EXTRACTION OF CAFFEINE FROM COFFEE AND TEA

DESIGN PROJECT-2 REPORT

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ABSTRACT

Caffeine(3,7-Dihydro-1,3,7-trimethyl-1H-purine-2,6-dione) is a widespread naturally occurring xanthine derivative found in a variety of plants but commonly found in coffee beans and tea leaves. Caffeine containing products have been consumed for hundreds of years for their taste, aroma and CNS stimulating properties. We estimated the amount of caffeine present in tea and coffee, which people consume regularly. We extracted caffeine from theseusing 'liquid-liquid separation' method. As an extracting solvent, we have used chloroform in which caffeine is highly soluble than in any other solvent. Thereafter chloroform from extract was evaporated until only white crystals remained, which were considered to be pure Caffeine.

Keywords: Caffeine, Tea, CNS, chloroform.

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I. INTRODUCTION:

Tea and coffee are the most popular beverages for centuries, primarily due to their aroma, pleasant taste and stimulant effects. Caffeine is an odourless, slightly bitter, bioactive heterocyclic amine present in more than 60 plants. It is found mostly in beverages such as coffee or tea and in some chocolates. A number of products used as the counter pain relievers, headache remedies and antihistamines also contain Caffeine. In recent years, caffeine received increasing attention in food and pharmaceutical industries, due to its pharmacological properties which comprise stimulation of the central nervous system, peripheral vasoconstriction, relaxation of the smooth muscle and myocardial stimulation. The caffeine is still facing many controversies and misconceptions like its intake could result in enhanced risks of caffeine addiction, cancer, miscarriages, breast diseases, osteoporosis and hypertension etc. Caffeine is one of the most thoroughly investigated ingredient in the human food.

Caffeine has been used as a medicinal and recreational drug since before recorded history, by consumption of caffeine bearing plants. However, the discovery of the chemical did not occur until a young physician called Friedlieb Ferdinand Runge isolated and purified the white crystalline substance in 1819 as result of encounter with 70-year-old Johann Wolfgang von Goethe.

Caffeine is thought to act on the brain by blocking adenosine receptors. Adenosine, when bound to receptors of nerve cells, slows down nerve cell activity; this happens, among other times, during sleep. The Caffeine molecule, being similar to Adenosine, binds to the same receptors but doesn't cause the cells to slow down; instead, the Caffeine blocks the receptors and thereby Adenosine action. The resulting increased nerve activity causes the release of the hormone Epinephrine, which in turn leads to several effects such as higher heart rate, increased blood pressure, increased blood flow to muscles, decreased blood flow to the skin and inner organs, and release of glucose by the liver.

Caffeine acts as a stimulant. It stimulates the heart, respiration, the central nervous system, and is a diuretic. Its use can cause nervousness, insomnia and headaches. It is physically addictive. A person who drinks as few as 4 cups of coffee a day and who attempts to stop “cold turkey” may experience headache, insomnia, and possibly nausea as the result of withdrawal.

It is generally agreed that there is little risk of harm when a person consumes less than 300 mg of caffeine a day1,2. However at times of anxiety or stress, or during pregnancy, the FSA recommends consumption of less than 200 mg a day3. While there are no regulatory requirements to control or label food products with their caffeine content, numerous studies have been carried out to determine the typical caffeine content of commonly consumed beverages.

1.1 PHYSICAL AND CHEMICAL PROPERTIES

Caffeine is sparingly soluble in most polar solvents but is highly soluble in less polar solvents. The melting point is 234°C-239°C and the chemical formula is C8 H10N4 O2. It is an intensely bitter, white powder in its pure state. Caffeine is an alkaloid of the methylxanthine family, which also includes the similar compounds theophylline and theobromine.

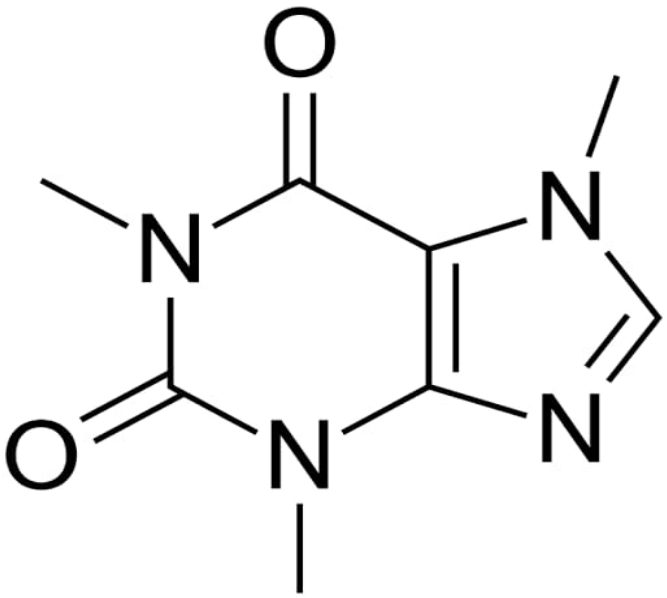

Fig 1 Structure of a caffeine molecule

1.2 APPLICATION OF CAFFEINE IN MEDICAL INDUSTRY

Caffeine which is found in tea and coffee imparts bitterness and also acts as a flavour constituent. It is a mild nervous stimulant towards drowsiness and fatigue. In this respect, is used by athletes to enhance performance since it mobilizes fats from stores a process that normally does not become maximal until intense activity is underway. Caffeine is used as a drug on the basis of its effect on respiratory, cardiovascular and the central nervous system. It is included with aspirin in some preparations for treatment of headaches as it decreases cerebral eye blood flow. Caffeine is administered in the treatment of mild respiratory depression caused by central nervous system depressants such as narcotic. Caffeine may also be used in the treatment of acute circulatory failure. In either beverage or in non-prescription tablet form, it may be used to relieve fatigue since it increases the amount of urine flow. In fact, there are about 2000 non-prescription and about 1000 prescription drugs containing caffeine.

II. LITERATURE REVIEW:

Friedrich Ferdinand Runge etal. Isolated relatively pure caffeine for the first time. In 1827, Oudry isolated "theine" from tea, but it was later proved by Mulder and Jobat that theine was the same as caffeine.

The structure of caffeine was elucidated near the end of the 19th century by Hermann Emil Fischer, who was also the first to achieve its total synthesis. This was part of the work for which Fischer was awarded the Nobel Prize in 1902.

Clementz and Dailey (1988) etal. determined Pure caffeine occurs as odourless, white, fleecy masses, glistening needles of powder. Its molecular weight is 194.19 g/gmol, melting point is 236, point at which caffeine sublimes is 178, at atmospheric pressure, pH is 6.9 (1% solution), specific gravity is 1.2, volatility is 0.5 %, vapour pressure is 760 mm Hg at 178, solubility in water is 2.17 g per 100 mL water at 25, and vapour density is 6.7.

Gebely, Mumin (2006) etal. reported that; Every time we drink tea, coffee, cocoa, chocolate or cola, we are giving our body a hit of caffeine. Alcohol and nicotine, along with caffeine are the three most widely used mood-affecting drugs in the world. The effects of caffeine on human being depend on concentrations. Consuming high dosage of this compound causes various physiological and psychological effects which include stimulation of the central nervous system.

Belay (2011) etal. reported that caffeine has a tendency of rapidly and completely absorbed from gastrointestinal tract within very short period of time and get distributed in the body. It is not removed from the circulation until metabolized initially into paraxanthine and thyobromine then into derivative of uric acid and diaminourcil, which is eventually removed from the circulation. It is reported that, the plasma half-life of caffeine in man, that is; the time required for its level to be diminished by 50% via biotransformation and excretion is 5 to 6 hours.

III. MATERIALS AND METHOD

3.1 MATERIALS REQUIRED

LAB APPARATUS:

500 mL Beaker,250 mL Erlenmeyer flask, Funnel, Distilled Water, separating funnel, Separatory funnel stand, stirring rod, Whatman filter paper, Watch glass.

REAGENTS AND MATERIALS:

- Tea Bags(or) Coffee bags
- Sodium Carbonate (Na_2Co_3)
- Dichloromethane (Ch_2Cl_2)

3.2 Preparation of Sample

7 grams, of tea (or) coffee were taken in 150 ml of distilled water and 5g of sodium carbonate is added. The solution was then heated and was kept at 100C for 15 min. Then, the solution was cooled and filtered using Whatman filter paper.

Fig 2 Sample is heated

3.3 Caffeine Extraction Procedure

This sample was placed into a separating funnel and 6 ml of dichloromethane (DCM) was added. The caffeine was extracted by inverting the funnel at least three times, venting the funnel after each inversion. Vigorous shaking will produce an intractable emulsion, while extremely gentle mixing will fail to extract the caffeine. The bottom layer containing dichloromethane (DCM) was removed to a clean flask, leaving behind the layer of water and the extraction procedure was repeated twice more and the solvent layers combined.

Figure 3 Bottom layer containing dichloromethane

3.4 Separation of Caffeine

The dichloromethane was evaporated from the extract by heating the flask on mantle or by covering with perforated aluminium foil and leave it for some time and allow it to get evaporated and it was recovered in the other beaker using Heat Reflux Extraction method. The residue obtained was whitish powder which was considered to be pure caffeine. The mass of flask with residue was measured on electronic scale.

Figure 4 Caffeine

3.5 Murexide test

Confirmative Test for Caffeine Detection Murexide test can be carried out for caffeine detection as follows:

1. In a watch glass, small amount of a sample with 2-3 drops of concentrated hydrochloric acid is mixed. Use a glass rod for mixing.
2. Then we add a few small crystals of potassium chlorate and mix well.
3. Heat the watch glass until the sample is dry.
4. Allow to cool.
5. Add a drop of ammonium hydroxide solution. The sample should turn purple.

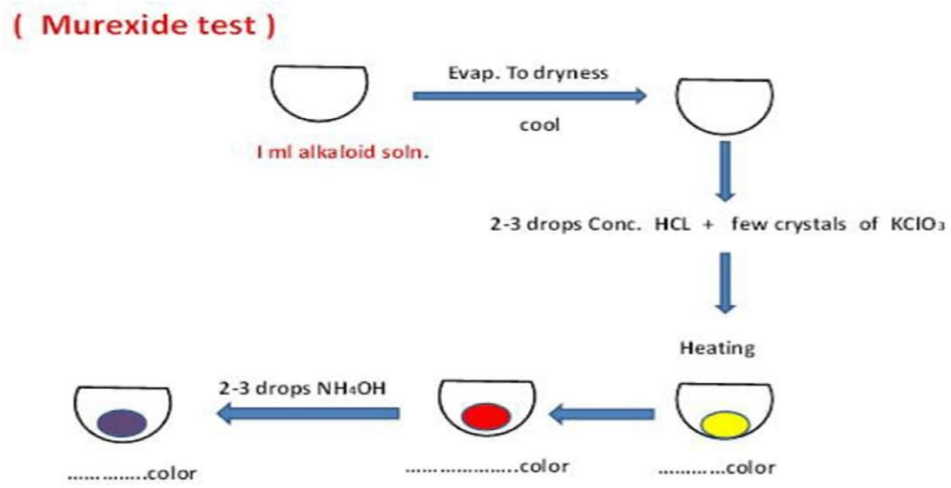

Figure 5 Murexide Test

IV. RESULT & DISCUSSION

Extraction of caffeine from tea and coffee was achieved by using Dichloromethane as an extracting solvent.

S.NO	SAMPLE	AMOUNT OF SAMPLE(g)	AMOUNT OF CAFFEINE EXTRACTED(g)
1	TEA	7	0.226
2	COFFEE	7	0.345

Table 1 Extraction of caffeine from tea and coffee

It was observed that the extraction efficiency of caffeine from various sources by using dichloromethane was much higher than other solvents. Table 6.1 shows the extraction efficiency of crude caffeine from tea and coffee leaves. The amount of caffeine obtained from L- L extraction after further recrystallization was found to be 3.37% from tea and 5.04% from coffee. We observed that coffee contained a high amount of crude caffeine as compared to tea. To purify the crude caffeine, similar procedures were utilized. The pure white crystalline caffeine isolated from sources was found to melt at 238 C.

The Infrared-spectrum of isolated caffeine showed similar absorption bands similar to that given in literature. The Infrared-spectrum indicates the absolute purity of the purified caffeine. We have developed a high-performance liquid chromatography method for the determination of caffeine, which was carried by High Performance Liquid Chromatography instead of using UV- Visible spectrophotometer. We chose High performance liquid chromatography method for the determination of caffeine, because High performance liquid chromatography is the most widely used qualitative and quantitative determination and separation method. This method is popular because it is non-destructive and unlike gas chromatography may be applied to thermally liable compounds. Moreover, it is also a very sensitive technique as it incorporates a wide range of detection methods. With the use of post column derivatization methods to improve selectivity and detection limits, High performance liquid chromatography can easily be extended to trace determination of compounds that do not usually provide adequate detector response.

V. CONCLUSION

A method has been developed for the extraction, purification of caffeine from tea and coffee. Caffeine from tea and coffee was extracted by liquid- liquid extraction followed by recrystallization. The purified caffeine was then analysed by High performance liquid chromatography. Effective characterization of caffeine was achieved by determining IR spectrum, and employing a melting point apparatus and differential scanning calorimeter. The serious concern about potential use of caffeine for pathogenic effects has made it one of the most broadly studied drugs. It provides clinicians with the information they require in order to understand, diagnose and treat the effects of caffeine consumption in their patients.

As stated by 'Barone, J.J. and Roberts, H.R.' in their book 'caffeine consumption' that caffeine is a pharmacological active substance and depending on the dose, can be a mild central nervous system stimulant. It is noted that caffeine is not food but a drug working through nervous system. Excessive amount should be avoided since caffeine consumed in large amounts has adverse health effects. In particular, people suffering from high blood pressure should be advised to avoid use of caffeine containing beverages since caffeine is known to increase the blood pressure. In addition, those with coronary heart disease should avoid such beverages as caffeine disrupts normal heart rhythm.

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