

## Chapter 4. Conclusions

---

### CONCLUSIONS

From the variation in amount of co-surfactants study it has been found that amount of water consumed with [60]fullerene is more in case of both the non ionic surfactants Tween 80 and Triton X 100 than without [60] fullerene. While in case of ionic surfactants SDS and CTAB amount of water consumed does not differ with [60]fullerene than without [60]fullerene in the system. The increase in amount of co-surfactants shows more water consumption gradually. It was also found that as co-surfactant is changed from 1-propanol to 1-octanol, water consumption decreases. Thus as the polar nature of co-surfactant reduces i.e. carbon chain increases the water required for the formation of the emulsion is decreased.

To understand the behavior of [60] fullerene in microemulsion system phase diagrams were plotted. Triangular phase diagrams illustrated that monophasic region i.e. microemulsion area increases in presence of [60]fullerene in case of cosurfactants 1-alkanols (n=3,4 and 5) than in absence of [60]fullerene. While monophasic region decreases i.e. microemulsion area decreases in presence of [60]fullerene in case of cosurfactants 1-alkanols (n=6 and 8) than in absence of [60] fullerene, Triton X 100, SDS and CTAB. TW-80 showed variation in the microemulsion area. It is also to be noted that for the microemulsion systems, as cosurfactant is changed from 1-propanol to 1-octanol the microemulsion region increases gradually in presence as well as in absence of [60]fullerene using Tween 80, Triton X100, SDS and CTAB surfactants at room temperature i.e. at 30<sup>0</sup>C. Use of co-surfactants builds the microemulsion system stable for a long period of time.

As carbon chain increases the microemulsion area decreases in presence of [60]fullerene than without [60]fullerene. These results support the solubility trends of [60]fullerene based on molar volumes. It has been shown that higher alcohols dissolve [60]fullerene better than lower alcohols i.e the solubility of [60]fullerene is better in higher alcohols than in lower alcohols. The basis for this increased solubility has been explained due to the molar volume ratios of the [60]fullerene and the alcohol. Since fullerene is more soluble in hexanol and octanol, the microemulsion region decreases.

## Chapter 4. Conclusions

---

**Table 4.1 Phase region of Emulsion and Microemulsion for Tween 80/[60] fullerene-toluene /Water/1-alkanol system**

Co-surfactants	Without C <sub>60</sub>		With C <sub>60</sub>	
	E region (%)	μE region (%)	E region (%)	μE region (%)
<b>1-Propanol</b>	16.89	83.11	23.69	76.31
<b>1-Butanol</b>	17.82	82.18	18.32	81.68
<b>1-Pentanol</b>	4.12	81.68	3.03	96.97
<b>1-Hexanol</b>	2.27	97.73	2.86	97.14
<b>1-Octanol</b>	2.02	97.98	2.69	97.31

**Table 4.2 Phase region of Emulsion and Microemulsion for Triton X 100/[60] fullerene-toluene /Water/1-alkanol system**

Co-surfactants	Without C <sub>60</sub>		With C <sub>60</sub>	
	E region (%)	μE region (%)	E region (%)	μE region (%)
<b>1-Propanol</b>	25.30	74.70	24.45	75.55
<b>1-Butanol</b>	13.28	86.72	12.27	87.73
<b>1-Pentanol</b>	4.62	95.38	4.79	95.21
<b>1-Hexanol</b>	3.19	96.81	4.54	95.46
<b>1-Octanol</b>	1.26	98.75	1.93	98.07

## Chapter 4. Conclusions

**Table 4.3 Phase region of Emulsion and Microemulsion for SDS/ [60] fullerene-toluene /Water/1-alkanol system**

Co-surfactants	Without C <sub>60</sub>		With C <sub>60</sub>	
	E region (%)	μE region (%)	E region (%)	μE region (%)
<b>1-Propanol</b>	33.19	66.81	26.97	73.03
<b>1-Butanol</b>	16.97	83.03	12.77	87.23
<b>1-Pentanol</b>	4.54	95.46	4.12	95.88
<b>1-Hexanol</b>	2.69	97.31	3.61	96.39
<b>1-Octanol</b>	1.34	98.66	1.51	98.49

**Table 4.4 Phase region of Emulsion and Microemulsion for CTAB/[60] fullerene-toluene /Water/1-alkanol system**

Co-surfactants	Without C <sub>60</sub>		With C <sub>60</sub>	
	E region (%)	μE region (%)	E region (%)	μE region (%)
<b>1-Propanol</b>	24.29	75.71	21.26	78.74
<b>1-Butanol</b>	8.82	91.18	8.66	91.34
<b>1-Pentanol</b>	2.69	97.31	3.61	96.39
<b>1-Hexanol</b>	3.11	96.89	3.19	96.81

Area under the curve as well as upper area of the curve was calculated using digital planimeter (Koizumi, PLA COM, KP-90) with accuracy of  $\pm 0.2\%$ . As observed from the results obtained by UV-VIS spectroscopy, [60]fullerene forms reverse micelle with structurally different non ionic surfactants like Tween 80 and Triton X 100. Absorbance of surfactant solution with [60] fullerene in toluene is lower than that of pure [60]fullerene in Toluene in all the four systems.

## Chapter 4. Conclusions

---

Break point in the spectra gives the value for critical reverse micelle,  $C_{rmc}$ , for that particular surfactant. By considering the value of  $C_{rmc}$ , thermodynamic properties like standard free energy, enthalpy and entropy of reverse micelle were calculated. The values for  $\Delta G^\circ$ ,  $\Delta H^\circ$  and  $\Delta S^\circ$  for Tween 80, Triton X 100, SDS and CTAB are found to be negative at 30°C and 40°C. It indicates the spontaneous and exothermic formation of a reverse micelle. Entropy values found to be increasing due to significant decrease in enthalpic interactions for the surfactants Tween-80, Triton X 100, SDS and CTAB in [60]fullerene-Toluene solution at higher temperature that is at 40°C than at 30°C.

From the fluorescence spectroscopy results, it shows that [60]fullerene-toluene solution gives peak at 700nm at room temperature which is in agreement of previous results given by Kim et al<sup>183</sup> and Y Zhao et al<sup>184</sup>. It can be observed from the spectra that as nature of cosurfactants changes to more polar i.e. from 1-octanol to 1-propanol intensity of peaks decreases.

Using cosurfactants, strong and very well resolved fine spectra were observed due to strong interactions with [60]fullerene molecules and strong solute-solvent interactions between [60]fullerene-toluene-surfactant solution.