Iranian J. Publ. Health , 1994 , Vol. 23 , Nos. 1-4

EVALUATION OF ACTIVATED CHARCOAL SAMPLER TUBES

P. Nassiri [1], PhD ; F. Golbabaie [1], PhD ; K. Mehrain [1] ; A. Hematian [2]

Key Words: *Charcoal tubes, Solvents, Adsorption capacity, Relative recorery percentage humidity*

Abstract

This study has been conducted to evaluate the effectiveness of the local made charcoal tubes against adsorption of benzene, toluene and xylene vapors.

Results indicate that the desorption capacity and the recovery precentage decrease as the benzene, toluene and xylene concentrations and also relative humidity increase. It is concluded that the water vapor is the major interferent in the adsorption of mentioned vapors when the air is passed through the activated charcoal bed. The experiments show that the local made charcoal tubes are suitable for sampling in the predicted ranges existing in the work place.

Introduction

An essential requirement for the development of tests for the detection and estimation of hazardous gases and vapors which may be present in the atmosphere and also for the calibration of instruments used for this purpose is the provision of accurate standards.

1- Dep. of ocupational Health, School of Public Health, P.O.Box 6446-14155, Tehran, Iran.

2- Dep. of Gas Chromatography, Research Center of Petroleum Industry.

There are two general methods for preparing known concentration of gas mixtures: static and dynamic. Despite their limitations, static methods for the preparation of gas mixtures have the adventage of being relatively simple and provided that only small volumes of the standard are required over short periods of time as in the calibration of single instruments, for example gas chromatographs and gas detector tubes, they can be very useful. One of the most convenient methods of making a gas standard is to introduce a predetermined amount of solvent or gas into a single, rigid container of known volume containing the diluent gas. Vaporisation of solvent may be necessary before dilution. The containers may take many forms from small syringes, bottles and flasks to specially fabricated test chambers and rooms. To ensure that the system is kept at atmospheric pressure it is necessay to provide an inlet for replacement gas when a sample is withdrawn for use. For this reason the size of the vessel must be fairly large, usually about 20-40 litres, if excessive dilution of the standard is to be avoided.(1,2).

The objective of this study was to evaluate the effectiveness of the locally made charcoal tubes via calibration by static method against benzene, toluene and xylene whose performance has been investigated previously (4).

Materials & Methods

In order to calibrate the charcoal tubes a 45.5 litre bottle was used(1), then we predetermined known concentrations of the solvents for exposing the sampler tubes by adding 0.02 ml of each solvents into the above-mentioned container. Some time was spent to evaporate the solvents at laboratory temperature and pressure.

For proper mixing the inside atmosphere of the container, a small fan was applied as a stirrer, (Fig 1). The temperature ranged from 12-21C^0 and since there was not actually any sensible temperature gradient inside the laboratory so there was no need to have a severe thermal insulation.

After complete evaporation of the aromatic solvents, known volums were sampled by water displacement through charcaol tubes. Relatvie humidity in the container was measured by the wet bulb/dry bulb technique and ranged

from 47% to 94% (3).

The sampling period was 5 min and the sampling flow-rate was 20 ml/min.

The desorption was performed by the chemical methods(4). So, the tube contents i.e. sampler and back up layers were separately, transferred to the vials and 0.5 ml carbon disulphide was added to each one. The mixture was shaken and allowed to desorbe for half an hour(4).

Aliquots of the extraction solvent were then analysed using gas chromatography method(GC). The GC instrument was Perkin Elmer 900 and the optimum conditions were obtained by standard solutions in following conditions.

Carrier gas: He
H2 at 20 PSI
N2 Flow rate= 2.3 ml/min
Air pressure= 40PSI
Inject. temp.= 200 C^0
Manifold temp.= 200 C^0
Oven temp.= 80C^0

Detector= FID
Sample size 0.2-0.5 ulit

Column: TCEP, 100m, 0.25 mm
Stainless steel

Results & Discussion

The weight in mg of above-mentioned compounds corresponding to the total peak area are read from the standard curves. No volume corrections are needed, because the standard curve is based on mg/0.5 ml of Carbon disulfide and the volume of sample injected is identical to the volume of the standards injected. Table I, II and III show the known concentrations to which the randomized selected charcoal tubes are exposed, desorption amount from the sampler and back up layer and relative errors for benzene, toluene and xylene, respectively.

Fig 2 shows the mean value of relative error for different ranges of predetermined concentrations of the above-mentioned solvents. As the curves show, the relative error is high in concentrations less than 0.05 mg of the solvents, but they gradually decrease to certain limit (Fig 2).

The results indicate that the recovery percentage for the lowest (0.038 gr) & highest concentrations (> 0.153 gr) of organic vapors are low with high relative errors. These are carried out in constant dry bulb temperature but in different percentages of relative humidities so that the recovery percentage has different values against a constant concentration of solvents, and it decreases as the relative humidity increases over a certain concentration. It is concluded that the humidity interferes with absorption capacity of charcoal.

A complementary effect is that at a sufficiently high concentration of an organic vapor, relative humidity over a certain value cause a reduction in the absorption coefficient of the organic component (5,7) especially for benzene.

The effect of relative humidity on high concentration of toluene and xylene was not as high as its effect on benzene. A significant error was also observed at the lowest concentration which may be due to the less sensitivity of analytical apparatus in detecting low concentratons of benzene, toluene and xylene.

Acknowledgement

The authors would like to acknowledge Miss Maryam Hosseinian for her assistance with experimental procedures.

Sincere thanks are extended to Mr. Afshar for his contributions in preparing the analytical apparatus.

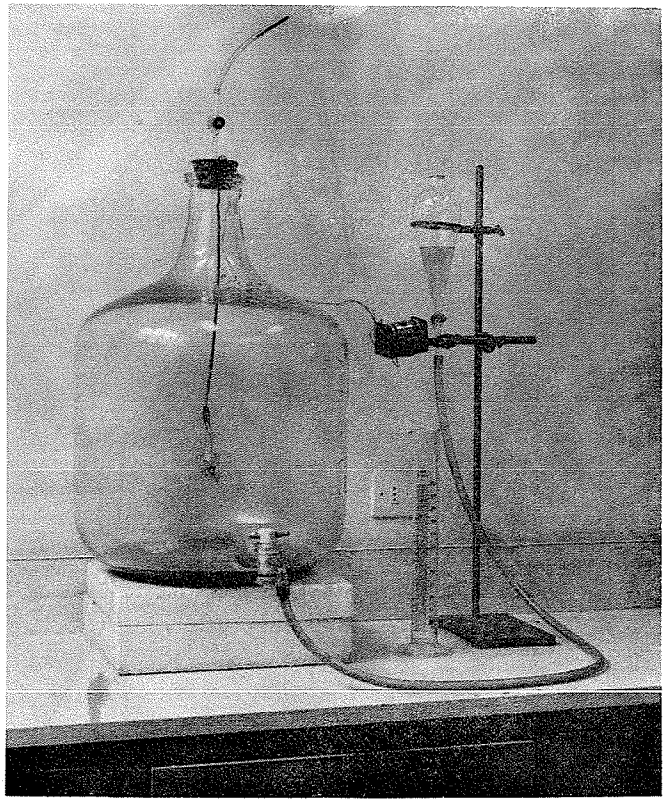

Fig 1- Static assembly for preparation of known concentration of solvents

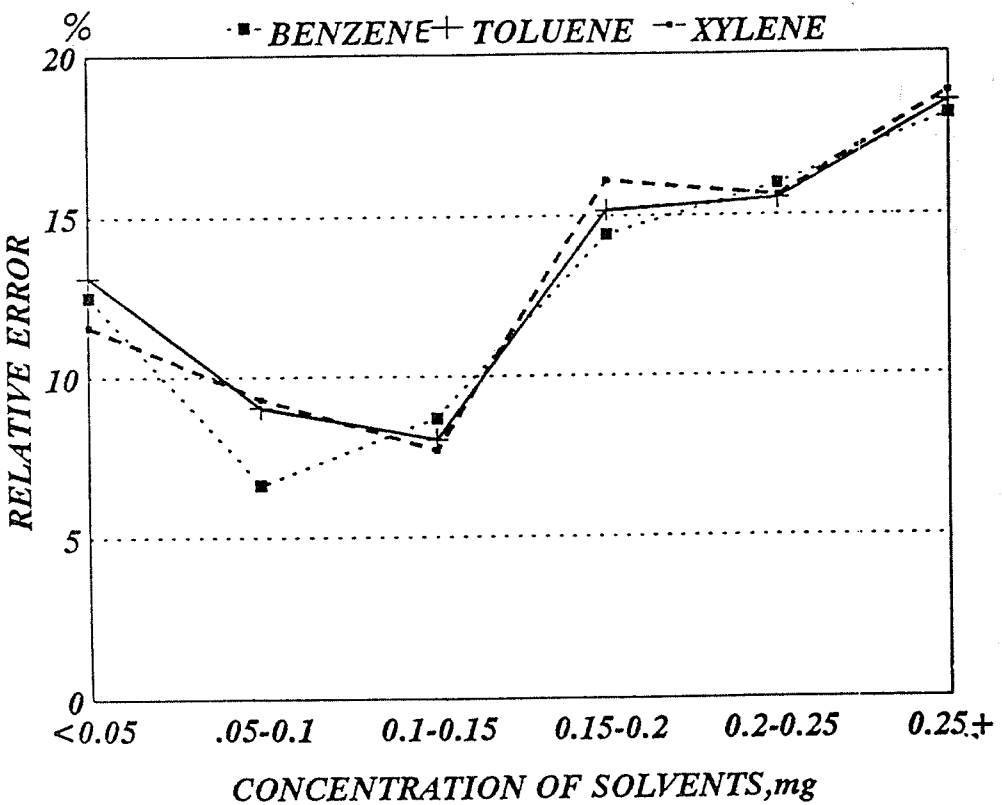

Fig 2- Mean of relative error for different ranges of concentrations of solvents

Table 1- The known Concentration of benzene to which the charcoal tubes are exposed.

Volume of sampled air, cc	Absorbed, mg	Desorbed		Relative Error	Percent Recovery	
		Sample layer	Back up layer		Sample layer	Back up layer
100	0.039	0.034 (0.01224)	0	12.5 (3.18)	87.18 (2.81)	0
150	0.058	0.0534 (O.OOO54)	0	7.92 (0.931)	92.07 (0.84)	0
200	0.077	0.0724 (0.00054)	0	5.98 (0.712)	94.03 (0.64)	0
250	0.097	0.0912 (0.00054)	0	6 (1.095)	94.02 (1.01)	0
300	0.116	0.1076 (0.0029)	0	7.24 (1.86)	92.76 (1.96)	0
350	0.135	0.1212 (0.00164)	0	10.16 (1.15)	89.78 (1.09)	0
400	0.155	0.134 (0.00270)	0	13.52 (1.15)	86.45 (1.58)	0
450	0.174	0.1424 (0.00215)	0	14.1 (1.391)	85.86 (1.24)	0
500	0.193	0.1628 (0.00216)	0	15.6 (1.086)	84.35 (1.0)	0
550	0.213	0.179 (0.00300)	0	15.26 (1.366)	84.04 (1.26)	0
600	0.232	0.1834 (0.00120)	0.0014 (0.00045)	20.24 (0.403)	79.05 (0.44)	0.60 (0.21)
650	0.251	0.1836 (0.00140)	0.0158 (0.00098)	20.54 (0.408)	73.15 (0.54)	6.29 (0.39)

N = 5 ( ) = Standard Deviation

Table 2- The known Concentrations of toluene to which the charcoal tubes are exposed

Volume of sampled air, cc	Absorbed, mg	Desorbed		Relative Error	Percent Recovery	
		Sample layer	Back up layer		Sample layer	Back up layer
100	0.038	0.0336 (0.00054)	0	11.58 (1.48)	88.42 (1.29)	-
150	0.057	0.0508 (0.0011)	0	10.9 (1.91)	89.12 (1.72)	-
200	0.076	0.0688 (O.0011)	0	9.46 (1.42)	90.53 (1.29)	-
250	0.096	0.0888 (0.0011)	0	7.5 (1.095)	92.50 (1.02)	-
300	0.115	0.107 (O.0027)	0	6.94 (2.41)	93.04 (2.13)	-
350	0.134	0.1226 (0.0013)	0	8.46 (1.021)	91.49 (0.90)	-
400	0.153	0.1264 (0.0015)	0	17.36 (1.009)	82.61 (0.89)	-
450	0.172	0.1462 (0.00164)	0	14.98 (0.985)	85.0 (0.86)	-
500	0.191	0.1606 (0.00134)	0	15.9 (0.67)	84.09 (0.63)	-
550	0.210	0.177 (0.00187)	0	15.6 (0.909)	84.29 (0.80)	- (0.70)
600	0.229	0.1784 (0.00196)	0.0016 (0.00049)	21.38 (0.741)	77.91 (0.86)	(0.22)
650	0.249	0.1798 (10.0047)	0.0114 (0.00103)	23.22 (0.531)	72.21 (0.47)	4.58 (.40)

N= 5 ( )= Standard Deviation

Table 3- THe known Concentration of xylene to which the charcoal tubes are exposed.

Volume of sampled air, cc	Absorbed, mg	Desorbed		Relative Error	Percent Recovery	
		Sample layer	Back up layer		Sample layer	Back up layer
100	0.038	0.0268 (0.00054)	0	12.12 (1.48)	87.89 (1.29)	-
150	0.057	0.0508 (0.00109)	0	10.9 (1.917)	89.12 (1.72)	-
200	0.076	0.0694 (0.00054)	0	8.68 (0.712)	91.32 (0.65)	-
250	0.096	0.0888 (0.00109)	0	7.5 (1.095)	92.50 (1.02)	-
300	0.115	0.107 (0.0040)	0	6.98 (0.40)	93.04 (2.13)	-
350	0.134	0.1206 (0.0054)	0	6.98 (0.383)	90.0 (0.37)	-
400	0.153	0.1308 (0.0011)	0	14.48 (0.712)	85.49 (0.64)	-
450	0.172	0.146 (0.00187)	0	15.1 (1.12)	84.84 (0.98)	-
500	0.191	0.16.6 (0.00134)	0	15.9 (0.67)	84.09 (0.63)	-
550	0.210	0.177 (0.0024)	0	15.52 (1.152)	84.47 (1.02)	-
600	0.229	0.1786 (0.00017)	0.0014 (0.00049)	21.46 (0.5389)	77.99 (0.76)	0.62 (0.22)
650	0.249	0.1788 (0.0013)	0.0118 (0.00075)	23.46 (0.48)	71.81 (0.53)	4.74 (0.30)

N = 5 ( )= Standard Deviation

References

1- Cullis, C.F., Firth, J.G., (1981). Detection and Measurement of Hazardous Gases , Heinemann, PP.195.

2- Lich, A.L., (1981). Evaluation of Ambient Air Quality by personnel Monitoring , Vol. I, 2nd Ed., CRC Press, Inc.

3- Mequiston, F.C., Parker, J.D., (1988). " Heating , Ventilating and Air Conditioning , Analysis and Design" John Wiley & Sons , Inc, U.S.A.

4- Nassiri, P., Golbabaei, F., Nasseri, S., Mahmood. , M., Mehrain, K. (1988). Production of Activated Charcoal Sampler Tubes for Sampling Air Contaminats, Iranian J. Publ. Health. Vol. 17, No. 1-4.

5- Peterson, J.E. (1980). Calculation of Vapor penetration in Charcoal Sampling Tubes, Am. Ind. Hyg. Assoc. J., 41(6): pp. 450-451.

6- Underhill, D.W. (1987). Calculation of the Performance of Activated Carbon at High Relative Humidities, Am. Ind. Hyg. Assoc. J., 48(11): pp. 909-913.

7- Wood, G.O. (1987). A Model for Adsorption Capacities of Charcoal Beds, I. Relative Humidity Effects, Am. Ind. Hyg. Assoc. J. 48(7): pp. 622-625.