Chapter 6

Overall Conclusion

The versatility of surfactants originates from their amphiphilic character, and the molecules possess both polar, water-soluble sections and non-polar, water-insoluble moieties. Numerous compositional modifications to the aqueous surfactant systems have been carried out to enhance their efficiencies at various fronts. Among them, gemini surfactants with two hydrophilic heads and two hydrophobic groups per molecule separated by a covalently bound spacer chain at the head groups have generated tremendous interest both from technological as well as academic point of view.

Nowadays, some established surfactant classes have been replaced by surfactants that are less toxic. The trend towards more environmentally benign surfactants systems continues. With the aim to develop efficient surfactant systems with multifunctional properties, various conventional, gemini, bio- surfactants are utilized. Various physico-chemical properties are used to determine different aggregation and surface properties. Mixed surfactant systems are having better properties (cmc or cloud point or MSR) over to their constituting components.

The mixing of the two surfactants or surfactant + quaternary salt produces lower cmc than the corresponding individual components. Various theories (Clint, Rubingh and Motomura) are used to treat the cmc data. Synergistic and antagonistic interactions takes place between component of the mixture. The study helped in selecting the samples for CP and solubilization studies.

It is observed that anionic surfactants produces clouding phenomenon in presence of quaternary salt. However, conventional inorganic salts (NaCl, NaBr, KBr etc.), fails to produce clouding phenomenon with anionic surfactants. Cloud point (CP) variation shows it is dependent on nature/alkyl tail of quaternary salt as well as class of the head group present in the surfactant. The mutual dehydration of counterion and head group at micellar surface seems important cause of the appearance of clouding phenomenon in charged surfactants systems. Another important factor for the CP phenomenon, is the presence of alkyl chains (>4 carbon atoms) in a typical quaternary salt which facilitate the connections between two micelles in order to produce hydrophobic aggregates, which come out from the solution at an elevated temperature. The CP of a typical surfactant + quaternary salt system can be tuned to either side by the use of an appropriate additive (sugars, amino acids ascorbic acid). These systems can be useful in cloud point extraction methodologies (CPEM) at the desired temperature (ambient, physiological or higher).

Various surfactant mixtures (conventional, gemini and bile salt) have also been selected on the basis of cmc studies conducted with various combinations. Mixing of surfactants is responsible for increased solubilizing power for PAH solubilization. The order was fluorene > pyrene > anthracene. When CG with polymethylene spacer (CG3) mixed with anionic surfactant/bile salt produces better system for PAH solubilization. However, AG was found better than bile salt, as one of the component of the mixture with CG, in solubilizing the PAH as reflected from the MSR values. However, mixtures with bile salt can be applied to various biological applications where conventional anionic surfactants are undesirable.

In the last it can be said that judicious mixing of surfactant components in aqueous solution can used as a tool to modify various physico-chemical properties like cmc, cloud point (CP), solubilization potential (MSR). Studies should be directed towards in such of more effective greener surfactant mixtures to save our environment from further deterioration.

List of Publications from the Work:

1) **S. K. Yadav**, R. B. Yadav and S. Kumar, Tuning of Cloud Point by the Nature of of Surfactant Headgroup: Infuence of Counterion and Additives, *J. Surfact. Deterg.* 19 (2016) 1063-1069.
2) **S. K. Yadav**, K. Parikh and S. Kumar, Solubilization potentials of single and mixed oppositely charged gemini surfactants: A case of polycyclic aromatic hydrocarbons, *Colloids Surf. A: Physicochem. Eng. Aspects* 514 (2017) 47-55.
3) **S. K. Yadav**, K. Parikh and S. Kumar, Mixed micelle formation of cationic Gemini surfactant with anionic bile salt: a PAH Solubilization study, *Colloids Surf. A: Physicochem. Eng. Aspects* 522 (2017) 105-112.
4) **S. K. Yadav** and S. Kumar, Counterion-specific clouding in aqueous anionic surfactant: a case of Hofmeister-like, *Colloid Polym. Sci.* 5 (295) (2017) 869-876.
5) S. Singh, A. Bhadoria, K. Parikh, **S. K. Yadav**, S. Kumar, V. K. Aswal and S. Kumar, Self Assembly in aqueous oppositely charged Gemini surfactants: a correlation between morphologies and Solubilization efficacy. *J. Phys. Chem*. B, 2017, **Under publication** (JP2017-03989YR1).
6) S. Singh, **S. K. Yadav**, K. Parikh, A. Desai, S. Dixit and S. Kumar, Micellization, Clouding and Solubilization in Mixture of Anionic Gemini Surfactant with tetar-*n*-Pentyl Amonium Bromide, **Manuscript Under Preparation**.

Papers Presented at various Conferences/Symposia/Seminars:

[1] Effect of Biomolecules on the Clouding Behaviour of Sodium DodecylSulfate + tetra-n-pentylammonium Bromide System. **Sanjay Kumar Yadav** and Sanjeev Kumar, Modern Trends in Chemistry (**MTC**) – 2013, 21th-23th March 2015, held at Department of Chemistry, Faculty of Science, The MSU Baroda, Vadodara

[2] Clouding phenomenon in sodium dodecylsulfonate in presence of symmetrical and unsymmetrical Quaternary Halides. **Sanjay Kumar Yadav** and Sanjeev Kumar, National Conference on Recent Trends in Science of Materials (**NCSM**) – 2015, 28th-30th December 2015, held at Department of Chemistry, Faculty of Science, The MSU Baroda, Vadodara

[3] Solubilization capabilities of mixtures of cationic Gemini surfactant with anionic sodium cholate towards polycyclic aromatic hydrocarbons: Influence of chain length and spacer. **Sanjay Kumar Yadav** and Sanjeev Kumar, Recent Scenario in Science and Technology (**RSST**) – 2016, 27th February 2016, held at Applied Chemistry Department, Faculty of Tech. & Engg The MSU Baroda, Vadodara.

[4] Micellar Solubilization of Polycyclic Aromatic Hydrocarbons in the Mixture of Cationic Gemini surfactant with Sodium Deoxycholate: Chain length and Spacer effect. **Sanjay Kumar Yadav** and Sanjeev Kumar, Frontier Areas in Chemical Sciences (**FACS**) – 2016, 19th March 2016, held at Department of Chemistry, Faculty of Science, The MSU Baroda, Vadodara.