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Strategies of Learning Graduate Level Experiments and Its Application for the Removal of Toxic Waste Related To Mutual Solubility of Liquids and Phase Coexistence

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ABSTRACT
This paper describes graduate chemistry practical related to mutual solubility of liquids and phase coexistence. The diversity of the phase transition shows that heating produces mixing and separation. The practical consists of short experiment on the general theme of miscibility of aqueous and organic phases by varying the temperature. The phases were selected as phenol - water and nicotine- water system. The experiment was preceded by the interaction of equal quantities of phenol-water and nicotine-water at room temperature and higher temperature about 80°C. There was a change in miscibility of phases at higher temperature. At about 80°C the phenol-water mixture becomes monophasic while it is heterogeneous at room temperature. The water – phenol phase show limited miscibility below 70 °C. While the nicotine -water phases become heterogenous at higher temperature and at room temperature they were monophasic. The temperature at which these phases were merges is known as clearing temperature or cloud temperature. It lies on the liquid-liquid coexistence line. The experiment required careful observations by students at various temperatures ranges from 20^{o}C to 100^{o}C at the step of 20 ^{0}C and followed by result and discussions. Analysis of the data predicted that students were enjoying by working out the practical and it would be bestowing tremendously beneficial learning experience. The aim of this study was to explore the concept of the phenomenon of phase changes by varying the temperatures and can interpret macroscopic and microscopic properties of the system by relating to the thermodynamic properties. These experiments were beneficial for the isolation and separation of toxic compounds like nicotine and phenol from the waste stream. It is effective and low cost method to save the environment and ecosystem.

Keywords: Miscibility of phases**,** water-phenol, water – nicotine, temperature changes, clearing temperature, macroscopic and microscopic, purification of waste.

1. INTRODUCTION
A review of the chemical education literature indicates that teaching chemistry in a demonstrative way is gaining popularity [1]. Emerging out of the success of the Salters chemistry courses used in pre-university chemistry teaching in the UK ' the university chemistry courses would be design to have more experiments at the introductory level that teach students[2].

Although some of the traditional methods of teaching and learning chemistry do not enables students to ganging many of these skills and not provide academics with evidences so various strategies have been developed to understand the thermodynamics and the concept of phase co-existence by proceeding experiments[3].

The national pretreatment program was established to reduce the level of pollutants discharged by industry into municipal sewer systems and to improve opportunities for the reuse of wastewater and bio solids that are generated. Industrial treatment of phenols and nicotine is typically accomplished through expensive UV oxidation systems or activated carbon. A mutual solubility of liquids and phase coexistence experiments can be employed to reduce the cost of phenol and nicotine treatment and control its level in the effluents by following the EPA standards.

2. HISTORY OF EXPERIMENTS
These experiments were design to reduce the environmental burden by changing the temperature. The experiment was preceded in two sets. A group of two students perform one set of experiment containing phenol-water while the other performs nicotine-water set, along with observations and results. The phase transitions of phenol-water system were observed by changing temperature. The phenol, is also known as carbolic acid and phenic acid, is an organic compound with the chemical formula C_6H_5OH. The molecule consists of phenyl ($-C_6H_5$), which is bonded to a hydroxyl (-OH) group. It produces on a large scale as a precursor to many materials and useful compounds[4]. It was first extracted from coal tar, and its major uses involve its conversion to plastics or related materials. Phenols are used for building polycarbonates, epoxies, bakelite, nylon, detergents and a large collection of drugs, herbicides and pharmaceuticals[5].The major uses of phenol, involves its conversion to plastics or related materials. Phenol is moderately soluble in water; about 8 g of phenol will dissolve in 100 g of water. If try to dissolve more than this, then get two layers of liquid. The top layer is a solution of phenol in water, and the bottom one a solution of water in phenol. The solubility behavior of phenol and water is complicated[6,7]. Similarly nicotine also shows diversity in its behavior by changing the temperature. Nicotine is well-known alkaloid and has high toxicity in its lethal dosage of 30–60 mg causes severe effects[8].

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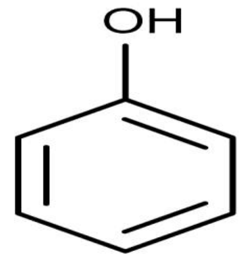

Fig-1: Structure of Phenol

It is an important constituent of tobacco and is highly soluble in cold water, below 61 °C[9], and represents significant water pollution. However, recent studies revealed that this alkaloid might have beneficial effects on neurodegenerative disorders, such as Parkinson's disease and on cognitive functions[10]. Tobacco dust, a waste by-product of the tobacco industry, is a cheap and rich source of nicotine, which can be easily, extracted using only pure cold water as a solvent[11].

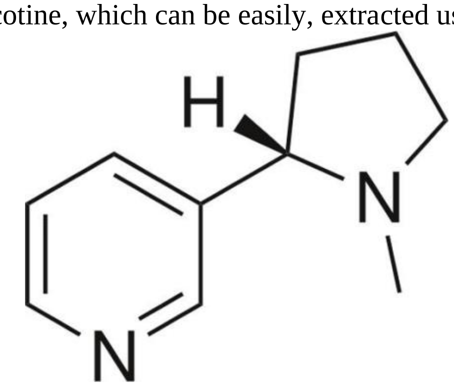

Fig-2: Molecular structure of nicotine

These practical were preceded by considering the toxicity of phenol and nicotine and employing safety measures. Under careful observations and peer discussions which promote the idea of their separation and isolation to reduce the harmful effects of industrial and domestic waste containing such solvents to save our ecosystem and environment and develop learning and deep understanding of thermodynamics.

3. EXPERIMENTAL

3.1*Experiment (Heating produces mixing and separation)*

Students were provided ten sets of sealed tubes – five sets containing roughly equal volumes of phenol/water (set A) which has two phases, and the other five sets contains nicotine/water (set B), which is miscible at room temperature. Students heat the tubes of (set A and B) together in a beaker containing water. By heating the water to its boiling point the mixing and separation of phases were observed. The whole experiment was needed about 30 minutes time to observe drastic changes in phases. Temperatures were varied from 20 -100°C at the step of 20^{o}C.

The first set of A and B was drawn from water bath at 20^{o}C and recorded observations. While the second and other subsequent sets were drawn at the step of 20^{o}C. The phenol-water mixture becomes monophasic at 80^{0}C, while the nicotine-water phase becomes separated. These drastic changes bring the idea of removal of toxic substances by changing the temperature instead of using adsorbents, ion exchangers, catalyst or other separation method. Students were also provided the molecular structure of nicotine and phenol and interpreted macroscopic and microscopic properties thermodynamically[12].The phase transions are shown in Figure-3.

4. RESULT AND DISCUSSION

The experimental observations showed that by the interaction of equal quantities of phenol/water and nicotine/water phases at room temperature and higher temperature about 80°C. There is a change in miscibility of phases at higher temperature. At about 80°C the phenol/water mixture becomes monophasic while it is heterogeneous at room temperature. Liquid water and phenol show limited miscibility below 70 °C. The temperature at which they merge is known as clearing temperature or cloud temperature, and it lies on the liquid-liquid coexistence line[12].Phenol is somewhat soluble in water because of its ability to form hydrogen bonds with the water. The weak acidity of phenol is explained on the basis of the poor resonance effect of the phenate anion in water—DMSO solutions.

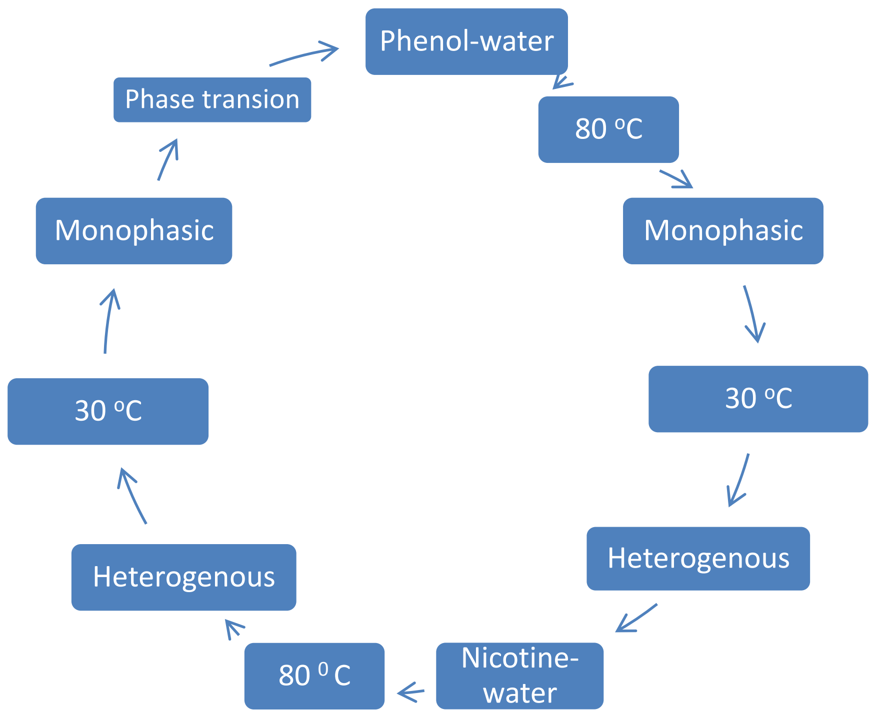

Fig-3: Showing changes in phases at room temperature and higher temperature

While nicotine/water phases become separated when the temperature rises to 80°C.The upper phase of the system brings to the consulate temperature about 210°C. At that temperature the thermal motion prevents the separation into two phases and the nicotine and water become miscible. When the mixture cools then separated into two-phase, thermal motion is no longer capable of preventing phase separation and a water-saturated nicotine- rich phase begins to form and it is in equilibrium with the nicotine-saturated water-rich phase[13].

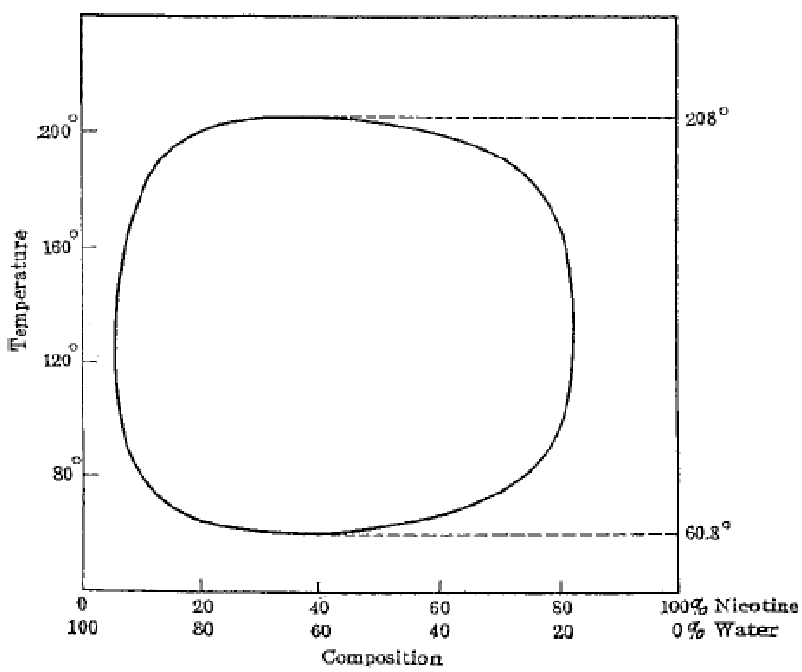

Fig-4: Nicotine-water miscibility gap

Nicotine is third-hand smoke, the residue from tobacco smoke that clings to virtually all surfaces long after a cigarette has been extinguished, reacts with the common indoor air pollutant nitrous acid to produce dangerous carcinogens. This new potential health hazard was revealed in a multi-institutional study led by researchers.

Nicotine is also a major alkaloid of tobacco, from Nico- tinianatabacum: among its famous properties is the closed solubility loop in water, established by Hudson[14]. The version from Glasstone[15] is reproduced in Figure-4. The significant structure theory of liquids has been applied to the partially miscible systems, of which the temperature-composition phase diagrams are of closed loop type.

Famously, nicotine-water has a miscibility gap with both upper and lower consulate temperatures - that is there is a one-phase field above and below the two-phase field.

5. EDUCATIONAL OBJECTIVES

The educational objectives of this experiment are to develop:

5.1 *Theoretical and conceptual knowledge*

Students will learn about the chemical changes which produced by change in temperature. Heating and cooling can induces mixing and separation of solvents. Students will learn how to interpret the results.

5.2 *Scientific and practical skills*

By preceding the experiment students will know the safe handling of chemicals and apparatus. Precession and accuracy of the data can be achieved by obtaining reproducible results so experiment must be repeated and calculate the standard the deviation in the results.

5.3 *Develop thinking skills and generic attributes*

By performing these experiments students will observe various chemical changes and summarizes the observations and interpret the result thermodynamically.

5.4 *Experimental idea about the homogenous and heterogeneous system.*

The theoretical idea of thermodynamic can be explained by experimental observations.

5.5 *Waste minimization*

By employing low cost method the toxic substances can be isolated and remove from waste water and develop strategy to the students how can remove toxic substances[16].

6. CONCLUSION

These experiments would enable the graduate chemistry students to develop their understanding of various aspects of physical chemistry especially thermodynamic, during the early and engaging environment which promotes the students learning about the subject. The concept of waste minimization can be developed and employed on industrial scale. The feedback data from the students show that these experimentsare extremely successful in achieving the objective.

7. REFERENCES

1. Zielinski, T. J., and Schwenz, R. W., Physical Chemistry, *Journal of Chemical Education*, **(2001)**, 78, 1173-1174, http://dx.doi.org/10.1021/ed078p1173.
2. Belta, T., Mathias, J. L., Andrew, J., Hydeb, and Tina, L. O., *Chemistry Education* Research and *Practice*, **(2005)**, 6 (3), 166-179.
3. Azmat, R., Pak. J. Chem. **(2011)**, 1(3): 138-139, http://dx.doi.org/10.15228/2011.v01.i03.p06.
4. Donna, K., Studies in Science Education, Taylor & Francis, **(2012)**, 48(1), 51–87, http://dx.doi.org/10.1080/03057267.2012.655037.
5. Salters Advanced Chemistry, *www.york.ac.uk* **(2012)**.
6. Bahram, H., Ahmad, R. M., RaminMiri, and Mojtaba, S., *Chem. Biol. Drug Des*, **(2010)**, 75: 521-531.
7. Brix, R., Hvidt, S., Carlsen, L., *Chemosphere,* **(2001)**, 44 (4), 759-763, http://dx.doi.org/10.1016/S0045-6535(00)00366-0.
8. Kristine, S., Khachatryan, Svetlana, V., Smirnova Irina, I., Torocheshnikova, E., Natalia, V., Shveden, A., Bio. Anal. Chem **(2005)**, 381, 464–470.
9. Robert, B., *Chemical Educ. Intern.*, **(2005)**, 6(1).
10. Linda, P., Dwoskin, LiHongTeng, Susan, T., Buxton, Alain Ravard, NiranjanDeo, Peter, A., Crooks *European Journal of Pharmacology*: **(1995)**, 276 (1–2), 195–199.

11. Maggio, R., Riva, M., Vaglini, F., Fornai, F., and Racagni, G., *Journal of Neural Transmission*, **(1997)**, 104 (10), 1113-1123, http://dx.doi.org/10.1007/BF01273324.
12. Bailey, P. D., and Garratt, J., Chemical education: theory and practice, University Chemistry *Education*, **(2002)**, 6, 39-57.
13. Jean, F., Le, M., and Rania, E. I. B., *Int. J. of Thermodynaics*, **(2008)**, 11(2), 91-99.
14. Nicola, S. A., Davies, N. E., and Robert, D., Gillard, Transition Metal Chemistry 25, 628-629, Kluwer Academic Publishers. Printed in the Netherlands, **(2000)**.
15. Glasstone, S., Textbook of Physical Chemistry, British re-issue, 2nd. edit., p. 728, Macmillan, London: see also V.B. John **(1951)**.
16. Tahir, H., Jahanzeb, Q., and Sultan, M., Pak. J. Chem. **(2011)**, 1(3) 114-119, http://dx.doi.org/10.15228/2011.v01.i03.p02.