanitary requirements and optimization of production processes.

Key words: alcoholic products, photoelectric colorimetry, optical density, Beer–Lambert law, ethanol, fusel oils, quality control, laboratory analysis.

Introduction

Alcoholic products (wine, vodka, beer, etc.) contain ethanol as the main component, and in addition to it, various organic and inorganic compounds are also found. Their quantitative and qualitative determination determines the safety of the product and its compliance with standards. One of the widely used methods in modern analytical chemistry is photoelectric colorimetry.

A photoelectric colorimeter determines the concentration of a substance by measuring the degree to which a solution absorbs light of a specific wavelength.

The main component of alcoholic products (wine, vodka, beer and liqueurs) is ethanol (C_2H_5OH), the content of which is usually in the range of 4–96%. In addition, the following substances are present:

• Methanol (CH_3OH)
• Acetaldehyde (CH_3CHO)
• Fusel oils (isoamyl alcohol, propanol, butanol)
• Organic acids

Theoretical foundations

Beer–Lambert law Photoelectric colorimetry is based on the following equation:

$$A=\varepsilon\cdot l\cdot cA$$

Where:

• A – optical density
• ε – molar absorption coefficient
• l – cuvette thickness
• c – solution concentration
• As the optical density increases, the concentration of the substance in the solution increases in direct proportion.

Research methodology

1. Equipment
• Photoelectric colorimeter

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- Standard reference solutions
- Cuvettes
- Reagents (chromotropic acid, sulfuric acid, etc.)

2. Experimental steps
- Sample preparation
- Formation of a colored complex by adding a reagent
- Measurement of optical density at a specified wavelength
- Determination of concentration based on a calibration graph

3. Wavelength of the analytes.

Substance	Wavelength (nm)	Reaction type
Ethanol	580 nm	Forms a colored complex
Methanol	575 nm	Oxidizes to formaldehyde
Acetaldehyde	365 nm	Absorption in the UV range
Fusel oils	540 nm	Oxidation reaction

4.1 Photoelectric colorimeter operation scheme

Light source → Filter → Cuvette (sample) → Photocell → Meter Calibration data Standard solutions table

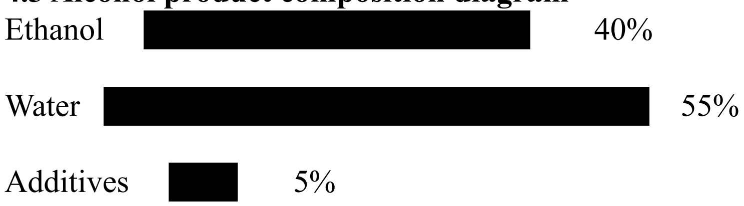
Concentration (mol/L)	Optical density (A)
0.001	0.150
0.002	0.300
0.003	0.450
0.004	0.600
0.005	0.750

4.2 Calibration Graph

Optical Density (A)

Concentration (C)

4.3 Alcohol product composition diagram



Results and discussion

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As a result of the experiment, the optical density of the unknown sample was A = 0.600.
According to the table, this is equal to a concentration of 0.004 mol/L.
Mass fraction calculation:
m=c·Mm
Mm=c·M
Molar mass of ethanol is 46 g/mol:
m=0.004×46=0.184 g/Lm = 0.004
46 = 0.184 g/L
m=0.004×46=0.184 g/L
This result is compared with standard values.

Advantages of the method

1. Fast (result within 10–15 minutes)
2. Accuracy ±1–2%
3. Performed in ordinary laboratory conditions
4. Requires inexpensive equipment
5. Easy to calibrate
6. Convenient in quality control
7. Possibility of multi-component analysis
8. Small sample size is sufficient

Disadvantages

• Colored impurities may interfere
• Requires high-purity reagent
• There is a possibility of spectral error

Conclusion

The photoelectric colorimetric method is an effective and reliable analytical method for determining the chemical composition of alcoholic products. This method can determine the amount of ethanol, fusel oils and other additives. The use of this method in the quality control system plays an important role in ensuring product safety.

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