Application of Surfactants in Separation Technology

Cloud Point Extraction of Organic and Inorganic compounds.

Ajay K. Vanjara
Applied Chemistry Division, UDCT

Surfactants are often considered as super molecules due to their widespread applications in almost every scientific and technological field. In surfactants the balance between hydrophobic and hydrophilic groups plays an important role at solid-liquid, liquid-liquid and air-liquid interfaces. This balance is of prime importance in deciding the role of surfactants and the effectiveness of the process[1-4] to which they are employed.

The fields in which surfactants play an important role are separation processes like adsorption, flotation, solvent extraction, liquid membrane separation, separation based on aphron, foams etc.[5]. Separations based on cloud point is an emerging area of research for the separation of organic and inorganic pollutants[6]. The technique has also got widespread analytical applications. Cloud point separation is basically a two phase aqueous - aqueous extraction technique.

Over the years many polymers have been used in two phase systems. One of the most popular aqueous two-phase systems is the one formed by polyethyleneglycol(PEG) and dextran and many other polymers like hydroxypropyl starch, pollen and polyvinyl alcohol have also been used for this purpose due to their low cost[7-8].

Cloud Point Extraction Technique

1) Nonionic surfactants are soluble in water due to hydration of oxyethylene groups present in them. The solution of a nonionic surfactant when gradualy heated to a particular temperature, process of dehydration starts and the nonionic surfactant again re-appears in its original form. This phenomena is called as cloud point. It can be determined by heating or cooling and recording the temperature at which the solution becomes turbid. Cloud point depends on number of factors like concentration of surfactant, addition of inorganic salt like NaCl, pH, HLB etc. The addition of inorganic salt reduces cloud point drastically.

2) In cloud point extraction technique the aqueous solution containing the solute is mixed vigorously in a graduated glass tube and heated slowly at suitable temperature in thermostatic water bath. The temperature at which solution become turbid is recorded as cloud point. After cloud point has been observed the solution is kept at the prescribed temperature which is also called the settling temperature (ST) in a thermostatic bath or an incubator for phase separation[6]. The settling temperature is higher than that of cloud point of surfactant. The lower phase is surfactant rich phase from which the concentration of the solute can be determined by suitable techniques.

Cloud point extraction of organic compounds.

Removal of toxic organic pollutants including phenols, chloro phenols, pesticides, aromatic hydrocarbon, etc.[9-11] from aqueous solutions can be achieved by cloud point extraction. Besides this it also has applications in the removal of biological materials like anti biotics such as ampicillin, amoxycillin etc.[12]. The extraction effectiveness can be related to the binding constant of the solute-micelle, which in turn depends upon substrate by hydrophobicity. The binding constant (KB) of a solute 'S' in the presence of large excess of a surfactant is given by the following equation[6].

$$K_B = [S]_m / [S]_w C_D$$

were the subscript m and w indicate the micellar and aqueous phase respectively and CD is the concentration of the micellized surfactant. According to pseudo phase approach the binding constant is related to the partition coefficient (P) through the equation[13]

$$K_B = (P - V)V'$$

where V' is the partial molar volume of the surfactant. The separation parameters can be independently evaluated using different experimental techniques.

Experimental studies performed by et al. Paramaruro[11] on chlorophenols indicate that there

is a threshold value of binding constant (K_B = 1000M - 1) which ensures quantitative recovery of an analyte in the lower volume of surfactant rich phase. Many toxic pesticides like Lindane, Endrin, DDT, Adrin and phenols and derivatives of phenol have been removed from waste water stream by cloud point extraction technique.

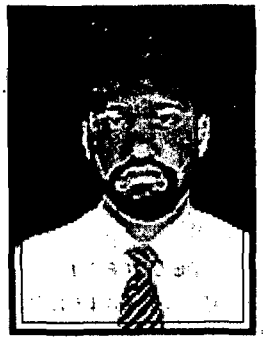
Cloud Point Extraction of Inorganic Compounds:

Extraction of metal ions by cloud point extraction deals with the extraction of metal ions in the form of sparingly water soluble chelate complexes with various ligands such as 1-(2-thioazoyl-azo)-2-naphthol, PAR, SCNC- and several others using nonionic surfactants.

Many nonionic surfactants like Triton X -100, Triton X- 114 and polyoxyethylene compounds can be used for cloud point extraction. The could point can be adjusted by changing pH, addition of salts which can drastically reduce the cloud point and settling temperature to nearly room temperature. The technique has been effectively used for extraction of different metal ions like Zn (III), Ni(II),[14,15] Fe(II),[16] Cd (II), U(IV)[17] etc. In many cases the percentage extraction is comparable to that of conventional separation techniques.

References

1. Surfactants, Th F. Tadros, Eds, Academic Press, New York, 1984
2. Reagents in Mineral Technology, P. Somasundaran and Brij M. Moudgid , Eds, Marcel Dekker Inc. New York, 1987.
3. Surfactants in Chemical/Process Engineering., D.T.Wasan, Martin F. Ginn , D.O. Shan, Eds., Marcel Dekker Inc., New York, 1988.
4. Surfactant Science and Technology, 2nd ed, Drew Myers, Eds., VCH Publishers, New York, 1992.
5. Surfactant Based Separation Processes, JohnF. Schmehorn, Jeffery Harwell, Eds, New York , 1989.
6. E.paramaoro and A. Bianco Prevot , Pure and Applied chemistry, 67, 551, 1995
7. B.N.Aronstern, Y.M..Calvillo and A. Alexander, *Environ. Sci. Technol* ., 25, 1728, 1991.
8. H.F.Koch, J. Shen and D.M. Roundhill, *Sep. Sci. Technol.*, 35, 623, 2000
9. W.L.Hinze, H.N. Sinon, Z.F.Fu, R.Willams, D.J.Kippeberger, M.D.Morris ad F.S.Sadek in ' *Chemical Analysis of Polycyclic Aromatic Compounds*', T. Vo Dinh, Eds, Chp.5,New York, 1989.
10. C.G.Pinto, J.L.P.Pavon and B.M.Cordero, *Anal. Chem.*, 64, 2334, 1992.
11. E. Paramauro, *Ann. Chim.(Romo)* 80, 101, 1990.
12. Cheng-Kang Lee, *Sep. Sci. Technol*, 33, 1003, 1998.
13. I.V.Bere Zin, K. Martinek and A.K. Yatsimirski, *Russ. Chem. Rev (Eng.),* 42, 87, 1973.
14. H. Watanade and H. Tanaka. *Talanta.* 25, 585(1978).
15. H watanade, T Kamidate, S. Kawamorita, K Haraguchi and M. Miyajima. *Anal. Sci.* 3, 433(1987).
16. Pramauro, C. Minero and E. Pelizzeti in: Ordered Media in Chemical Separations. W. L. Hinze and D. W. Armstrong (Eds.). ACS Symp. Ser 342 pp. 152-161. American Chemical Society Washington D. C. (1987).
17. E. F. Laespada, J. L. P. Pavon and B. M. Cordero. *Analyst.* 118, 209(1993).



Dr. Ajay K.Vanjara is a Lecturer in Applied Chemistry division, UDCT, University of Mumbai. He obtained his M.Sc.degree in Inorganic chemistry from Institute of Science, University of Mumbai, in 1992 and Ph.D. in the field of Surface chemistry, under the guidance of Prof.S.G.Dixit, at UDCT, Mumbai. His area of research is adsorption of organic pollutants and surface chemistry.