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Solubilization of 1–butanol and 2–methyl-1-propanol by copper, zinc, silver and cadmium dodecylsulphates

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Abstract

Various organic compounds which are either insoluble or sparingly soluble in water can be brought into their aqueous solutions in the presence of surfactants. The solubilization of alcohols (1-butanol and 2-methyl-1-propanol) in the aqueous solutions of copper, zinc, silver and cadmium dodecylsulphates was studied. Differing quantities of solubilizate were added to these aqueous systems with the help of a microburette with constant shaking. The first excess over the solubilizing point rendered the solutions turbid. The maximum additive concentration, MAC, results were further confirmed by checking their conductivity in presence of varying amounts of solubilizates. The accuracy of MAC data was found to be ±0.01M. The results for maximum additive concentration, MAC suggest that the solubility of l-butanol and 2-methyl-1-propanol in water increases in the presence of transition metal dodecylsulphates i.e. the alcohols are thereby solubilized in presence of surfactant moieties. Micellization further increases the efficacy of solubilization which is found to obey as : Ag(I)DS>Zn(II)DS>Cd(II)DS>Cu(II)DS.

Keywords: Solubilization, Solubilizate, Maximum Additive Concentration (MAC), hydrotropy, co-micellization

Introduction

Solubilization is one of the most important properties of the surface-active agents. The spontaneous dissolving of a normally water insoluble substance with the help of surfactants is termed as the process of solubilization. Various organic compounds which are either insoluble or sparingly soluble in water can be brought into their aqueous solutions in presence of surfactants. Solubilization, however along with some other processes like emulsification and adsorption etc., has a major role to play in cleaning a surface free from dirt.

The phenomenon of solubilization is of great interest from theoretical as well as practical point of view and many aspects thereof were accordingly reviewed (1, 2). Abe and Hayashi etal (3) have observed the similarity between adsorption on activated carbon and solubilization into surfactant micelle. The study (3) suggested that both adsorption and solubilization were found to proceed involving hydrophobic interaction and increasing size of the non-polar aminoacid residue only assisted the processes. Another study on solubilization of alkaline earth metal soaps (4) brought forth that the process followed an order as : Mg > Sr > Ba > Ca. A review (5) however considered various techniques and applications of solubilization involving various aqueous solutions. Hydrotropy and solubilization for C_4–C_{18} alkyltrimethylammonium bromides has however been another useful study (6). Tsuji et al. (7) investigated the influence of surfactants upon solubility and aqueous stability of beta-lactam antibiotics. Varied solubilizing effectiveness of sodium dodecylsulphate complexes with various proteins (8) was probed. Quantitative analysis of interfacial barrier to membrane transport of cholesterol solubilized in a charged micellar system was carried out by research workers (9) in the past. A useful study on enhanced solubilization of immunoreactive proteins from Brugia malayi adult parasites using cetyltrimethylammonium bromide was conducted (10). Krishna and Flanagan (11) however worked on micellar solubilization of a new antimatarial drug, beta-arteether. Puri et al. (12) explored into solubilization of growth hormone and other recombinant proteins from Escherichia Coli inclusion bodies by using a cationic surfactant. Cserhati and Forgacs (13) searched into the binding of aminoacids to the cationic surfactants, cetyltrimethylammonium bromide. Rheological studies on the solubilization by the surfactant SDS of complexes between three acidic polysaccharides and an organic base chloride were carried out (14). Boonchan et al. (15) made a probe into the surfactant-enhanced biodegradation of high molecular weight polycyclic aromatic hydrocarbons by stenotrophomonas maltophilia.

An attempt to modify sparingly water soluble drugs to easily water soluble drugs was made possible by an investigation on crystalline molecular complexes generated between surfactant and various additive compounds (16). Solubilization of gliclazide by aqueous micellar solutions was studied by Alkhamis et al. (17), whereas Saito et al. (18) focussed on solubilization of (+) – limonene by anionic/cationic mixed surfactants system. Liao and Wiedmann (19) studied solubilization of cationic drugs in lung surfactant, whereas Van Eeden et al. (20) had studied solvent and surfactant enhanced stabilization, and degradation of amitraz. Solubilizatoin of n-alkylbenzenes in aggregates of sodium dodecylsulphate and a cationic polymer of high charge density (II) was studied by Lee and Moroi (21) while Paul and Mitra (22) probed into water solubilization capacity of mixed reverse micelles: effects of surfactant component, the nature of oil, and electrolyte concentration. Another significant work on experimental and theoretical investigation of the micellar-assisted solubilization of ibuprofen in aqueous media was however carried out by Stephenson et al. (23). A very useful recent study on effects of electrokinetics and cationic surfactant cetyltrimethylammonium bromide (CTAB) on the hydrocarbon removal and retention from contaminated soils has appeared in the literature (24). Fuangswasdi et.al. (25) undertook a study on the effect of admicellar properties upon adsolubilization: column studies and solute transport. A very recent study (26) on mixed-micelle formation and solubilization behaviour towards polycyclic aromatic hydrocarbon of binary and ternary cationic-nonionic surfactant mixtures has been reported in the literature.

Materials and methods

The aqueous solutions of transition metal dodecylsulphates with requisite varying concentrations were obtained by diluting the stock solution which was prepared by taking the weighed quantity of the compounds in a measuring flask for their dissolution. The solubilization of alcohols (1-butanol and 2-methyl-1-propanol) in aqueous surfactant solution was studied. Differing quantities of solubilizate were added to these aqueous systems with the help of a microburtte with constant shaking. The first excess over the solubilizing point rendered the solutions turbid. The maximum additive concentration, MAC, results were further confirmed by checking their conductivity in presence of varying amounts of solubilizates. The measurements were carried out at a constant temperature 40 ±0.05°C in a thermostat and the accuracy of MAC data was found to be ±0.01M.

Results and discussion

The process of solubilization involves preparation of a thermodynamically stable isotropic solution of a substance normally insoluble or very slightly soluble in a given solvent by the introduction of an additional amphiphilic component or components. Such an eventuality encompasses dilute and concentrated solutions, taking into account whether the solubilizates are polar or not, and includes hydrotropy and co–micellization. Here, the final solution is isotropic and the process is not synonymous with 'dissolve'.

The results (Table-1) for maximum additive concentration, MAC, suggest that the solubility of 1– butanol and 2–methyl–1–propanol in water increases in the presence of surfactant molecules (transition metal dodecylsulphates). It may therefore be concluded that the alcohols are thereby solubilized in presence of surfactant moieties. The nature of MAC vs concentration plots (Fig. 1 and 2) suggest sigmoid curves which is a common scenario for solubility vs. temperature plots for endothermic dissolution. The solubilizing capability (premicellar region) for different surfactants as deduced from these results is found to follow an order as: AgDS > $Zn(DS)_2$ > $Cu(DS)_2$ > $Cd(DS)_2$. However, the efficacy of these compounds for solubilization in post micellar region shows a different trend i.e. AgDS > $Zn(DS)_2$ > $Cd(DS)_2$ > $Cu(DS)_2$.

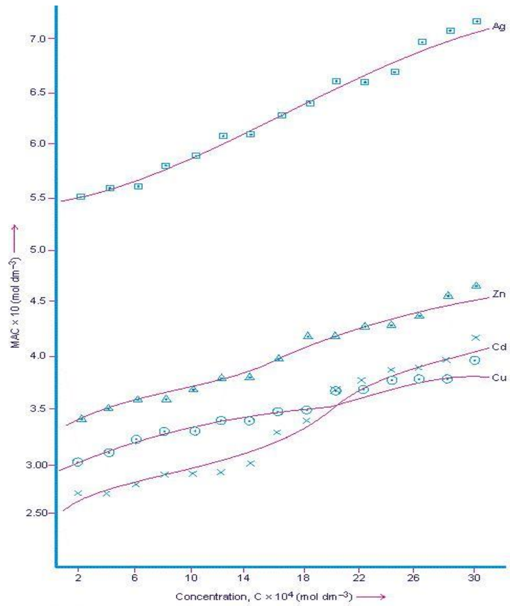

Fig. 1: The Plots of maximum additive Concentration, MAC (mol dm–3) of 1-butanol vs. transition metal dodecylsulphates concentration, C (mol dm^{-3}).

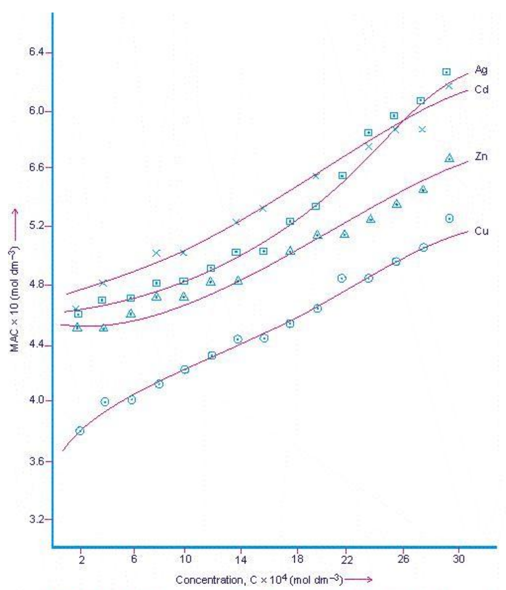

Fig. 2 : The Plots of maximum additive Concentration, MAC of 2methyl-1 propanol (mol dm^{-3}) vs. transition metal dodecylsulphates concentration, C (mol dm^{-3}).

Table 1: Maximum additive concentration (mol dm^{-3}) of 1–butanol and 2–methyl-1–propanol in aqueous transition metal dodecylsulphates at 40°C.

Conc. (mol dm^{-3})	MAC (mol dm^{-3}) of 1–butanol				MAC (mol dm^{-3}) of 2–methyl –1–propanol			
	CuDS	ZnDS	AgDS	CdDS	CuDS	ZnDS	AgDS	CdDS
0.0002	0.30	0.34	0.55	0.27	0.38	0.45	0.46	0.46
0.0004	0.31	0.35	0.56	0.27	0.40	0.45	0.47	0.48
0.0006	0.32	0.36	0.56	0.28	0.40	0.46	0.47	0.48
0.0008	0.33	0.36	0.58	0.29	0.41	0.47	0.48	0.50
0.0010	0.33	0.37	0.59	0.29	0.42	0.47	0.48	0.50
0.0012	0.34	0.38	0.61	0.29	0.43	0.48	0.49	0.51
0.0014	0.34	0.38	0.61	0.30	0.44	0.48	0.50	0.52
0.0016	0.35	0.40	0.63	0.33	0.44	0.49	0.50	0.53
0.0018	0.35	0.42	0.64	0.34	0.45	0.50	0.52	0.53
0.0020	0.37	0.42	0.66	0.37	0.46	0.51	0.53	0.55
0.0022	0.37	0.43	0.66	0.38	0.48	0.51	0.55	0.55
0.0024	0.38	0.43	0.67	0.39	0.48	0.52	0.58	0.57
0.0026	0.38	0.44	0.70	0.39	0.49	0.53	0.59	0.58
0.0028	0.38	0.46	0.71	0.40	0.50	0.54	0.60	0.58
0.0030	0.40	0.47	0.72	0.42	0.52	0.56	0.62	0.61

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