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ASSESSING CARBON EMISSIONS IN BEVERAGES FROM THE SAUDI ARABIAN MARKET WITH CLOSED SIMPLE DISTILLATION

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Abstract: The determination of carbon dioxide (CO2) in aqueous solutions is crucial for process and quality control in industries that deal with beverages. This study investigated a novel method for the direct determination of CO2 in aqueous solutions using a closed simple distillation system. The experimental setup for the simple distillation involved transferring 3 ml of a sample into a round bottom flask and fitting it with condensers. The closed system was checked for leaks to ensure accurate results. The results of the study showed that the determination of CO2 using the closed simple distillation system was successful. This method offers a direct and selective approach for determining CO2 content in aqueous solutions, particularly in situations where other gases are present in the liquid.

Keywords: carbon dioxide, aqueous solutions, closed simple distillation system, beverage industry, process control, quality control, Saudi market.

1. Introduction

High-pressure solvent extraction (HPSE) is becoming increasingly popular in the chemical, food and pharmaceutical sectors. Extraction by means of CO_2, has been extensively studied in the last decade and has shown to be a good technique for the production of flavors and fragrances from plant materials. Conventional processes, such as steam distillation, solvent extraction, *etc.*, often require additional steps, such as separating the extract and their selectivity is usually inferior to that of CO_2. Due to the lower temperature and low water content in HPSE, thermal degradation and hydrolysis are avoided. The extract obtained in this manner contains all active compounds unaltered from the plant and exhibits a scent more similar to the starting material. Marigold (*Calendula officinalis* L.) is a widely cultivated plant in Europe and America for ornamental and medicinal purposes. In folk medicine, the flowers of this plant are used to treat inflammatory conditions of internal organs, gastrointestinal ulcers, diuretic and diaphoretic convulsions. Calendula extracts are also used in diverse preparations, mainly ointments for the treatment of some dermatological conditions, such as ulcers, eczema, burns and hemoroides. Pharmacological studies of conventional marigold extracts (infusions, tincture, fluid extract) show that its most important constituents are saponines, glycosides of sesquiterpenes, lavonoids and triterpenes.

Rapid and accurate determination of carbon dioxide in aqueous samples is of industrial importance, especially in the beverage industry. As the CO_2 content in water and soft drinks, as well as in alcoholic beverages, is an important parameter for process and quality control, therefore, it is frequently measured. The measuring principle of the currently most popular CO_2 process analyzer is based on Henry's law, which states that the volume of a gas dissolved in a liquid is proportional to its partial pressure at a given temperature. During a measuring cycle a sample is drawn from the process stream and its volume is expanded in a measuring chamber. Due to the volume expansion a gas phase is generated in the measuring chamber. To accelerate equilibration of pressure and temperature between the liquid and gas phase, the sample is stirred with an impeller. In some measuring systems the equilibrium pressure is not reached within an acceptable time and must therefore be extrapolated. The CO_2 content is then calculated from the measured equilibrium pressure and temperature.

This measuring principle is inherently not selective for CO_2 as all other gases dissolved in the sample will also influence the gas pressure and thus cause interferences. A selective method for CO_2 determination would be of special interest in situations where in addition to CO_2 other gases are also contained in the liquid. In the present study, CO_2 determination under closed simple distillation system was investigated. The samples used were tap water, lemon juice (Kareem), milk (Nada), 7up, orange juice, Red Bull and Pepsi. The results obtained, with all of these products available in local Saudi market, are discussed in this paper.

2. Experimental

The experimental set up for the simple distillation is shown in figure1. The glassware used includes condensers, round bottom flask, heating mantle, thermometer, stopper, stands, and adapter, receiving flask and rubber hose.

The essential part of the procedure is as follows: Transferred 3ml of a sample into a round bottom flask and fitted with condensers as shown in figure1. The temperature of the heating mantle was slowly increased at a slow heating rate. When the temperature reaches to 50 and 60^0C, the pressure gauge detects the CO_2 gas; the corresponding barometer readings were taken. The qualitative determination of CO_2 was done by bubbling the outlet gas into calcium hydroxide solution. The whole process is repeated four times to ensure the reproducibility of the experiment and average values are reported in this paper.

3. Results and Discussion

From the pressure of CO_2 gas collected, the mass is calculated as follows.

System Pressure = Δh(mmHg) + P(atm)

CO_2 Pressure = System pressure – Vapour pressure of water

P(CO_2 mmHg) = P(system)- P(water)

P(CO_2 atm) = P(CO_2 mmHg)/760 mmHg

PV=nRT , n = PV/RT , n = {P(CO_2)xV(system)}/ RT n = {P(CO_2 atm)x (0.962L)}/ {(0.0821 L.atm/mol.K)x(331K)}

Mass of CO_2 in vapour part of system = $\frac{\{M.W\ (CO2)x\ P(CO_2\ atm)x\ (0.962L)\}}{\{(0.0821\ L.atm/mol.K)x(331K)\}}$

Mass of CO_2 in vapour part of system = {44.01 g/mol x P(CO_2 atm)x (0.962L)}

{(0.0821 L.atm/mol.K)x(331K)}

Mass of CO_2 in vapour part of system = P (CO_2 atm) x (1.558 g of CO_2/atm)

Mass of CO_2 in liquid part of system = $1.5675x10^{-3}$ g CO_2

The total mass of CO_2 in the system = Mass of CO_2 in vapour part of system

+

Mass of CO_2 in liquid part of system

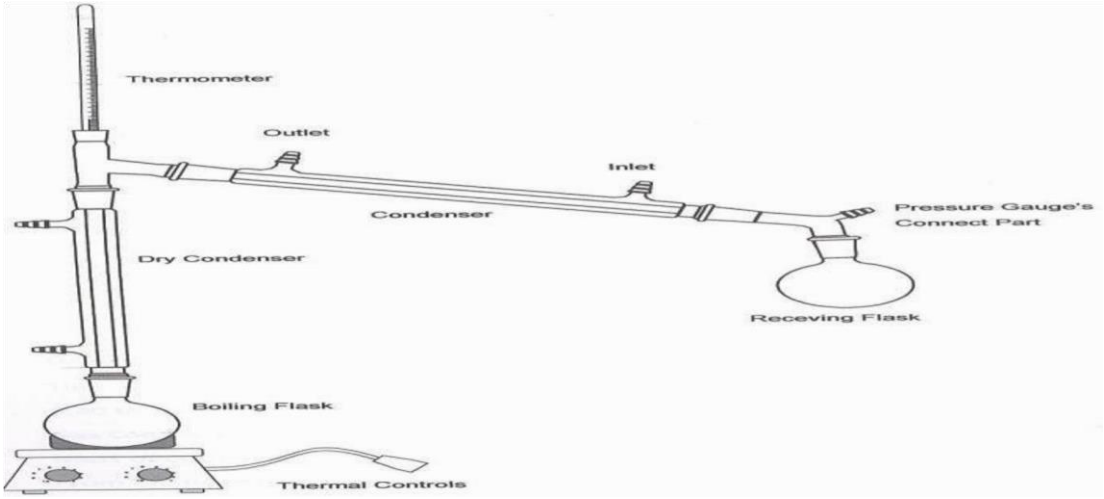

Figure 1. The experimental set up for the simple distillation The results obtained with different samples are tabulated in table 1.

Sample	**Average mass of CO_2**	**Number of moles CO_2**	**Calculated Molarity (M)**
Tap water	1.32	0.021	0.298
Lemon juice(Kareem)	1.31	0.029	0.297
Milk (Nada)	1.30	0.029	0.296
7UP	1.33	0.030	0.302
Orange Juice (Nada)	1.31	0.029	0.298
Red Bull	0.31	0.029	0.299
Pepsi	1.33	0.030	0.303

Table 1. CO_2 content in different analyzed samples.

From this table it is clear that, different samples have different concentrations of CO_2. Among the soft drink samples available in the market, the CO_2 content is approximately the same.

4. Conclusions

From this study it can be concluded that CO_2 content of any liquid sample can be estimated by a simple distillation method. The accuracy of the method depends on maintaining a closed system, as any escape of CO_2 can affect the accuracy of the results. The amount of CO_2 estimation has not been previously performed using this direct method. It is known that CO_2 content varies with pressure of CO_2 gas above the liquid. So it is difficult to have a standard amount of CO_2 in solutions. This present study shows the usefulness of this novel method to measure the CO_2 content in liquids and the results are very interesting especially for carbonated soft drinks, as the one company have two different products, has the same amount of CO_2 content.

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