JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Phase diagram of Three component system A Green Chemistry Approach

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Abstract: Study of ternary system is a usual physical chemistry experiment at the undergraduate and post graduate level. Components involved in studying these kinds of systems, are usually organic solvents. Experiments using large quantity of such organic solvents are carcinogenic and should be avoided. Experiment explained in this paper is a green chemistry approach, using only limited quantity of solvents.

IndexTerms - Three component system, green chemistry. Chemical Education.

I. INTRODUCTION

A phase is defined as a chemically homogeneous and physically distinct part of the system that is separated from other parts by boundaries. All the parts of the systems can be termed as components. We have to have a fixed number of variables to define a system or state of each phase in a system. The phase rule, which is based on thermodynamics, helps us to determine the non-reactive multicomponent heterogeneous or poly phase system to exhibit phase equilibria (1-4). This was proposed by J. W. Gibbs in 1847. Mathematically this can be written as F= C-P+2, where F is the degree of freedom, the number of independent variables required to define the state of the system, C is the number of components and P is the number of phases.

The phase diagram of a three-component system is represented in the form of a triangular graph with each pure component located at the apex of the triangle. The edge opposite to each apex represents a two-component mixture and any point inside the triangle is a three-component system. This paper deals with the study of benzene-water-acetic acid as the three-component system. Benzene and water are soluble only to a lesser extent because of the large difference in their polarity. When acetic acid is added to mixture, it increases the solubility of all three components and finally it forms a single phase due to solvation (5). Amount of benzene used in all these experiments are minimal which is the novelty of this experiment.

2 Experimental:

Extra care was taken handling organic solvents. In one set of experiments 10ml of benzene was taken from the burette into a 50 ml conical flask. To this 0.2 ml water was added from another burette, shaken well and kept in a water bath at room temperature. We can see the turbidity since they do not mix with each other. This solution was titrated with acetic acid taken in another burette. The titration was continued until the turbidity of the solution disappeared and all three components are in the single phase. From the volumes of the three components in the mixture percentage by mass of each component can be calculated knowing the density of each pure component. The experiment was repeated using the same solution and by adding different volumes of water and doing the titration. The experimental values are given in the Table 1. In the second set of experiments add 10 ml of water to the conical flask and different volumes of benzene is added. It was titrated with acetic acid. This will give another set of mass percentage of three components. Using these values, a graph can be plotted as shown in figure 1

3 Results are Discussion:

The mass percentage of the three components are calculated from the table and plotted in the triangular graph shown in the figure. This experiment gives us the full range of data needed for constructing a three-component system graph. The most important advantage of this experiment is that the quantity of organic solvents used is very minimum, thus creating only minimum amount of pollution. Also, the cost of doing the experiment can be considerably reduced. The same procedure can be adopted for doing the chloroform- water-acetic acid mixture.

4 Conclusion:

This is a cost effective and environmentally less hazardous way of performing the experiment which can practiced in any undergraduate and post graduate laboratory.

5 Acknoledgements:

UGC minor project funding (MRP(S)-0592/13-14/KLCA009/UGC-SWRO) and DST-FIST support 2018-23 to the department of chemistry are gratefully acknowledged.

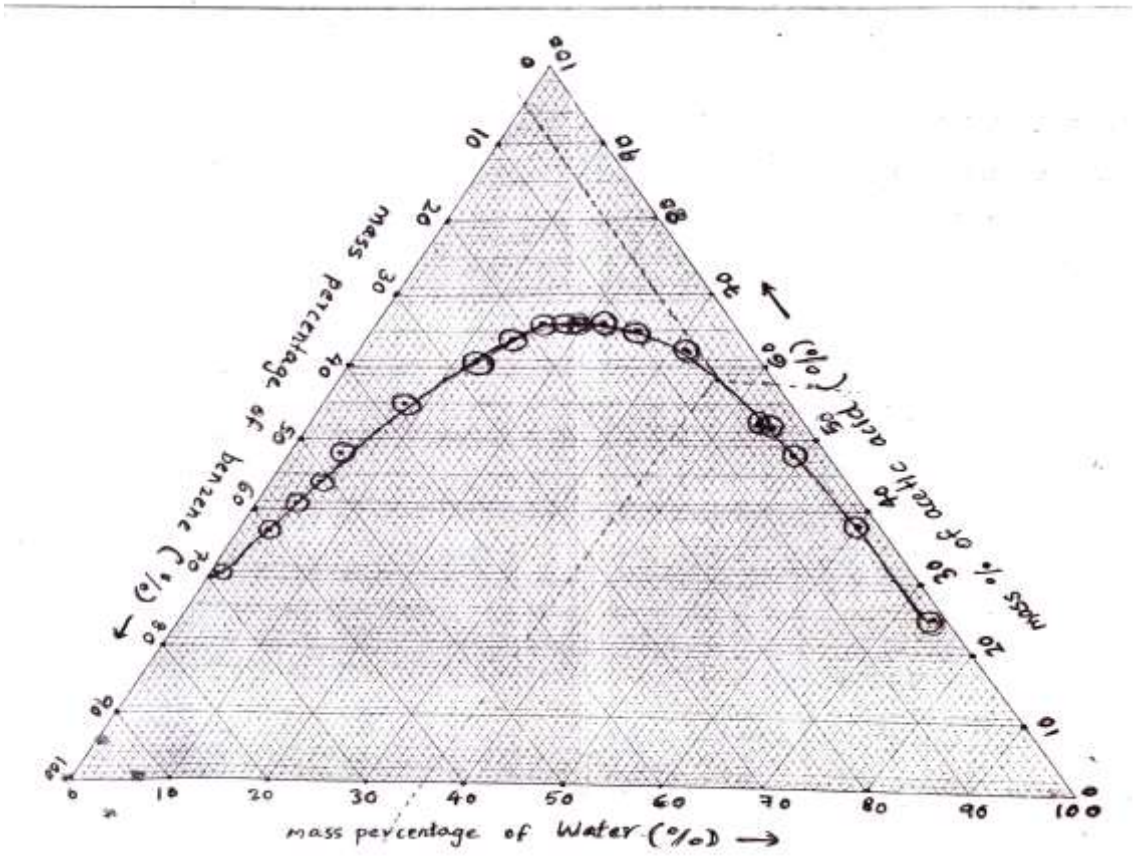

Figure 1: Triangular graph for the benzene-water-acetic acid system at room temperature.

Table 1: Data showing the composition of benzene=-water-acetic acid mixture.

Sl. No.	Volume of C_6H_6 (ml)	Mass of C_6H_6 (g)	Volume of water (ml)	Mass of water (g)	Volume of acetic acid (ml)	Mass of acetic acid (g)	Total mass of mixture (g)	Mass % of C_6H_6 (g)	Mass of % water (g)	Mass % of acetic acid (g)
1	10	8.84	0.2	0.1963	3.8	3.9862	13.0225	67.8825	1.5074	30.6101
2	Volume is the same after the first addition	8.84	0.4	0.3927	5.3	5.5597	14.7924	59.7604	2.6547	37.5848
3		8.84	0.6	0.589	6.3	6.6087	16.0377	55.1201	3.6726	41.2073
4		8.84	0.8	0.7854	7.3	7.6577	17.2831	51.1482	4.5443	44.3074
5		8.84	1	0.9817	8.4	8.8116	18.6333	49.4419	5.2685	47.2895
6		8.84	2	1.9634	12.4	13.0076	23.811	37.1257	8.2488	54.6285
7		8.84	4	3.9268	19.5	20.4555	33.2223	26.6086	11.2458	61.5716
8		8.84	6	5.8902	25.1	26.3299	41.0601	21.5294	14.3453	64.1263
9		8.84	8	7.8536	30.2	31.6798	48.3734	18.2745	16.2354	65.4901
10		8.84	10	9.817	34.6	36.2954	54.9524	16.0866	17.8646	66.0488
11	0.2	0.1768	10	9.817	3.1	3.2519	13.2457	1.3348	74.1146	24.5506
12	0.4	0.3536	Volume is the same after adding 10ml.	9.817	6	6.294	16.4646	2.1476	99.6249	38.2275
13	0.6	0.5304		9.817	9.1	9.5459	19.8933	2.6662	49.3483	47.9855
14	0.8	0.7072		9.817	10.6	11.1194	21.6436	3.2675	45.3575	51.375
15	1	0.884		9.817	11.2	11.9488	22.4498	3.9377	43.7287	52.3336
16	2	1.768		9.817	17.9	18.7371	30.3621	5.823	32.331	61.8438
17	4	3.536		9.817	20.8	24.9662	38.3192	9.2278	25.619	65.1532
18	6	5.304		9.817	28	29.372	44.493	11.921	22.0641	66.0149

19	8	7.072		9.817	31.8	33.3582	50.2472	14.7442	9.5374	66.3882
20	10	8.84		9.817	34.6	36.2954	54.9524	16.0866	17.8646	66.0488

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