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Adsorption Study of Benzene and Toluene by HPLC Method on Low Cost Material – A Case Study

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ABSTRACT

The newest result in the employment of carbon-based composites in chromatographic techniques such as high-performance liquid chromatography was carried. In the present investigation the adsorption studies of aromatic compounds like benzene and toluene by HPLC method onto the surface of Low Cost Material (LCM) (Kammoni, Nilgiri, Jaswand, Raatrani, Ashoka, Pattakobi, Chana, Palak, Chiku Dalimb and Ambadi) as adsorbent was carried. Adsorption capacity of LCM adsorbent was calculated from its area itself. The results are concisely described and critically evaluated.

Keywords: LCM, adsorbent, HPLC, Benzene, Toluene.

INTRODUCTION

Volatile organic compounds (VOCs) are pollutants of great concern because they are toxic and are known or suspected to be carcinogenic when present at elevated levels in the environment. These major pollutants are released in a large number from industries such as chemical, petrochemical, petroleum refining, and coal conversion. Benzene, toluene and xylene (BTX) are aromatic compounds which are categorized as volatile organic compounds and usually released in large amounts from industries. The sources of these pollutants are normally found from leakage of petrol and diesel fuel from underground storage tanks and man made sources including municipal wastes, petrochemical, industrial, plastics and agricultural effluents [1].These compounds have been designated as priority pollutants by the United States Environmental Protection Agency.

The reduction, if not the elimination, of such pollutants can be achieved through a combination of resource management, product reformulation, process modification and some form of end-of-pipe treatment[2]. Application of traditional methods such as flocculation, sedimentation, filtration, wet oxidation, incineration an activated sludge treatment seems impractical for the low level contaminants of organic compounds[1]. Activated carbon adsorption is an important separation technology, which is widely used, in chemical and environmental engineering. It is a complex material which has a variety of surface groups, impurities and irregularities with the pore sizes ranging from microspores to macrospores that are randomly connected in their pore networks

[3].Activated carbons have been widely employed as adsorbents in decontamination processes due to their high adsorption capacity, fast adsorption kinetics, ease of regeneration, extended surface area, micro

porous structure and special surface reactivity [4,5]. Many types of carbonized raw materials can be activated by means of steam activation or chemical activation[6]. The adsorption capacity of activated carbons depend on various factors such as surface area, pore distribution and surface functional groups of activated carbon, polarity, solubility, pH and concentration of adsorbate and so on [4,5,7].
Many studies have been reported on the adsorption of organic compounds from gas stream. However, very limited studies were reported on the adsorption from aqueous solution. The liquid phase adsorption is a more complicated process than gas or vapor phase adsorption[8]. Therefore, the main aim of the present work was to study the adsorptive capacity of benzene, toluene onto the surface of, Kammoni, Nilgiri, Jaswand, Raatrani, Ashoka, Pattakobi, Chana, Palak, Chikku, and Dalimb by using HPLC for better understanding of the adsorption process.

MATERIALS AND METHODS

Reagents and Materials: All of the reagents used in the present investigation were of analytical grade and procured from Sd Fine chemical Ltd. All glassware was of Pyrex and cleaned with a 20% nitric acid solution.
Sample preparation: 50 mg of sample dissolve in 1.0 ml Benzene and toluene (1:1) mix and finally diluted up to 50ml with methanol.
Chromatographic condition:
HPLC system: Shimadzu Class VP
Column: Water nova –pack (150X4.6) mm, 5µ
Flow: 1.0ml min^{-1}
Column temp: Ambient
Wavelength: 254 nm
Run time: 10 min
Mobile phase:

A) Water
B) Methanol

Mobile phase composition: Water: Methanol (40:60)

Sorption method

The sorbed concentration of the chemicals was calculated by the difference in the Area under curve.

$$R_d = \frac{\text{Area of sample} \times \text{wt. Of std} \times 1.0 \times 50\ (cm^3.g^{-1})}{\text{Area of standard} \times \text{wt. Of sample} \times 50 \times 50}$$

R_d = Distribution coefficient.

$$\% \text{ Sorption} = \frac{100 \times R_d}{R_d + \frac{V}{W}}$$

Where, V = Volume of solution
W = Amount of sample

RESULTS AND DISCUSSION

The volatile aromatic compounds such as benzene, toluene are fuel components commonly found in groundwater contamination. Benzene and Toluene are aromatic hydrocarbons which comprised six-carbon ring structures.
The constituent carbon atoms of the benzene ring do not contain maximum possible number of hydrogen atoms; thus the molecule is unsaturated. In addition, the bonds between the carbon atoms in the benzene ring are neither single nor double but some of hybrid type [9-10]. The basic characteristics of BT

compounds are presented in table 1 while the molecular dimensions of BT compounds are described in table 2 .

Table 1. Physical and chemical characteristics of benzene, toluene.

Compounds	Molecular weight	Boiling point (oC)	Solubility in water (mg/l)	Density (g/ml)	Vapor pressure (kPa)
Benzene	78.11	80.1	1780	0.88	10.00
Toluene	92.10	110.8	515	0.87	2.93

Table 2. Molecular dimensions of benzene and toluene

Compounds	Thickness (mm)	Length (mm)
Benzene	3 x 10-7	6.6 x 10-7
Toluene	3 x 10-7	8.2 x 10-7

Adsorption is a process, which involves the contact of a free aqueous phase with a rigid particulate phase, which has the property to remove or store one or more solutes present in the solution selectively[11]. The process of adsorption involves separation of a substance from one phase accompanied by its accumulation or concentration at the surface of another. The adsorbing phase is the adsorbent and the material concentrated or adsorbed at the surface of that phase is the adsorbate[12]. Separation occurs due to differences in molecular weight, shape or polarity which cause some molecules to be held more strongly on the surface than others or because the pores
are too small to admit the larger molecules[13-15].

Maximum adsorption capacity for benzene shown by Palak may be attributed to the presence of active centers like peaks, corners, pores which helps in accumulation and also the affinity of benzene for the surface of it. Minimum adsorption capacity for benzene shown by Jaswand surface may be attributed to the least affinity of benzene to the surface of it. Similarly maximum adsorption capacity for toluene shown by Ambadi(74.78%) which may be attributed to the affinity of toluene and for making large surface area for adsorption , whereas minimum adsorption capacity shown by Chikku adsorbent which may be attributed to the least affinity shown by toluene to its surface. Results of adsorption of benzene and of toluene onto the surface of LCM are presented in tables 3 and 4 respectively. The adsorption of benzene and toluene onto the surface of LCM was affected by the temperature and agitation time between solid and liquid phase.

Table 3. Adsorption of Benzene onto the surface of LCM

Sr. No	Name of LCM used as an adsorbent.	Area of LCM	% Adsorption
1	Kammoni	6925975	54.33
2	Nilgiri	6751437	64.33
3	Jaswand	6854718	47.45
4	Raatrani	6564493	66.33
5	Ashoka	6637271	58.79
6	Pattakobi	6386505	57.44
7	Chana	6587646	59.55
8	Palak	6975722	69.49
9	Chikku	6158366	68.88
10	Dalimb	6867116	57.46
11	Ambadi	6886055	65.47

Table 4. Adsorption of Toluene onto the surface of LCM

Sr. No	Name of LCM used as an adsorbent	Area of LCM	% Adsorption
1	Kammoni	8944361	60.40
2	Nilgiri	8842219	58.46
3	Jaswand	8974881	59.72
4	Raatrani	8588963	56.87
5	Ashoka	8713294	60.99
6	Pattakobi	8392444	54.63
7	Chana	8737284	56.98
8	Palak	9144217	73.22
9	Chikku	8120950	52.54
10	Dalimb	9064860	71.43
11	Ambadi	9181085	74.78

APPLICATIONS

The present studies are useful for adsorption of aromatic compounds like benzene and toluene by HPLC method onto the surface of Low Cost Materials (LCM) -Kammoni, Nilgiri, Jaswand, Raatrani, Ashoka, Pattakobi, Chana, Palak, Chiku Dalimb and Ambadi as adsorbents.

CONCLUSIONS

In the present study vegetable and fruits material waste were used as LCM adsorbent for the removal of BT (benzene and toluene) by using HPLC method and adsorptive capacity for benzene shown by different LCM are enlisted below as:
Palak > Chikku> Raatrani > Ambadi > Nilgiri > Chana > Ashoka > Dalimb > Pattakobi > Kammoni > Jaswand.
Similarly, adsorptive capacity for toluene shown by different LCM is enlisted below as:
Ambadi > Palak > Dalimb > Ashoka > Kammoni > Jaswand > Nilgiri > Chana > Raatrani > Pattakobi > Chikku.

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