International Journal of Latest Trends in Engineering and Technology
Vol.(16)Issue(1), pp.066-068
DOI: http://dx.doi.org/10.21172/1.163.10
e-ISSN:2278-621X

METHODS FOR EXTRACTION OF ESSENTIAL OILS: A CASE STUDY

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Abstract: Usage and extraction of essential oils is discussed in this paper. Here, the separation of eucalyptus oil from its leaves using steam distillation and leaching is studied. A comparison is made on the basis of the amount of solvent used to extract 100g of essential oil in both the techniques. Steam distillation was found to be economical.

Key Words: eucalyptus, steam distillation, essential oils, leaching.

I. INTRODUCTION

As the market sees an upsurge in the demand of essential oils, the techniques for their separation are in prime focus. They are termed as essential oils because they contain the essence of the plant, that is, the aroma or beneficial chemicals. They are highly volatile, non-greasy and light as compared to vegetable oils. The essential oils, based on their composition, are biologically beneficial in different medical situations and are used as specialty chemicals. They find use in a wide range of daily products such as balms and ointments, cosmetics, soaps, perfumes etc. based on their anti-bacterial, nutritional and aroma characteristics.

Essential oils are extracted from natural foliage through different processes. Some of the traditional methods such as solvent extraction, steam distillation, water-steam distillation (when the feed to distillation has water in it) etc. are still used along with the new techniques of supercritical fluid extraction, membrane separation, microwave distillation etc. Recently we have studied extraction of various essential oils using steam distillation and liquid-liquid extraction[1,2].
Here, for the extraction of eucalyptus oil from its leaves, the processes of steam distillation and leaching has been discussed. The key component of eucalyptus oil is 1,8-cineole. It constitutes 50 to 90 % of the eucalyptus oil, for this reason it is also called eucalyptol. 1,8-cineole is a widely used chemical due to its pharmaceutical effects. Some of which are as an antiseptic, pain reliever, reliever in cough, congestion and other respiratory diseases. For the essential oil to be biologically beneficial, the concentration of 1,8-cineole should be more than 70% . The pharmaceutical grade has around 80-90% which can be obtained by rectification[3].
To the best of our knowledge data on theoretical requirement of solvent or steam is unavailable in open literature and hence a comparative study of the processes is undertaken in this paper.

The properties of the eucalyptus oil (1,8-cineole) can be summarized as follow[4]:
Description: Colourless to pale yellow liquid with an aromatic and camphoraceousodour and pungent, cooling, spicy taste.

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Freezing Point: 0ºC- +1ºC
Boiling Point at 760 mmHg: 176 - 177 ºC
Flash Point: 49 ºC
Melting Point at 760 mmHg: 1.5 ºC
[5]Molecular formula: $C_{10}H_{18}O$
Molar mass: 154.25g/mol
Vapour pressure: 1.9 mm Hg @ 25°C
Soluble in ; ethanol, ether, chloroform, and hexane. Very slightly soluble in water
Water : 332.1 mg/L @ 25°C (est)
3500 mg/ L @ 21°C(exp)

II. Methods Of Extraction

The essential oil from eucalyptus is extracted from dried leaves. Since it is nearly immiscible with water, one can opt for steam distillation for extraction of the oil. The immiscibility results in independent partial pressures of oil and water. Hence the mixture boils at a temperature lower than the boiling point of the more volatile component. Here, the more volatile component is water and hence separation is enabled at temperatures lower than 100°C, at standard atmospheric pressure. The other method is leaching using a suitable solvent. For the purpose of comparing the two processes, water is selected as the solvent. And the temperature of operation is adjusted so as to get a suitable solubility. The separation of oil from water is easy at room temperatures owing to their immiscibility. The extraction of 100g of essential oil is assumed as the basis for calculation.

2.1 *Steam Distillation*

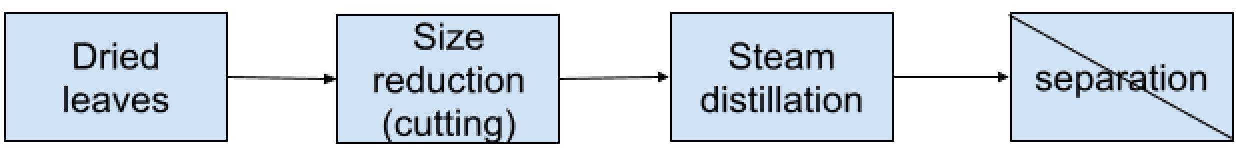

Figure 1. Block diagram for separation using steam distillation.

This method is used to distill high boiling volatile components from nonvolatile impurities at atmospheric pressure. High temperatures might cause deterioration of these compounds. The total pressure above the solution, [Dalton's law and Raoult's law]

$$P_t = p_a x_a + p_b x_b \quad (1)$$

Where, P_t = total pressure; p_a, p_b= vapour pressure of oil and water respectively; x_a, x_b = mole fractions of oil and water respectively in the solution.
In case of the volatile component being immiscible with steam, they will exert their true vapour pressures, that is, the mole fractions x_a, x_b are equal to 1 in equation (1) and the total pressure is the sum of their individual vapour pressures.
The steam distillation can be done by contacting steam to the dry charge or to an aqueous mixture. The degrees of freedom are then two and one respectively. Here we consider an aqueous mixture and therefore fix the pressure as atmospheric.
E.F.K. Denny et al[6]. reported that at 97.42°C and atmospheric pressure, the vapour pressure of steam and oil are 692.7 mm Hg and 67.3 mm Hg respectively. Thus, the mixture boils at 97.42°C.
From the material balance for steam distillation we arrive at equation (2). The ratio of the moles of oil distilled to the amount of steam is given as

$$\frac{n_a}{n_b}=\frac{y_a}{y_b}=\frac{p_a}{p_b}=\frac{m_a/M_a}{m_b/M_b} \quad (2)$$

Where, y_a ,y_b are mole fractions of oil and steam in the distillate and m and M are fed mass and molar mass of the compounds respectively.
From the values of all the other parameters, the amount of steam to be fed can be calculated using equation (2).

$$\frac{100/154}{m_b/18}=\frac{67.3}{692.7}$$

$$m_b = 120.30 \text{ g}$$

Thus, for extraction of 100g oil from leaves by steam distillation, approximately 120.30g steam has to be used.

2.2 *Leaching*

It is a solid-liquid extraction technique where a solvent is used to separate a desired constituent from the solid. The solvent with the desired component is called extract while the left over leached solid is called raffinate. The solvent to be used depends upon the affinity and solubility of the desired component. In this case, the feed is dried eucalyptus leaves and water. The extract consists of solvent (water) and essential oil while the raffinate is a cake or slurry of leached solids based on the particle size of the feed. Leaching can be described simply by the following diagram.

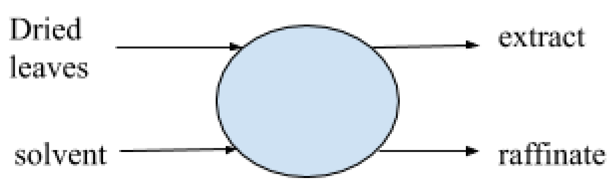

Figure 2. Block diagram of leaching.

B.A.Abdul-Majeed et al.[4]reported that an extraction conducted at 100℃ with the specifications of particle size: 0.5cm, solvent to solid ratio: 5:1 mL/gm , resulted in a yield of 27.72 (w/w)%.

$$\text{Yield}=\frac{\text{oil extracted}}{\text{wt.of dry leaves}}=\frac{100}{M_t}\times 100 = 27.72 \qquad (3)$$

Hence, M_t = mass of dry leaves(solid) = 360.75g

Using the solvent to solid ratio, mass of water fed as solvent = 5360.75 = 1803.75mL = 1.80375L

Also, the amount of total oil is nearly 46.25(w/w)% in the dry leaves[4],

and the distribution coefficient,

$$K_d=\frac{\text{mass of solute in dry solid g}}{\text{mass of solute in dry solidof solute in solvent g/L}}=\frac{0.4625100}{1.80375}=0.00834 \qquad (4)$$

Thus, for extraction of 100gm of oil through solvent extraction, the amount of water used is 1803.75mL or 1803.75g.

Ⅲ. Conclusion

The above calculations estimate the amount of water that has to be fed for recovery of 100g of essential oil from dry solid using steam distillation and solvent leaching, which comes out to be 120.3045g and 1803.75g of water respectively. The power requirements for both processes can be assumed nearly the same due to the choice of operating temperature. The results show a huge amount of water has to be used for leaching than in steam distillation. Thus, the optimum process based on the above study is steam distillation.

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