3.1. Effect of change in concentration of solvent in phase transition of microemulsion to emulsion

Phase transition from clear to turbid solution i.e. microemulsion to emulsion with Tween-80 by using varying the amount of 1-propanol as co-surfactant with and without C_{60} at 30ºC ± 2ºC in water bath was measured. It was observed that as there is an increase in the amount of co-surfactant or decrease in amount of solvent (oil phase-toluene) in the system more amount of water is required for the formation of stable emulsion. In this phase transition variation in the amount of water consumed was measured by titrating water with a fixed quantity of oil component i.e. toluene and surfactant (Tween 80) with [60] fullerene and without [60] fullerene at 30^{0}C in water-bath. As co-surfactant is changed from 1-propanol to 1-octanol water consumption decreased. 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.

All the observations to study the effect of variation of co-surfactants (1-propanol, 1-butanol, 1-pentanol,1-hexanol and 1-octanol on the nature of solution using non ionic surfactant Tween 80 with and without [60] fullerene are summarized in Table 3.1.a.(1 to 10), using non ionic surfactant Triton X 100 with and without [60] fullerene are summarized in Table 3.1.b.(1 to 10) , using anionic surfactant SDS with and without [60] fullerene are summarized in Table 3.1.c.(1 to 10) and using cationic surfactant CTAB with and without [60] fullerene are summarized in Table 3.1.d.(1 to 10) .

Figure 3.1.a.1 & 3.1.a.2, 3.1.b.1 & 3.1.b.2, 3.1.c.1 & 3.1.c. 2 and 3.1.d.1. & 3.1.d.2 represents the effect of the change in ratio of (toluene/co-surfactants) on the water required during the formation of emulsion in the system with and without [60] fullerene respectively for all four surfactants.

3.1.a. Phase Transition of microemulsion to emulsion with Tween 80 surfactant:

Table 3.1.(a).1. Effect of variation of amount of co-surfactant 1-propanol on the nature of solution using Tween 80 without [60]fullerene*

Toluene (Oil) (ml)	Tween 80 (Surfactant) (ml)	1-Propanol (co-surfactant) (ml)	Distilled water (ml)	Solution Clear to
5.0	0.05	1. 0	0.03	Turbid
5.0	0.05	2.0	0.06	Turbid
5.0	0.05	3.0	0.09	Turbid
5.0	0.05	4.0	0.11	Turbid
5.0	0.05	5.0	0.21	Turbid

Table 3.1.(a).2. Effect of variation of amount of co-surfactant 1-propanol on the nature of solution using Tween 80 with [60] fullerene*

Toluene + C_{60} (Oil) (ml)	Tween 80 (Surfactant) (ml)	1-Propanol (co-surfactant) (ml)	Distilled water (ml)	Solution Clear to
5.0	0.05	1.0	0.03	Turbid
5.0	0.05	2.0	0.07	Turbid
5.0	0.05	3.0	0.10	Turbid
5.0	0.05	4.0	0.14	Turbid
5.0	0.05	5.0	0.23	Turbid

Table 3.1.(a).3. Effect of variation of amount of co-surfactant 1-butanol on the nature of solution using Tween 80 without [60] fullerene*

Toluene (Oil) (ml)	Tween 80 (Surfactant) (ml)	1-Butanol (Co-surfactant) (ml)	Distilled water (ml)	Solution Clear to
5.0	0.05	1.0	0.03	Turbid
5.0	0.05	2.0	0.06	Turbid
5.0	0.05	3.0	0.09	Turbid
5.0	0.05	4.0	0.14	Turbid
5.0	0.05	5.0	0.20	Turbid

Table 3.1.(a).4. Effect of variation of amount of co-surfactant 1-butanol on the nature of solution using Tween 80 with [60] fullerene*

Toluene + C_{60} (Oil) (ml)	Tween 80 (Surfactant) (ml)	1-Butanol (co-surfactant) (ml)	Distilled water (ml)	Solution Clear to
5.0	0.05	1.0	0.03	Turbid
5.0	0.05	2.0	0.06	Turbid
5.0	0.05	3.0	0.10	Turbid
5.0	0.05	4.0	0.14	Turbid
5.0	0.05	5.0	0.17	Turbid

Table 3.1.(a).5. Effect of variation of amount of co-surfactant 1-pentanol on the nature of solution using Tween 80 without [60] fullerene*

Toluene (Oil) (ml)	Tween 80 (Surfactant) (ml)	1-Pentanol (co-surfactant) (ml)	Distilled water (ml)	Solution Clear to
5.0	0.05	1.0	0.02	Turbid
5.0	0.05	2.0	0.05	Turbid
5.0	0.05	3.0	0.09	Turbid
5.0	0.05	4.0	0.11	Turbid
5.0	0.05	5.0	0.15	Turbid

Table 3.1.(a).6. Effect of variation of amount of co-surfactant 1-pentanol on the nature of solution using Tween 80 with [60] fullerene*

Toluene+C_{60} (Oil) (ml)	Tween 80 (Surfactant) (ml)	1-Pentanol (co-surfactant) (ml)	Distilled Water (ml)	Solution Clear to
5.0	0.05	1.0	0.02	Turbid
5.0	0.05	2.0	0.04	Turbid
5.0	0.05	3.0	0.05	Turbid
5.0	0.05	4.0	0.07	Turbid
5.0	0.05	5.0	0.10	Turbid

***Temperature: 30º±2ºC**

Table 3.1.(a).7. Effect of variation of amount of co-surfactant 1-hexanol on the nature of solution using Tween 80 without [60] fullerene*

Toluene (Oil) (ml)	Tween 80 (Surfactant) (ml)	1-Hexanol (co-surfactant) (ml)	Distilled water (ml)	Solution Clear to
5.0	0.05	1.0	0.03	Turbid
5.0	0.05	2.0	0.05	Turbid
5.0	0.05	3.0	0.07	Turbid
5.0	0.05	4.0	0.09	Turbid
5.0	0.05	5.0	0.12	Turbid

Table 3.1.(a).8. Effect of variation of amount of co-surfactant 1-hexanol on the nature of solution using Tween 80 with [60] fullerene*

Toluene+C_{60} (Oil) (ml)	Tween 80 (Surfactant) (ml)	1-Hexanol (co-surfactant) (ml)	Distilled water (ml)	Solution Clear to
5.0	0.05	1.0	0.02	Turbid
5.0	0.05	2.0	0.03	Turbid
5.0	0.05	3.0	0.05	Turbid
5.0	0.05	4.0	0.07	Turbid
5.0	0.05	5.0	0.08	Turbid

Table 3.1.(a).9. Effect of variation of amount of co-surfactant 1-octanol on the nature of solution using Tween 80 without [60] fullerene*

Toluene (Oil) (ml)	Tween 80 (Surfactant) (ml)	1-Octanol (co-surfactant) (ml)	Distilled water (ml)	Solution Clear to
5.0	0.05	1.0	0.02	Turbid
5.0	0.05	2.0	0.04	Turbid
5.0	0.05	3.0	0.06	Turbid
5.0	0.05	4.0	0.07	Turbid
5.0	0.05	5.0	0.08	Turbid

***Temperature: 30°±2°C**

Table 3.1.(a).10. Effect of variation of amount of co-surfactant 1-octanol on the nature of solution using Tween 80 with [60] fullerene*

Toluene+C_{60} (Oil) (ml)	**Tween 80 (Surfactant) (ml)**	**1-Octanol (co-surfactant) (ml)**	**Distilled water (ml)**	**Solution Clear to**
5.0	0.05	1.0	0.01	Turbid
5.0	0.05	2.0	0.04	Turbid
5.0	0.05	3.0	0.06	Turbid
5.0	0.05	4.0	0.08	Turbid
5.0	0.05	5.0	0.10	Turbid

***Temperature: 30º±2ºC**

Figure 3.1.a.1 and 3.1.a.2 show the effect of the change in ratio of (toluene/co-surfactant) on the water required during the formation of emulsion in the system.

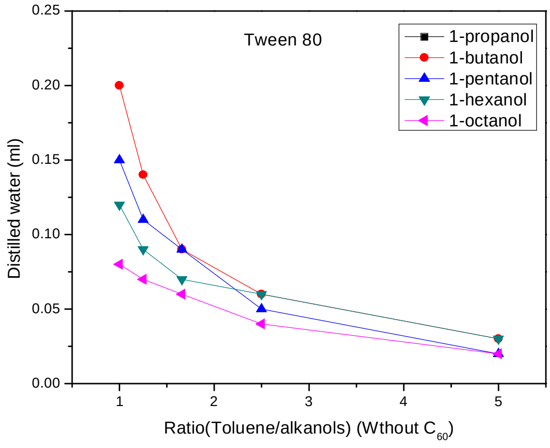


Figure 3.1.(a).1. Plot of amount of water required versus ratio (toluene/1-alkanol) using Tween 80 without [60] fullerene*

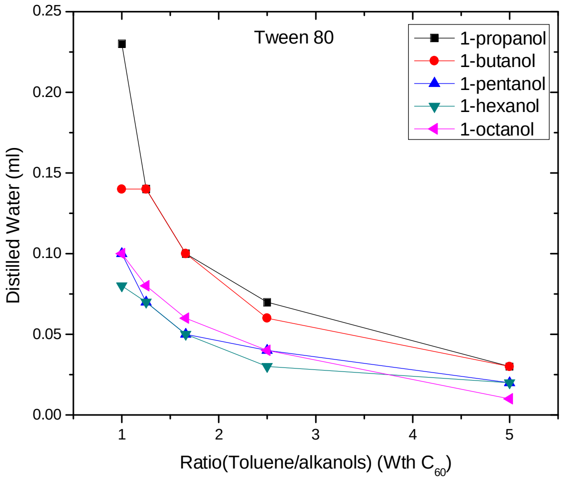


Figure 3.1.(a).2. Plot of amount of water required versus ratio (toluene/1-alkanol) using Tween 80 with [60] fullerene*

As co-surfactant 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. As well as it is also observed that more amount of water is required by the addition of more amount of co-surfactants using Tween 80 as surfactant. More amount of water is required for the formation of emulsion with [60] fullerene i.e. 0.23 ml than without fullerene i.e 0.20 ml using 1-propanol as co-surfactant in this system. ***Temperature: 30º±2ºC**

3.1. b. Phase Transition of microemulsion to emulsion with Triton X 100 surfactant

Phase transition from clear to turbid solution i.e. Microemulsion to Emulsion with Triton X -100 by using varying the amount of co-surfactants with and without C_{60} at 30ºC ± 2ºC in water bath was measured.

Table 3.1.(b).1. Effect of variation of amount of co-surfactant 1-propanol on the nature of solution using Triton X-100 without [60] fullerene*

Toluene (Oil) (ml)	Triton X-100 (Surfactant) (ml)	1-Propanol (co-surfactant) (ml)	Distilled water (ml)	Solution Clear to
5.0	1.0	1.0	0.03	Turbid
5.0	1.0	2.0	0.06	Turbid
5.0	1.0	3.0	0.09	Turbid
5.0	1.0	4.0	0.14	Turbid
5.0	1.0	5.0	0.2	Turbid

Table 3.1.(b).2. Effect of variation of amount of co-surfactant 1-propanol on the nature of solution using Triton X -100 with [60] fullerene*

Toluene+C_{60} (Oil) (ml)	Triton X-100 (Surfactant) (ml)	1-Propanol (co-surfactant) (ml)	Distilled water (ml)	Solution Clear to
5.0	1.0	1.0	0.03	Turbid
5.0	1.0	2.0	0.06	Turbid
5.0	1.0	3.0	0.11	Turbid
5.0	1.0	4.0	0.17	Turbid
5.0	1.0	5.0	0.22	Turbid

Table 3.1.(b).3. Effect of variation of amount of co-surfactant 1-butanol on the nature of solution using Triton X -100 without [60] fullerene*

Toluene (Oil) (ml)	Triton X-100 (Surfactant) (ml)	1-Butanol (co-surfactant) (ml)	Distilled water (ml)	Solution Clear to
5.0	1.0	1.0	0.06	Turbid
5.0	1.0	2.0	0.11	Turbid
5.0	1.0	3.0	0.15	Turbid
5.0	1.0	4.0	0.19	Turbid
5.0	1.0	5.0	0.21	Turbid

***Temperature: 30º±2ºC**

Table 3.1.(b).4. Effect of variation of amount of co-surfactant 1-butanol on the nature of solution using Triton X -100 with [60] fullerene*

Toluene+C_{60} (Oil) (ml)	**Triton X-100 (Surfactant) (ml)**	**1-butanol (co-surfactant) (ml)**	**Distilled water (ml)**	**Solution Clear to**
5.0	1.0	1.0	0.04	Turbid
5.0	1.0	2.0	0.06	Turbid
5.0	1.0	3.0	0.1	Turbid
5.0	1.0	4.0	0.13	Turbid
5.0	1.0	5.0	0.17	Turbid

Table 3.1.(b).5. Effect of variation of amount of co-surfactant 1-pentanol on the nature of solution using Triton X -100 without [60] fullerene*

Toluene (Oil) (ml)	**Triton X-100 (Surfactant) (ml)**	**1-Pentanol (co-surfactant) (ml)**	**Distilled water (ml)**	**Solution Clear to**
5.0	1.0	1.0	0.04	Turbid
5.0	1.0	2.0	0.06	Turbid
5.0	1.0	3.0	0.09	Turbid
5.0	1.0	4.0	0.09	Turbid
5.0	1.0	5.0	0.11	Turbid

Table 3.1.(b).6. Effect of variation of amount of co-surfactant 1-pentanol on the nature of solution using Triton X-100 with [60] fullerene*

Toluene+C_{60} (Oil) (ml)	**Triton X-100 (Surfactant) (ml)**	**1-Pentanol (co-surfactant) (ml)**	**Distilled Water (ml)**	**Solution Clear to**
5.0	1.0	1.0	0.04	Turbid
5.0	1.0	2.0	0.05	Turbid
5.0	1.0	3.0	0.08	Turbid
5.0	1.0	4.0	0.09	Turbid
5.0	1.0	5.0	0.1	Turbid

***Temperature: 30º±2ºC**

Table 3.1.(b).7. Effect of variation of amount of co-surfactant 1-hexanol on the nature of solution using TritonX-100 without [60] fullerene*

Toluene (Oil) (ml)	Triton X-100 (Surfactant) (ml)	1-Hexanol (co-surfactant) (ml)	Distilled water (ml)	Solution Clear to
5.0	1.0	1.0	0.04	Turbid
5.0	1.0	2.0	0.05	Turbid
5.0	1.0	3.0	0.07	Turbid
5.0	1.0	4.0	0.1	Turbid
5.0	1.0	5.0	0.11	Turbid

Table 3.1.(b).8. Effect of variation of amount of co-surfactant 1-hexanol on the nature of solution using Triton X -100 with [60] fullerene*

Toluene+C_{60} (Oil) (ml)	Triton X-100 (Surfactant) (ml)	1-Hexanol (co-surfactant) (ml)	Distilled water (ml)	Solution Clear to
5.0	1.0	1.0	0.03	Turbid
5.0	1.0	2.0	0.06	Turbid
5.0	1.0	3.0	0.07	Turbid
5.0	1.0	4.0	0.07	Turbid
5.0	1.0	5.0	0.07	Turbid

Table 3.1.(b).9. Effect of variation of amount of co-surfactant 1-octanol on the nature of solution using Triton X -100 without [60] fullerene*

Toluene (Oil) (ml)	Triton X-100 (Surfactant) (ml)	1-Octanol (co-surfactant) (ml)	Distilled water (ml)	Solution Clear to
5.0	1.0	1.0	0.04	Turbid
5.0	1.0	2.0	0.06	Turbid
5.0	1.0	3.0	0.07	Turbid
5.0	1.0	4.0	0.07	Turbid
5.0	1.0	5.0	0.09	Turbid

***Temperature: 30º±2ºC**

Table 3.1.(b).10. Effect of variation of amount of co-surfactant 1-octanol on the nature of solution using Triton X -100 with [60] fullerene*

Toluene+C_{60} (Oil) (ml)	**Triton X-100 (Surfactant) (ml)**	**1-Octanol (co-surfactant) (ml)**	**Distilled water (ml)**	**Solution Clear to**
5.0	1.0	1.0	0.03	Turbid
5.0	1.0	2.0	0.03	Turbid
5.0	1.0	3.0	0.04	Turbid
5.0	1.0	4.0	0.06	Turbid
5.0	1.0	5.0	0.06	Turbid

***Temperature: 30º±2ºC**

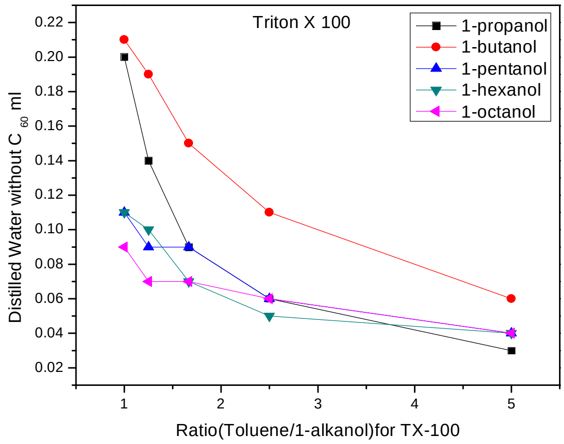


Figure 3.1.(b).1. Plot of amount of Water required versus ratio (Toluene/1-alkanol) using Triton X 100 without [60] fullerene*

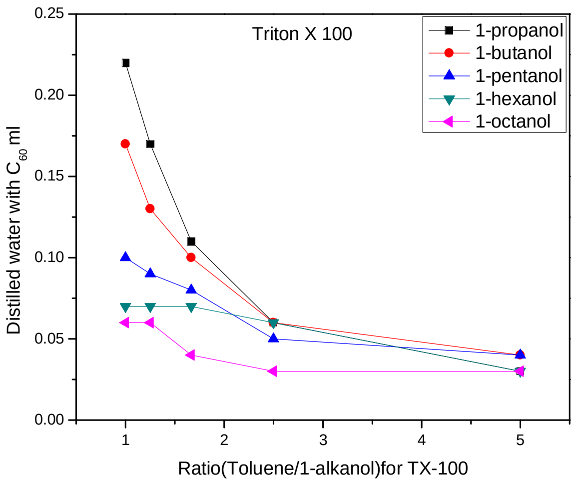


Figure 3.1.(b).2. Plot of amount of Water required versus ratio (Toluene/1-alkanol) using Triton X 100 with [60] fullerene*

By using another non ionic surfactant Triton X 100 more amount of water is required for the formation of emulsion with [60] fullerene i.e. 0.22 ml than without fullerene i.e. 0.20 ml using 1-propanol as co-surfactant. Same trend is observed like Tween 80 using Triton X 100 as co-surfactant changed from 1-propanol to 1- octanol water consumption decreases. So, the polar nature of co-surfactant reduces i.e. carbon chain increases the water required for the formation of the emulsion is decreased. ***Temperature: 30º±2ºC**

3.1. (c). Phase Transition of microemulsion to emulsion with SDS surfactant:

Phase transition from clear to turbid solution i.e. Microemulsion to Emulsion with SDS by using varying the amount of co-surfactants with and without C_{60} at 30ºC ± 2ºC in water bath was measured.

Table 3.1.(c).1. Effect of variation of amount of co-surfactant 1-propanol on the nature of solution using SDS without [60] fullerene*

Toluene (Oil) (ml)	**SDS (Surfactant) (gm)**	**1-Propanol (co-surfactant) (ml)**	**Distilled water (ml)**	**Solution Clear to**
5.0	0.0014	1.0	0.09	Turbid
5.0	0.0014	2.0	0.17	Turbid
5.0	0.0014	3.0	0.36	Turbid
5.0	0.0014	4.0	0.56	Turbid
5.0	0.0014	5.0	0.85	Turbid

Table 3.1.(c).2. Effect of variation of amount of co-surfactant 1-propanol on the nature of solution using SDS with [60] fullerene*

Toluene+C_{60} (Oil) (ml)	SDS **(Surfactant) (gm)**	**1-Propanol (co-surfactant) (ml)**	**Distilled water (ml)**	**Solution Clear to**
5.0	0.0014	1.0	0.08	Turbid
5.0	0.0014	2.0	0.20	Turbid
5.0	0.0014	3.0	0.32	Turbid
5.0	0.0014	4.0	0.54	Turbid
5.0	0.0014	5.0	0.78	Turbid

Table 3.1.(c).3. Effect of variation of amount of co-surfactant 1-butanol on the nature of solution using SDS without [60] fullerene*

Toluene (Oil) (ml)	**SDS (Surfactant) (gm)**	**1-Butanol (co-surfactant) (ml)**	**Distilled water (ml)**	**Solution Clear to**
5.0	0.0014	1.0	0.08	Turbid
5.0	0.0014	2.0	0.15	Turbid
5.0	0.0014	3.0	0.24	Turbid
5.0	0.0014	4.0	0.35	Turbid
5.0	0.0014	5.0	0.45	Turbid

Table 3.1.(c).4. Effect of variation of amount of co-surfactant 1-butanol on the nature of solution using SDS with [60] fullerene*

Toluene+C_{60} (Oil) (ml)	SDS (Surfactant) (gm)	**1-Propanol (co-surfactant) (ml)**	**Distilled water (ml)**	**Solution Clear to**
5.0	0.0014	1.0	0.11	Turbid
5.0	0.0014	2.0	0.12	Turbid
5.0	0.0014	3.0	0.25	Turbid
5.0	0.0014	4.0	0.39	Turbid
5.0	0.0014	5.0	0.49	Turbid

Table 3.1.(c).5. Effect of variation of amount of co-surfactant 1-pentanol on the nature of solution using SDS without [60] fullerene*

Toluene (Oil) (ml)	**SDS (Surfactant) (gm)**	**1-Pentanol (co-surfactant) (ml)**	**Distilled water (ml)**	**Solution Clear to**
5.0	0.0014	1.0	0.09	Turbid
5.0	0.0014	2.0	0.13	Turbid
5.0	0.0014	3.0	0.18	Turbid
5.0	0.0014	4.0	0.32	Turbid
5.0	0.0014	5.0	0.38	Turbid

Table 3.1.(c).6. Effect of variation of amount of co-surfactant 1-pentanol on the nature of solution using SDS with [60] fullerene*

Toluene+C_{60} (Oil) (ml)	SDS (Surfactant) (gm)	**1-Pentanol (co-surfactant) (ml)**	**Distilled water (ml)**	**Solution Clear to**
5.0	0.0014	1.0	0.13	Turbid
5.0	0.0014	2.0	0.16	Turbid
5.0	0.0014	3.0	0.29	Turbid
5.0	0.0014	4.0	0.41	Turbid
5.0	0.0014	5.0	0.52	Turbid

***Temperature: 30º±2ºC**

Table 3.1.(c).7. Effect of variation of amount of co-surfactant 1-hexanol on the nature of solution using SDS without [60] fullerene*

Toluene (Oil) (ml)	SDS (Surfactant) (gm)	1-Hexanol (co-surfactant) (ml)	Distilled water (ml)	Solution Clear to
5.0	0.0014	1.0	0.06	Turbid
5.0	0.0014	2.0	0.10	Turbid
5.0	0.0014	3.0	0.17	Turbid
5.0	0.0014	4.0	0.27	Turbid
5.0	0.0014	5.0	0.29	Turbid

Table 3.1.(c).8. Effect of variation of amount of co-surfactant 1-hexanol on the nature of solution using SDS with [60] fullerene*

Toluene+C_{60} (Oil) (ml)	SDS (Surfactant) (gm)	1-Hexanol (co-surfactant) (ml)	Distilled water (ml)	Solution Clear to
5.0	0.0014	1.0	0.07	Turbid
5.0	0.0014	2.0	0.09	Turbid
5.0	0.0014	3.0	0.17	Turbid
5.0	0.0014	4.0	0.20	Turbid
5.0	0.0014	5.0	0.23	Turbid

Table 3.1.(c).9. Effect of variation of amount of co-surfactant 1-octanol on the nature of solution using SDS without [60] fullerene*

Toluene (Oil) (ml)	SDS (Surfactant) gm	1-Octanol (co-surfactant) (ml)	Distilled water (ml)	Solution Clear to
5.0	0.0014	1.0	0.03	Turbid
5.0	0.0014	2.0	0.09	Turbid
5.0	0.0014	3.0	0.14	Turbid
5.0	0.0014	4.0	0.17	Turbid
5.0	0.0014	5.0	0.20	Turbid

***Temperature: 30º±2ºC**

Table 3.1.(c).10. Effect of variation of amount of co-surfactant 1-octanol on the nature of solution using SDS with [60] fullerene*

Toluene+C_{60} (Oil) (ml)	**SDS (Surfactant) gm**	**1-Octanol (co-surfactant) (ml)**	**Distilled water (ml)**	**Solution Clear to**
5.0	0.0014	1.0	0.05	Turbid
5.0	0.0014	2.0	0.11	Turbid
5.0	0.0014	3.0	0.13	Turbid
5.0	0.0014	4.0	0.17	Turbid
5.0	0.0014	5.0	0.22	Turbid

***Temperature: 30º±2ºC**

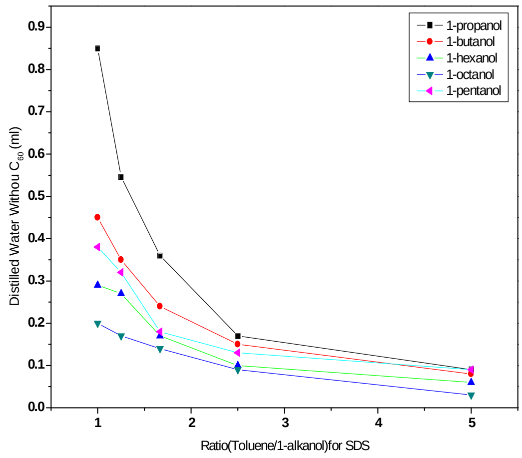


Figure 3.1.(c).1. Plot of amount of Water required versus ratio (Toluene/1-alkanol) using SDS without [60] fullerene*

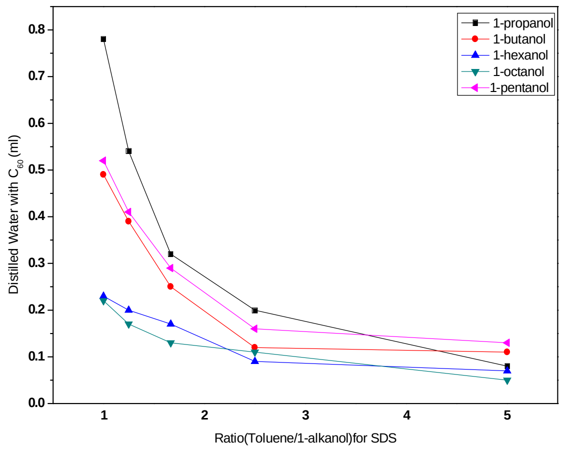


Figure 3.1.(c).2. Plot of amount of Water required versus ratio (Toluene/1-alkanol) using SDS with [60] fullerene*

Amount of water is required for the formation of emulsion with [60] fullerene i.e. 0.78 ml and without fullerene i.e 0.85 ml using 1-propanol as co-surfactant in this system. Similarly 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. ***Temperature: 30º±2ºC**

3.1. (d). Phase Transition ofs microemulsion to emulsion with CTAB surfactant:

Phase transition from clear to turbid solution i.e. Microemulsion to Emulsion with CTAB by using varying the amount of co-surfactants with and without C_{60} at 30ºC ± 2ºC in water bath was measured.

Table 3.1.(d).1. Effect of variation of amount of co-surfactant 1-propanol on the nature of solution using CTAB without [60] fullerene*

Toluene (Oil) (ml)	CTAB (Surfactant) gm	1-Propanol (co-surfactant) (ml)	Distilled water (ml)	Solution Clear to
5.0	0.0017	1.0	0.09	Turbid
5.0	0.0017	2.0	0.21	Turbid
5.0	0.0017	3.0	0.31	Turbid
5.0	0.0017	4.0	0.51	Turbid
5.0	0.0017	5.0	0.68	Turbid

Table 3.1.(d).2. Effect of variation of amount of co-surfactant 1-propanol on the nature of solution using CTAB with [60] fullerene*

Toluene+C_{60} (Oil) (ml)	CTAB (Surfactant) gm	1-Propanol (co-surfactant) (ml)	Distilled water (ml)	Solution Clear to
5.0	0.0017	1.0	0.10	Turbid
5.0	0.0017	2.0	0.21	Turbid
5.0	0.0017	3.0	0.25	Turbid
5.0	0.0017	4.0	0.48	Turbid
5.0	0.0017	5.0	0.69	Turbid

Table 3.1.(d).3. Effect of variation of amount of co-surfactant 1-butanol on the nature of solution using CTAB without [60] fullerene*

Toluene (Oil) (ml)	CTAB (Surfactant) gm	1-Butanol (co-surfactant) (ml)	Distilled water (ml)	Solution Clear to
5.0	0.0017	1.0	0.07	Turbid
5.0	0.0017	2.0	0.15	Turbid
5.0	0.0017	3.0	0.20	Turbid
5.0	0.0017	4.0	0.33	Turbid
5.0	0.0017	5.0	0.46	Turbid

Table 3.1.(d).4. Effect of variation of amount of co-surfactant 1-butanol on the nature of solution using CTAB with [60] fullerene*

Toluene+C_{60} (Oil) (ml)	CTAB **(Surfactant) gm**	**1-Butanol (co-surfactant) (ml)**	**Distilled water (ml)**	**Solution Clear to**
5.0	0.0017	1.0	0.08	Turbid
5.0	0.0017	2.0	0.19	Turbid
5.0	0.0017	3.0	0.24	Turbid
5.0	0.0017	4.0	0.31	Turbid
5.0	0.0017	5.0	0.47	Turbid

Table 3.1.(d).5. Effect of variation of amount of co-surfactant 1-pentanol on the nature of solution using CTAB without [60] fullerene*

Toluene (Oil) (ml)	**CTAB (Surfactant) gm**	**1-Pentanol (co-surfactant) (ml)**	**Distilled water (ml)**	**Solution Clear to**
5.0	0.0017	1.0	0.10	Turbid
5.0	0.0017	2.0	0.14	Turbid
5.0	0.0017	3.0	0.19	Turbid
5.0	0.0017	4.0	0.25	Turbid
5.0	0.0017	5.0	0.29	Turbid

Table 3.1.(d).6. Effect of variation of amount of co-surfactant 1-pentanol on the nature of solution using CTAB with [60] fullerene*

Toluene+C_{60} (Oil) (ml)	CTAB **(Surfactant) gm**	**1-Pentanol (co-surfactant) (ml)**	**Distilled water (ml)**	**Solution Clear to**
5.0	0.0017	1.0	0.1	Turbid
5.0	0.0017	2.0	0.15	Turbid
5.0	0.0017	3.0	0.20	Turbid
5.0	0.0017	4.0	0.25	Turbid
5.0	0.0017	5.0	0.31	Turbid

***Temperature: 30º±2ºC**

Table 3.1.(d).7. Effect of variation of amount of co-surfactant 1-hexanol on the nature of solution using CTAB without [60] fullerene*

Toluene (Oil) (ml)	**CTAB (Surfactant) gm**	**1-Hexanol (co-surfactant) (ml)**	**Distilled water (ml)**	**Solution Clear to**
5.0	0.0017	1.0	0.07	Turbid
5.0	0.0017	2.0	0.1	Turbid
5.0	0.0017	3.0	0.17	Turbid
5.0	0.0017	4.0	0.17	Turbid
5.0	0.0017	5.0	0.25	Turbid

Table 3.1.(d).8. Effect of variation of amount of co-surfactant 1-hexanol on the nature of solution using CTAB with [60] fullerene*

Toluene+C_{60} (Oil) (ml)	CTAB **(Surfactant) gm**	**1-Hexanol (co-surfactant) (ml)**	**Distilled water (ml)**	**Solution Clear to**
5.0	0.0017	1.0	0.09	Turbid
5.0	0.0017	2.0	0.11	Turbid
5.0	0.0017	3.0	0.12	Turbid
5.0	0.0017	4.0	0.20	Turbid
5.0	0.0017	5.0	0.21	Turbid

Table 3.1.(d).9. Effect of variation of amount of co-surfactant 1-octanol on the nature of solution using CTAB without [60] fullerene*

Toluene (Oil) (ml)	**CTAB (Surfactant) gm**	**1-Octanol (co-surfactant) (ml)**	**Distilled water (ml)**	**Solution Clear to**
5.0	0.0017	1.0	0.05	Turbid
5.0	0.0017	2.0	0.09	Turbid
5.0	0.0017	3.0	0.14	Turbid
5.0	0.0017	4.0	0.15	Turbid
5.0	0.0017	5.0	0.14	Turbid

***Temperature: 30º±2ºC**

Table 3.1.(d).10. Effect of variation of amount of co-surfactant 1-octanol on the nature of solution using CTAB with [60] fullerene*

Toluene+C_{60} (Oil) (ml)	CTAB **(Surfactant) gm**	**1-Octanol (co-surfactant) (ml)**	**Distilled water (ml)**	**Solution Clear to**
5.0	0.0017	1.0	0.05	Turbid
5.0	0.0017	2.0	0.13	Turbid
5.0	0.0017	3.0	0.11	Turbid
5.0	0.0017	4.0	0.13	Turbid
5.0	0.0017	5.0	0.15	Turbid

***Temperature: 30º±2ºC**

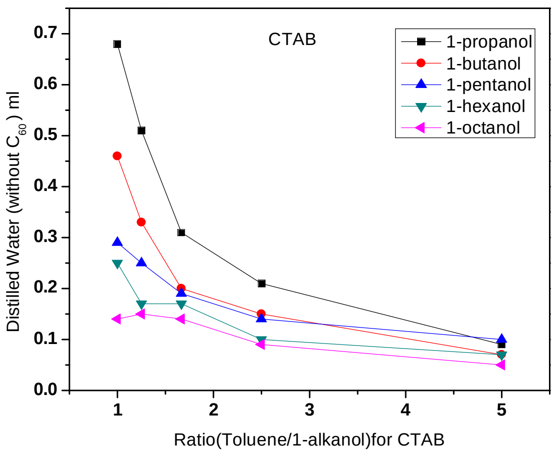


Figure 3.1.(d).1. Plot of amount of Water required versus ratio (Toluene/1-alkanol) using CTAB without [60] fullerene*

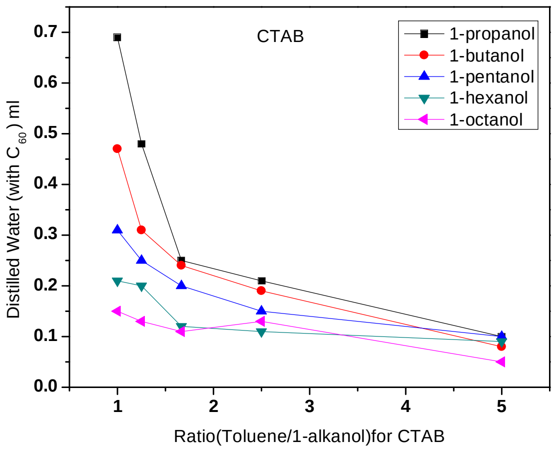


Figure 3.1.(d).2. Plot of amount of water required versus ratio (Toluene/1-alkanol) using CTAB with [60] fullerene*

Amount of water is required for the formation of emulsion with [60] fullerene i.e. 0.69 ml than without fullerene i.e 0.68 ml using 1-propanol as co-surfactant in this system.

***Temperature: 30º±2ºC**

Among all the four surfactants less amount of water is required using both non ionic surfactants Tween 80 and Triton X 100 than ionic surfactants SDS and CTAB. Using anionic surfactant SDS more amount of water i.e. 0.78ml and 0.85 ml is required than all rest surfactants used for the formation of stable emulsion in presence of [60] fullerene and in absence of [60] fullerene respectively at 30^0C.

Also it is prevailed that at low concentration of solvent (Toluene) more amount of water is required for the formation of stable emulsion as from 1-propanol to1-octanol water consumption decreases.

3.2. Phase behavior

The solubilization of water-insoluble compounds using surfactant-based assemblies is a widely used procedure. This method was applied to the fullerene: micelles and droplets of microemulsions were often used to solublise [60] fullerene into water, with or without sonication.

In this method, a stable w/o microemulsion at fixed amounts of water, surfactant and oil is prepared by titrating with an essential volume of co-surfactant. Hydrophobic molecule like [60] fullerene has low solubility because of the low interactions between solvent and solute. So by changing solute-solvent interactions solubility of hydrophobic molecule may be increased. This can be done by varying interactions between surfactant and solvent by forming microemulsion system.

For the microemulsion systems psuedoternary phase diagrams were drawn using the miscibility data of toluene in water in presence of and in absence of [60] fullerene using Tween 80,Triton X 100,SDS and CTAB with 1-alkanols (n=3,4,5,6&8) at 30^0C obtained by titration method. Table 3.2.a.(1-16),Table 3.2.b.(1-16),Table 3.2.c.(1-16) and Table 3.2.d.(1-16) contain the miscibility data of toluene in water with and without [60] fullerene. Triangular phase diagrams were plotted to signify the emulsion (biphasic) and microemulsion (monophasic) region. Figures 3.3.a.(1-10), Figures 3.3.b.(1-10), Figures 3.3.c.(1-10) and Figures 3.3.d(1-10) display the monophasic region above the curve and biphasic region below the curve in the triangular phase diagrams. In the ternary phase diagram, upper portion is the monophasic microemulsion region (1ǿ) while lower portion is the liquid/liquid (L/L) biphasic region (2ǿ) In the biphasic region, microemulsion is in equilibrium with excess oil (Toluene). 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 ± 0.2%. As per the area obtained from the triangular phase diagrams it can be concluded that area of microemulsion region is increased in presence of [60] fullerene than in absence of [60] fullerene.

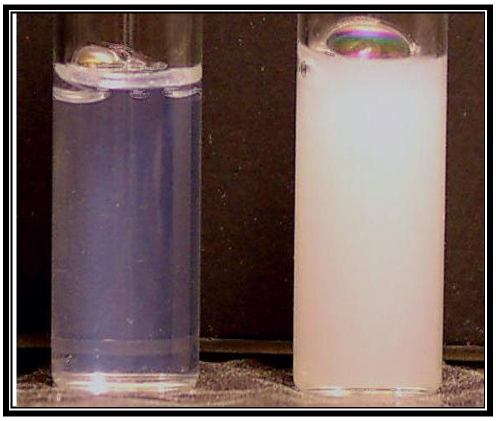


Figure 3.2.Microemulsion and emulsion

The most useful parameter to characterize is the size of microemulsion region/area. The microemulsion region/area was used to compare the solubilization capacity of different microemulsion systems. From the experimental data, phase diagrams were plotted taking water (aqueous phase), toluene (oil phase) and surfactant/co-surfactant (third phase) as the three components. The effect of the structure and nature of the surfactant on the microemulsion system in presence of [60]fullerene and in absence of [60] fullerene were studied. The corresponding pseudo-ternary phase diagrams are shown in the Figures 3.3.a.(1-10), Figures 3.3.b.(1-10), Figures 3.3.c.(1-10) and Figures 3.3.d(1-8) for all the three components in terms of weight fractions. In all the figures the upper portion of the curved line is monophasic (1Φ) microemulsion region and lower portion of the curved line is biphasic emulsion (2Φ) region. As reported previously by our group the phase diagrams remain unchanged for systems at room temperature (30°C) and also at higher temperature (40°C) for the surfactants Span 60 and Brij 35. In view of this all the studies were carried out at room temperature i.e. at 30°C. The data obtained are summarized in Table3.3.(a),(b),(c).16 and 3.3.(d)13.

Table3.2.(a).1. Miscibility data of toluene in water with surfactant Tween 80 and co-surfactant 1-propanol *

Water (ml)	Toluene (ml)	Tween 80 (ml)	1-Propanol (ml)	Solution
1.0	0.3	0.05	2.3	Clear
1.0	0.5	0.05	3.3	Clear
1.0	0.7	0.05	1.8	Clear
1.0	0.9	0.05	2.96	Clear
1.0	1.1	0.05	3.06	Clear
1.0	1.3	0.05	3.29	Clear
1.0	1.5	0.05	3.48	Clear
1.0	1.7	0.05	3.57	Clear
1.0	1.9	0.05	3.89	Clear
1.0	2.1	0.05	3.99	Clear
1.0	2.3	0.05	4.25	Clear
1.0	2.5	0.05	4.67	Clear

Table3.2.(a).2. Miscibility data of solution of [60] fullerene- toluene in water with surfactant Tween 80 and co-surfactant 1-propanol *

Water (ml)	Toluene-C_{60} (ml)	Tween 80 (ml)	1-Propanol (ml)	Solution
1.0	0.3	0.05	1.02	Clear
1.0	0.5	0.05	1.23	Clear
1.0	0.7	0.05	2.38	Clear
1.0	0.9	0.05	2.87	Clear
1.0	1.1	0.05	3.50	Clear
1.0	1.3	0.05	3.88	Clear
1.0	1.5	0.05	3.98	Clear
1.0	1.7	0.05	4.00	Clear
1.0	1.9	0.05	4.24	Clear
1.0	2.1	0.05	4.00	Clear

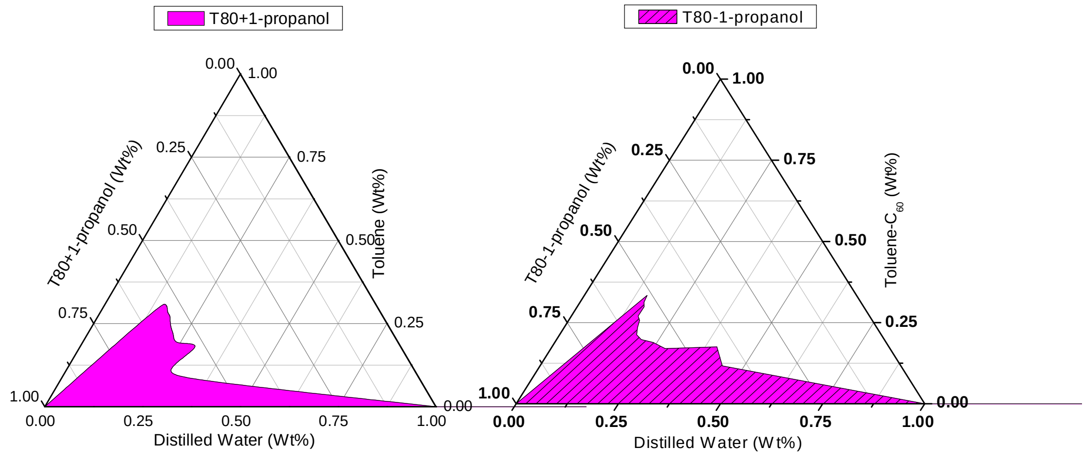


Figure 3.2.(a)1 and 2 Triangular phase diagram for Tween -80/1-propanol/toluene / water in absence and in presence of [60] fullerene *

Table3.2.(a).3. Area of microemulsion and emulsion for the system Tween-80/ 1-propanol/toluene and water in absence and in presence of [60] fullerene *

TW80/1-Propanol / Toluene / Water	Area under the curve (E) (cm^2)	Area above the curve (µE) (cm^2)	Total Area (cm^2)
Without C_{60}	20.1	98.9	119.0
With C_{60}	28.2	90.8	119.0

The microemulsion area above the curve for microemulsion system Tween 80/ 1-propanol-toluene and water found to be 98.9 cm^2 and 90.8 cm^2 while emulsion area was found to be 20.1 cm^2 and 28.2 cm^2 without and with [60] fullerene respectively at 30^0C.

Table3.2.(a).4. Miscibility data of toluene in water with surfactant Tween 80 and co-surfactant 1-butanol *

Water (ml)	**Toluene (ml)**	**Tween 80 (ml)**	**1-Butanol (ml)**	**Solution**
1.0	0.3	0.05	4.13	Clear
1.0	0.5	0.05	4.35	Clear
1.0	0.7	0.05	4.76	Clear
1.0	0.9	0.05	5.51	Clear
1.0	1.1	0.05	6.16	Clear
1.0	1.3	0.05	7.00	Clear
1.0	1.5	0.05	7.9	Clear
1.0	1.7	0.05	9.00	Clear
1.0	1.9	0.05	9.73	Clear
1.0	2.1	0.05	10.00	Clear
1.0	2.3	0.05	8.3	Clear
1.0	2.5	0.05	9.53	Clear

Table3.2.(a).5. Miscibility data of solution of [60] fullerene in toluene in water with surfactant Tween 80 and co-surfactant 1-butanol *

Water (ml)	Toluene-C_{60} (ml)	Tween 80 (ml)	1-Butanol (ml)	Solution
1.0	0.3	0.05	4.61	Clear
1.0	0.5	0.05	5.12	Clear
1.0	0.7	0.05	5.45	Clear
1.0	0.9	0.05	6.00	Clear
1.0	1.1	0.05	6.60	Clear
1.0	1.3	0.05	6.89	Clear
1.0	1.5	0.05	7.23	Clear
1.0	1.7	0.05	7.50	Clear
1.0	1.9	0.05	8.00	Clear
1.0	2.1	0.05	8.70	Clear
1.0	2.3	0.05	8.00	Clear
1.0	2.5	0.05	8.00	Clear

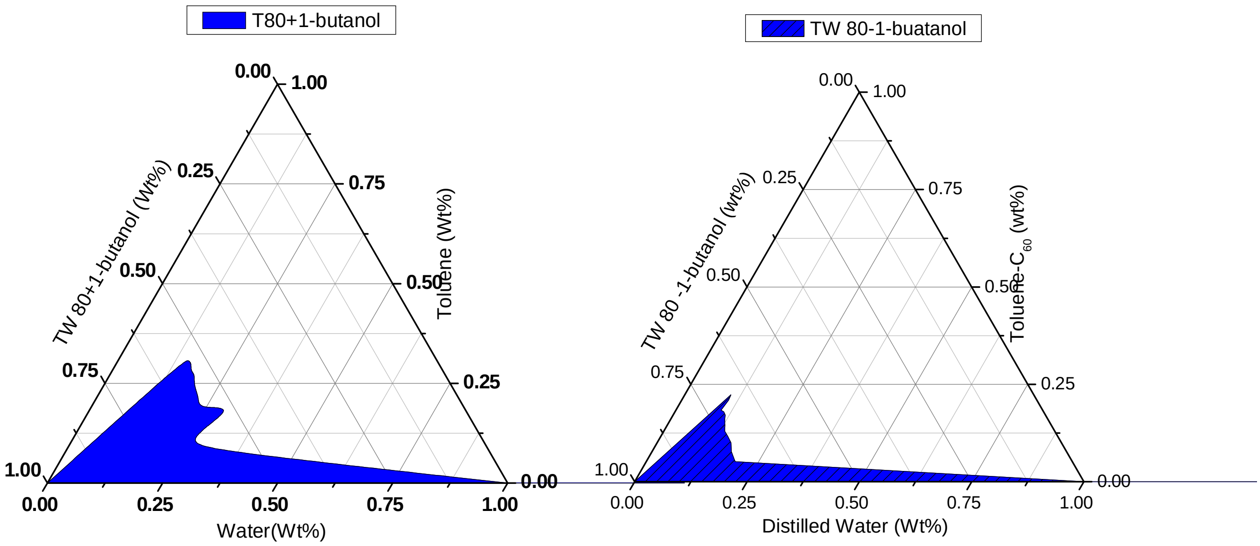


Figure 3.2.(a) 3 and 4. Triangular phase diagram for Tween-80/1-butanol/toluene/water in absence and in presence of [60] fullerene *

Table.3.2.(a).6. Area of microemulsion and emulsion for the system Tween-80/ 1-butanol/ toluene /water in absence and in presence of [60] fullerene *

Tween 80/1-Butanol /Toluene/Water	Area under the curve (E) (cm^2)	Area above the curve (μE) (cm^2)	Total Area (cm^2)
Without C_{60}	21.2	97.8	119.0
With C_{60}	21.8	97.2	119.0

The microemulsion area above the curve for microemulsion system Tween 80/ 1-butanol/toluene / water found to be 97.8 cm^2 and 97.2 cm^2 while emulsion area found 21.2 cm^2 and 21.8 cm^2 without and with [60] fullerene respectively at 30^0C.

Table3.2.(a).7. Miscibility data of toluene in water with surfactant Tween 80 and co-surfactant 1-pentanol *

Water (ml)	Toluene (ml)	Tween 80 (ml)	1-Pentanol (ml)	Solution
1.0	0.3	0.05	12.0	Clear
1.0	0.5	0.05	12.5	Clear
1.0	0.7	0.05	12.13	Clear
1.0	0.9	0.05	12.16	Clear
1.0	1.1	0.05	12.04	Clear
1.0	1.3	0.05	12.51	Clear
1.0	1.5	0.05	12.43	Clear
1.0	1.7	0.05	12.10	Clear
1.0	1.9	0.05	12.20	Clear
1.0	2.1	0.05	12.30	Clear
1.0	2.3	0.05	12.20	Clear
1.0	2.5	0.05	12.41	Clear

Table3.2.(a).8. Miscibility data of solution of [60] fullerene in toluene in water with surfactant Tween 80 and co-surfactant 1-pentanol *

Water (ml)	Toluene-C_{60} (ml)	Tween 80 (ml)	1-Pentanol (ml)	Solution
1.0	0.3	0.05	12.29	Clear
1.0	0.5	0.05	12.76	Clear
1.0	0.7	0.05	13.96	Clear
1.0	0.9	0.05	14.54	Clear
1.0	1.1	0.05	14.90	Clear
1.0	1.3	0.05	15.00	Clear
1.0	1.5	0.05	14.92	Clear

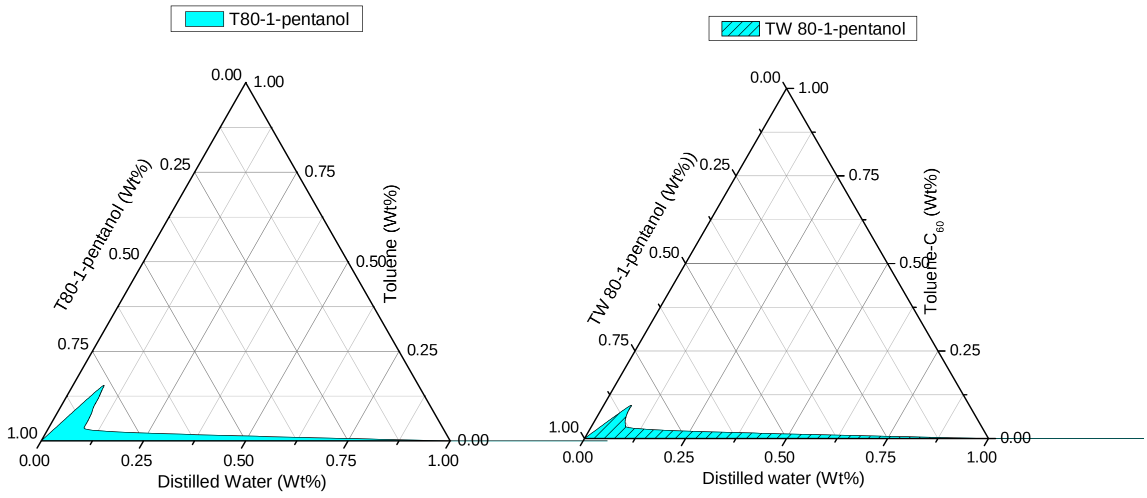


Figure 3.2.(a)5 and 6 Triangular phase diagram for Tween-80/1-pentnol/toluene/ water in absence and in presence of [60] fullerene *

Table.3.2.(a).9. Area of microemulsion and emulsion for the system Tween-80/ 1-pentanol/toluene / water in absence and in presence of [60] fullerene *

TW80/1-Pentanol /Toluene / Water	Area under the curve (E) (cm^2)	Area above the curve (μE) (cm^2)	Total Area (cm^2)
Without C_{60}	4.9	114.1	119.0
With C_{60}	3.6	115.4	119.0

The microemulsion area above the curve for microemulsion system Tween 80/ 1-pentanol/toluene/water found to be 114.1 cm^2 and 115.4 cm^2 while emulsion area found 4.9 cm^2 and 3.6 cm^2 without and with [60] fullerene respectively at 30^0C.

Table3.2.(a).10. Miscibility data of toluene in water with surfactant Tween 80 and co-surfactant 1-hexanol *

Water (ml)	Toluene (ml)	Tween 80 (ml)	1-Hexanol (ml)	Solution
1.0	0.3	0.05	15.28	Clear
1.0	0.5	0.05	15.67	Clear
1.0	0.7	0.05	16.43	Clear
1.0	0.9	0.05	17.48	Clear
1.0	1.1	0.05	19.10	Clear
1.0	1.3	0.05	19.7	Clear
1.0	1.5	0.05	20.19	Clear

Table3.2.(a).11. Miscibility data of solution of [60] fullerene in toluene in water with surfactant Tween 80 and co-surfactant 1-hexanol *

Water (ml)	Toluene-C_{60} (ml)	Tween 80 (ml)	1-Hexanol (ml)	Solution
1.0	0.3	0.05	14.00	Clear
1.0	0.5	0.05	16.58	Clear
1.0	0.7	0.05	18.07	Clear
1.0	0.9	0.05	19.04	Clear
1.0	1.1	0.05	19.10	Clear
1.0	1.3	0.05	19.09	Clear
1.0	1.5	0.05	19.12	Clear

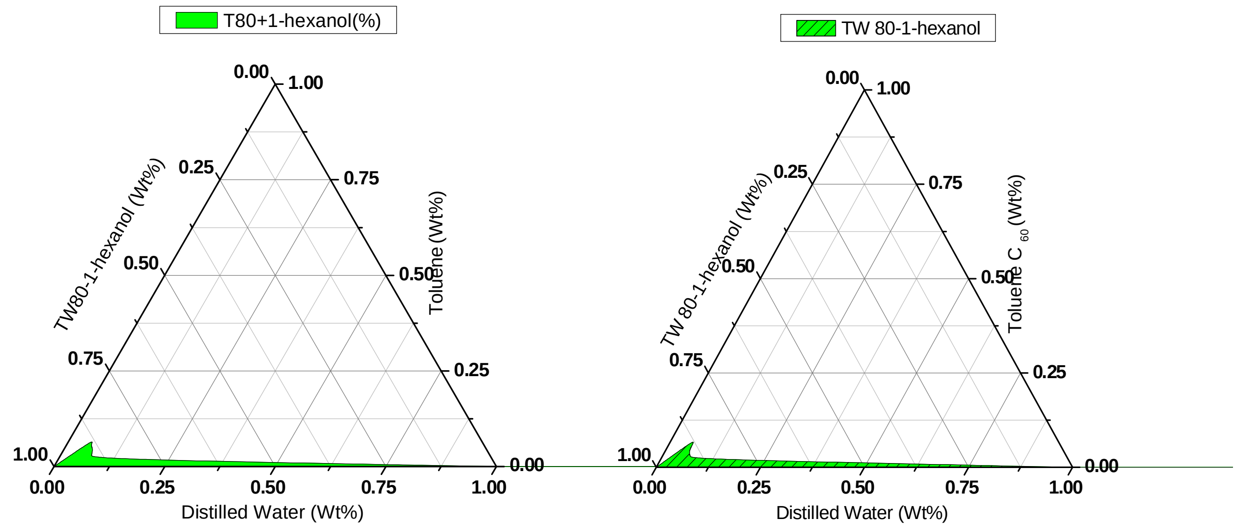


Figure 3.2.(a)7 and 8 Triangular phase diagram for Tween-80/1-hexanol/toluene/water in absence and in presence of [60] fullerene *

Table3.2.(a).12 Area of microemulsion and emulsion for the system Tween-80/ 1-hexanol/toluene / water in absence and in presence of [60] fullerene *

TW80/1-Hexanol /Toluene / Water	Area under the curve (E) (cm^2)	Area above the curve (μE) (cm^2)	Total Area (cm^2)
Without C_{60}	2.7	116.3	119.0
With C_{60}	3.4	115.6	119.0

The microemulsion area above the curve for microemulsion system Tween 80/ 1-hexanol/toluene and water was found to be 116.3 cm^2 and 115.6 cm^2 while emulsion area found 2.7 cm^2 and 3.4 cm^2 without and with [60]fullerene respectively at 30^0C.

Table3.2.(a).13. Miscibility data of toluene in water with surfactant Tween 80 and co-surfactant 1-octanol *

Water (ml)	Toluene (ml)	Tween 80 (ml)	1-Octanol (ml)	Solution
1.0	0.3	0.05	25.63	Clear
1.0	0.5	0.05	30.50	Clear
1.0	0.7	0.05	33.50	Clear

Table3.2.(a).14. Miscibility data of solution of [60] fullerene -toluene in water with surfactant Tween 80 and co-surfactant 1-octanol *

Water (ml)	Toluene-C_{60} (ml)	Tween 80 (ml)	1-Octanol (ml)	Solution
1.0	0.3	0.05	25.07	Clear
1.0	0.5	0.05	25.25	Clear
1.0	0.7	0.05	25.47	Clear
1.0	0.9	0.05	25.66	Clear
1.0	1.1	0.05	26.7	Clear
1.0	1.3	0.05	26.9	Clear
1.0	1.5	0.05	29.0	Clear

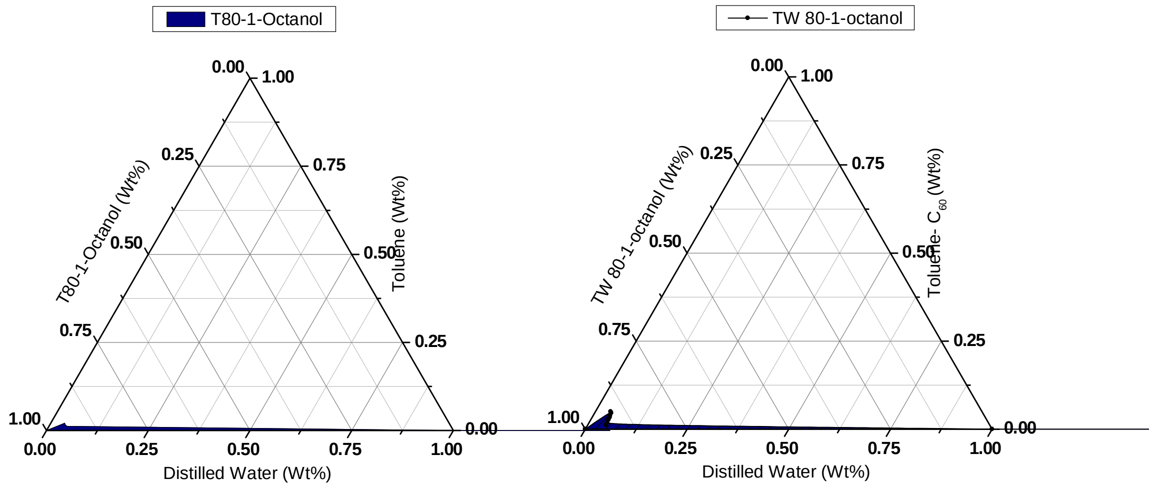


Figure 3.2.(a)9 and 10 Triangular phase diagram for Tween 80/1-octanol/toluene and water in absence and in presence of [60] fullerene *

Table3.2.(a).15 Area of microemulsion and emulsion for the system Tween 80/1-octanol/toluene /water in absence and in presence of [60] fullerene *

TW80/1-Octanol /Toluene / Water	Area under the curve (E) (cm^2)	Area above the curve (μE) (cm^2)	Total Area (cm^2)
Without C_{60}	2.4	116.6	119.0
With C_{60}	3.2	115.8	119.0

The microemulsion area above the curve for microemulsion system Tween 80/ 1-octanol/toluene/ water found to be 116.6 cm^2 and 115.8 cm^2 while emulsion area found 2.4 cm^2 and 3.2 cm^2 without and with [60]fullerene respectively at 30^0C.

Table3.2.(a).16. Summary of area using Tween 80:

Tween 80/ Toluene /Water		Area under the curve (E) (cm^2)	Area above the curve (µE) (cm^2)	Total Area (cm^2)
1- Propanol	Without C_{60}	20.1	98.9	119.0
1-Propanol	With C_{60}	28.2	90.8	119.0
1-Butanol	Without C_{60}	21.2	97.8	119.0
1-Butanol	With C_{60}	21.8	97.2	119.0
1-Pentanol	Without C_{60}	4.9	114.1	119.0
1-Pentanol	With C_{60}	3.6	115.4	119.0
1-Hexanol	Without C_{60}	2.7	116.3	119.0
1-Hexanol	With C_{60}	3.4	115.6	119.0
1-Octanol	Without C_{60}	2.4	116.6	119.0
1-Octanol	With C_{60}	3.2	115.8	119.0

From the above results it may be concluded that as polar nature of carbon chain decreases the microemulsion area increases in the ternary phase diagrams using Tween 80 surfactant.

The microemulsion area using 1-propanol was measured as 98.9 cm^2 and using 1-octanol was measured as 116.6 cm^2 without [60] fullerene. Microemulsion area was measured using 1-propanol as 90.8cm^2 and using 1-octanol as 115.8 cm^2 with [60] fullerene.

Table3.2.(b).1. Miscibility data of toluene in water with surfactant Triton X-100 and co-surfactant 1-propanol *

Water (ml)	Toluene (ml)	Triton X-100 (ml)	1-Propanol (ml)	Solution
1.0	0.3	0.1	1.2	Clear
1.0	0.5	0.1	1.4	Clear
1.0	0.7	0.1	1.46	Clear
1.0	0.9	0.1	1.63	Clear
1.0	1.1	0.1	1.68	Clear
1.0	1.3	0.1	2.2	Clear
1.0	1.5	0.1	2.31	Clear
1.0	1.7	0.1	2.55	Clear
1.0	1.9	0.1	2.89	Clear
1.0	2.1	0.1	3.26	Clear
1.0	2.3	0.1	3.57	Clear
1.0	2.5	0.1	4.00	Clear

Table3.2.(b).2. Miscibility data of solution of [60] fullerene- toluene in water with surfactant Triton X-100 and co-surfactant 1-propanol *

Water (ml)	Toluene-C_{60} (ml)	Triton X-100 (ml)	1-Propanol (ml)	Solution
1.0	0.3	0.1	1.19	Clear
1.0	0.5	0.1	1.35	Clear
1.0	0.7	0.1	1.44	Clear
1.0	0.9	0.1	1.56	Clear
1.0	1.1	0.1	2.01	Clear
1.0	1.3	0.1	2.38	Clear
1.0	1.5	0.1	2.50	Clear
1.0	1.7	0.1	2.94	Clear
1.0	1.9	0.1	3.28	Clear
1.0	2.1	0.1	3.58	Clear
1.0	2.3	0.1	3.87	Clear
1.0	2.5	0.1	4.18	Clear

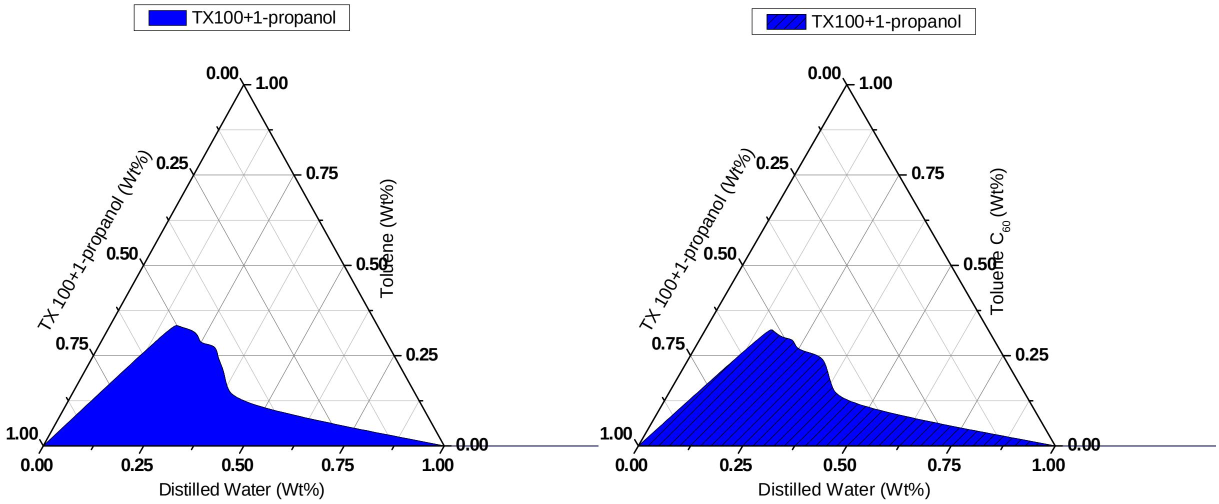


Figure 3.2.(b)1 and 2. Triangular phase diagram for Triton X 100/1-propanol/toluene / water in absence and in presence of [60] fullerene *

Table3.2.(b). 3. Area of microemulsion and emulsion for the system Triton X 100/ 1-propanol/toluene / water in absence and in presence of [60] fullerene *

Triton X 100 / 1-Propanol/ Toluene / Water	**Area under the curve (E) (cm^2)**	**Area above the curve (μE) (cm^2)**	**Total Area (cm^2)**
Without C_{60}	30.1	88.9	119.0
With C_{60}	29.1	89.9	119.0

The microemulsion area above the curve for microemulsion system Triton X 100/ 1-propanol/toluene / water found to be 88.9 cm^2 and 89.9 cm^2 while emulsion area found 30.1 cm^2 and 29.1 cm^2 without and with [60] fullerene respectively at 30^0C.

Table3.2.(b).4. Miscibility data of toluene in water with surfactant Triton X-100 and co-surfactant 1-butanol *

Water (ml)	Toluene (ml)	Triton X-100 (ml)	1-Butanol (ml)	Solution
1.0	0.3	0.1	2.27	Clear
1.0	0.5	0.1	3.03	Clear
1.0	0.7	0.1	3.94	Clear
1.0	0.9	0.1	4.75	Clear
1.0	1.1	0.1	5.46	Clear
1.0	1.3	0.1	6.13	Clear
1.0	1.5	0.1	6.79	Clear
1.0	1.7	0.1	6.77	Clear
1.0	1.9	0.1	6.84	Clear
1.0	2.1	0.1	6.84	Clear
1.0	2.3	0.1	6.68	Clear
1.0	2.5	0.1	7.12	Clear

Table3.2.(b).5. Miscibility data of solution of [60] fullerene- toluene in water with surfactant Triton X-100 and co-surfactant 1-butanol *

Water (ml)	Toluene-C_{60} (ml)	Triton X-100 (ml)	1-Butanol (ml)	Solution
1.0	0.3	0.1	2.76	Clear
1.0	0.5	0.1	3.3	Clear
1.0	0.7	0.1	4.0	Clear
1.0	0.9	0.1	5.3	Clear
1.0	1.1	0.1	6.27	Clear
1.0	1.3	0.1	6.41	Clear
1.0	1.5	0.1	6.55	Clear
1.0	1.7	0.1	6.6	Clear
1.0	1.9	0.1	6.82	Clear
1.0	2.1	0.1	7.01	Clear
1.0	2.3	0.1	7.29	Clear

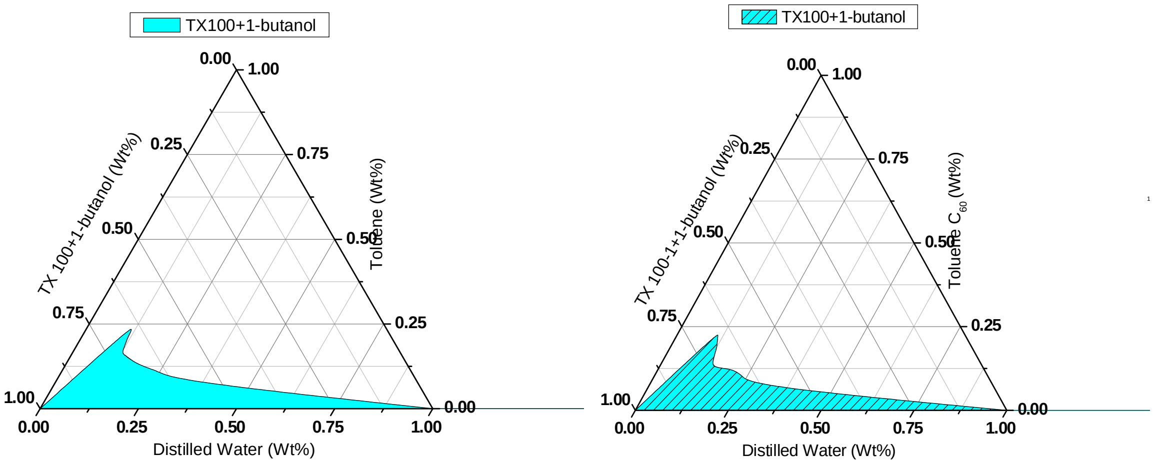


Figure 3.2.(b)3and 4 Triangular phase diagram for Triton X 100/1-butanol/toluene /water in absence and in presence of [60] fullerene *

Table 3.2.(b).6 Area of microemulsion and emulsion for the system Triton X 100/ 1-butanol/toluene / water in absence and in presence of [60] fullerene *

Triton X 100/ 1-Butanol / Toluene / Water	Area under the curve (E) (cm^2)	Area above the curve (μE) (cm^2)	Total Area (cm^2)
Without C_{60}	15.8	103.2	119.0
With C_{60}	14.6	104.4	119.0

The microemulsion area above the curve for microemulsion system Triton X 100/ 1-butanol/toluene / water found to be 103.2 cm^2 and 104.4 cm^2 while emulsion area found 15.8 cm^2 and 14.6 cm^2 without and with [60] fullerene respectively at 30^0C.

Table3.2.(b).7. Miscibility data of toluene in water with surfactant Triton X-100 and co-surfactant 1-pentanol *

Water (ml)	Toluene (ml)	Triton X-100 (ml)	1-Pentanol (ml)	Solution
1.0	0.3	0.1	8.44	Clear
1.0	0.5	0.1	9.05	Clear
1.0	0.7	0.1	10.12	Clear
1.0	0.9	0.1	10.27	Clear
1.0	1.1	0.1	11.07	Clear
1.0	1.3	0.1	11.63	Clear
1.0	1.5	0.1	12.49	Clear
1.0	1.7	0.1	13.93	Clear
1.0	1.9	0.1	14.61	Clear
1.0	2.1	0.1	15.61	Clear

Table3.2.(b).8. Miscibility data of solution of [60] fullerene-toluene in water with surfactant Triton X-100 and co-surfactant 1-pentanol *

Water (ml)	Toluene- C_{60} (ml)	Triton X-100 (ml)	1-Pentanol (ml)	Solution
1.0	0.3	0.05	9.22	Clear
1.0	0.5	0.05	9.89	Clear
1.0	0.7	0.05	10.37	Clear
1.0	0.9	0.05	10.80	Clear
1.0	1.1	0.05	11.32	Clear
1.0	1.3	0.05	11.76	Clear
1.0	1.5	0.05	12.13	Clear
1.0	1.7	0.05	12.60	Clear
1.0	1.9	0.05	13.16	Clear
1.0	2.1	0.05	13.62	Clear
1.0	2.3	0.05	14.05	Clear
1.0	2.5	0.05	14.63	Clear

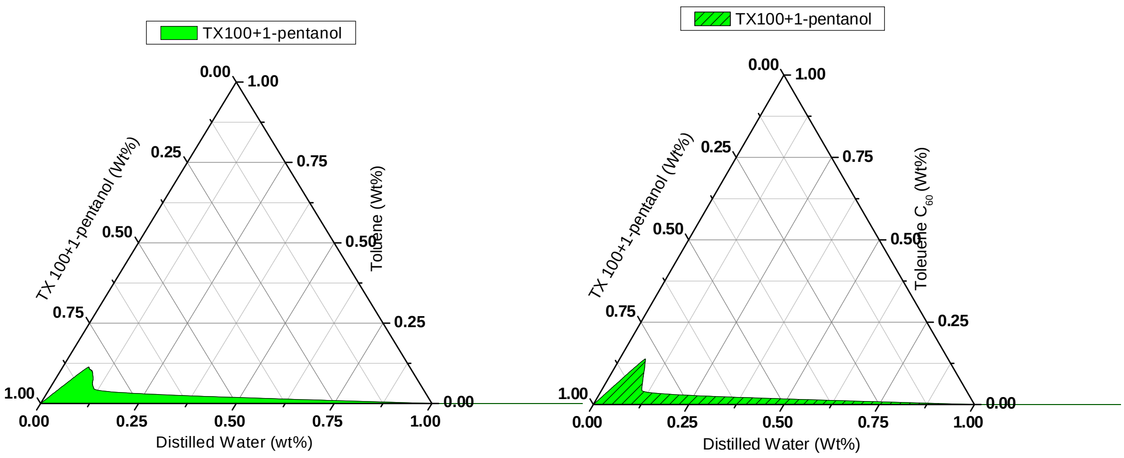


Figure 3.2.(b)5 and6 Triangular phase diagram for Triton X100/1-pentanol/toluene /water in absence and in presence of [60] fullerene *

Table3.2.(b).9. Area of microemulsion and emulsion for the system Triton X 100/ 1-pentanol/toluene /water in absence and in presence of [60] fullerene *

Triton X 100/ 1-Pentanol / Toluene / Water	**Area under the curve (E) (cm^2)**	**Area above the curve (µE) (cm^2)**	**Total Area (cm^2)**
Without C_{60}	5.5	113.5	119.0
With C_{60}	5.7	113.3	119.0

The microemulsion area above the curve for microemulsion system Triton X 100/ 1-pentanol/toluene/ water found to be 113.5 cm^2 and 113.3 cm^2 while emulsion area found 5.5 cm^2 and 5.7 cm^2 without and with [60] fullerene respectively at 30^0C.

Table3.2.(b).10. Miscibility data of toluene in water with surfactant Triton X-100 and co-surfactant 1-hexanol *

Water (ml)	Toluene (ml)	Triton X-100 (ml)	1-Hexanol (ml)	Solution
1.0	0.3	0.1	14.66	Clear
1.0	0.5	0.1	15.63	Clear
1.0	0.7	0.1	16.5	Clear
1.0	0.9	0.1	17.2	Clear
1.0	1.1	0.1	15.88	Clear
1.0	1.3	0.1	16.09	Clear
1.0	1.5	0.1	16.36	Clear
1.0	1.7	0.1	16.56	Clear
1.0	1.9	0.1	17.03	Clear

Table3.2.(b).11. Miscibility data of solution of [60] fullerene/toluene in water with surfactant Triton X-100 and co-surfactant 1-hexanol *

Water (ml)	Toluene (ml)	Triton X-100 (ml)	1-Hexanol (ml)	Solution
1.0	0.3	0.1	15.26	Clear
1.0	0.5	0.1	16.32	Clear
1.0	0.7	0.1	16.55	Clear
1.0	0.9	0.1	17.09	Clear
1.0	1.1	0.1	17.52	Clear
1.0	1.3	0.1	16.71	Clear
1.0	1.5	0.1	17.26	Clear

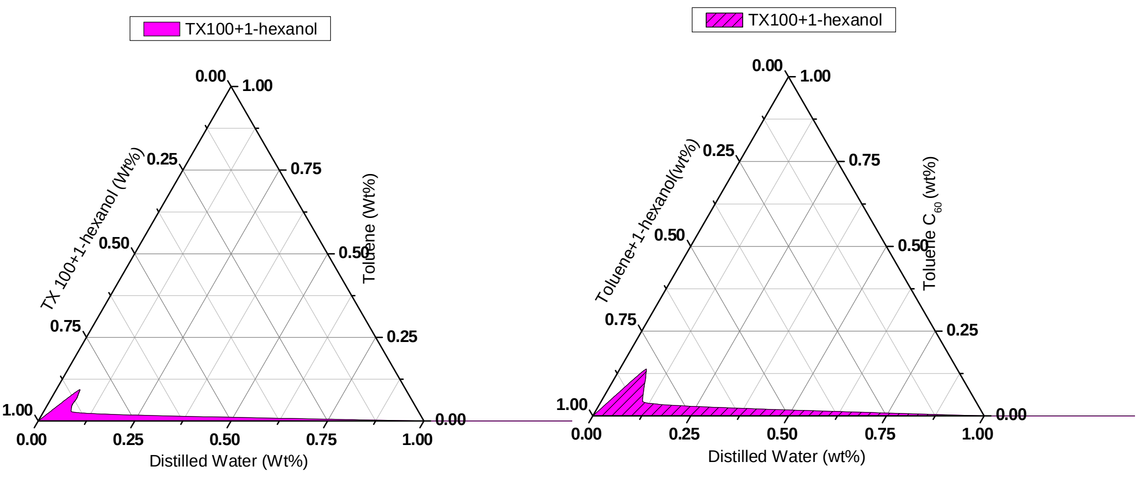


Figure 3.2.(b)7 and 8 Triangular phase diagram for Triton X 100/1-hexanol/toluene /water in absence and in presence of [60] fullerene *

Table 3.2.(b).12 Area of microemulsion and emulsion for the system Triton X 100/ 1-hexanol/toluene/ water in absence and in presence of [60] fullerene *

Triton X 100/ 1-Hexanol/ Toluene /Water	Area under the curve (E) (cm^2)	Area above the curve (μE) (cm^2)	Total Area (cm^2)
Without C_{60}	3.8	115.2	119.0
With C_{60}	5.4	113.6	119.0

The microemulsion area above the curve for microemulsion system Triton X-100/ 1-hextanol/toluene / water found to be 115.2cm^2 and 113.6 cm^2 while emulsion area found 3.8 cm^2 and 5.4 cm^2 without and with [60] fullerene respectively at 30^{0}C.

Table3.2.(b).13. Miscibility data of toluene in water with surfactant Triton X-100 and co-surfactant 1-octanol *

Water (ml)	Toluene (ml)	Triton X-100 (ml)	1-Octanol (ml)	Solution
1.0	0.3	0.1	28.04	Clear
1.0	0.5	0.1	28.36	Clear
1.0	0.7	0.1	28.3	Clear
1.0	0.9	0.1	28.54	Clear

Table3.2.(b).14. Miscibility data of solution of [60] fullerene-toluene in water with surfactant Triton X-100 and co-surfactant 1-octanol *

Water (ml)	Toluene-C_{60} (ml)	Triton X-100 (ml)	1-Octanol (ml)	Solution
1.0	0.3	0.1	27.54	Clear
1.0	0.5	0.1	27.87	Clear
1.0	0.7	0.1	28.34	Clear
1.0	0.9	0.1	28.0	Clear

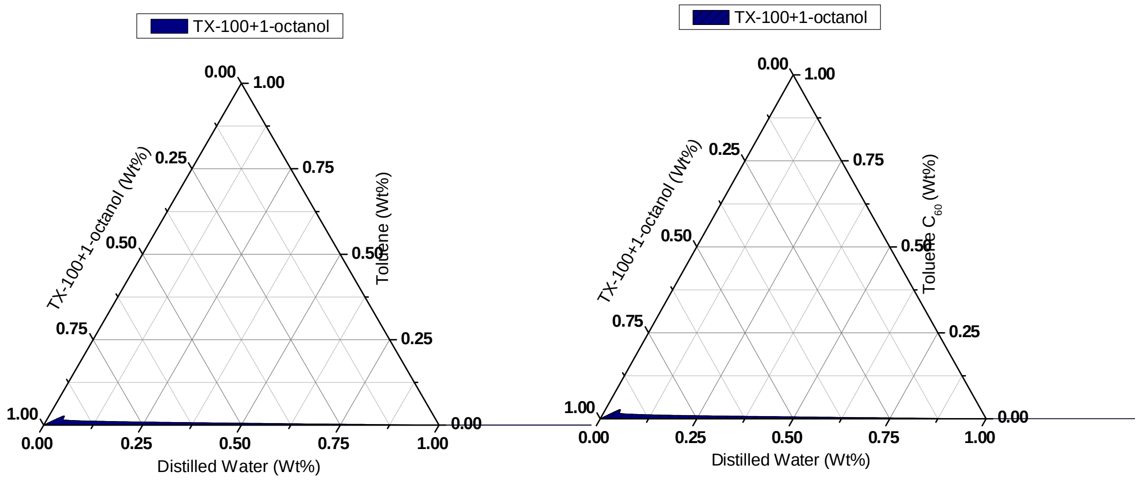


Figure 3.2.(b) 9 and 10 Triangular phase diagram for Triton X 100/1-octanol/toluene/ water in absence and in presence of [60] fullerene *

Table 3.2.(b).15. Area of microemulsion and emulsion for the system Triton X 100/ 1-octanol/toluene / water in absence and in presence of [60] fullerene *

Triton X 100/ 1-Octanol / Toluene / Water	Area under the curve (E) (cm^2)	Area above the curve (μE) (cm^2)	Total Area (cm^2)
Without C_{60}	1.5	117.5	119.0
With C_{60}	2.3	116.7	119.0

The microemulsion area above the curve for microemulsion system Triton X-100/ 1-octanol/toluene /water found to be 117.5 cm^2 and 116.7 cm^2 while emulsion area found 1.5 cm^2 and 2.3 cm^2 without and with [60]fullerene respectively at 30^0C.

Table 3.2.(b).16. Summary of area using Triton X 100

Triton X-100/ Toluene / Water		**Area under the curve (E) (cm^2)**	**Area above the curve (μE) (cm^2)**	**Total Area (cm^2)**
1- Propanol	Without C_{60}	30.1	88.9	119.0
1-Propanol	With C_{60}	29.1	89.9	119.0
1-Butanol	Without C_{60}	15.8	103.2	119.0
1-Butanol	With C_{60}	14.6	104.4	119.0
1-Pentanol	Without C_{60}	5.5	113.5	119.0
1-Pentanol	With C_{60}	5.7	113.3	119.0
1-Hexanol	Without C_{60}	3.8	115.2	119.0
1-Hexanol	With C_{60}	5.4	113.6	119.0
1-Octanol	Without C_{60}	1.5	117.5	119.0
1-Octanol	With C_{60}	2.3	116.7	119.0

The microemulsion area increases as 1-propanol and 1- butanol are used as co-surfactant in the system in presence of [60] fullerene but it decreases from 1-pentanol to 1-octanol than in absence of [60] fullerene.

Using 1-propanol as co-surfactant microemulsion area measured was 88.9 cm^2 and using 1-octanol as co-surfactant it was 117.5 cm^2 in absence of [60] fullerene. While using 1-propanol as co-surfactant microemulsion area measured was 89.9cm^2 and using 1-octanol as co-surfactant it was 116.7 cm^2 in presence of [60] fullerene.

Table3.2.(c).1. Miscibility data of toluene in water with surfactant SDS and co-surfactant 1-propanol *

Water (ml)	**Toluene (ml)**	**SDS (gm)**	**1-Propanol (ml)**	**Solution**
1.0	0.3	0.0014	0.49	Clear
1.0	0.5	0.0014	0.56	Clear
1.0	0.7	0.0014	0.72	Clear
1.0	0.9	0.0014	0.87	Clear
1.0	1.1	0.0014	1.49	Clear
1.0	1.3	0.0014	2.06	Clear
1.0	1.5	0.0014	2.57	Clear
1.0	1.7	0.0014	3.1	Clear
1.0	1.9	0.0014	3.25	Clear
1.0	2.1	0.0014	3.4	Clear
1.0	2.3	0.0014	3.59	Clear
1.0	2.5	0.0014	3.95	Clear

Table3.2.(c).2. Miscibility data of solution of [60] fullerene-toluene in water with surfactant SDS and co-surfactant 1-propanol *

Water (ml)	Toluene-C_{60} (ml)	SDS (gm)	1-Propanol (ml)	Solution
1.0	0.3	0.0014	0.64	Clear
1.0	0.5	0.0014	1.25	Clear
1.0	0.7	0.0014	1.95	Clear
1.0	0.9	0.0014	2.04	Clear
1.0	1.1	0.0014	3.21	Clear
1.0	1.3	0.0014	3.95	Clear
1.0	1.5	0.0014	4.02	Clear
1.0	1.7	0.0014	4.12	Clear
1.0	1.9	0.0014	4.14	Clear
1.0	2.1	0.0014	4.18	Clear
1.0	2.3	0.0014	4.23	Clear
1.0	2.5	0.0014	4.27	Clear

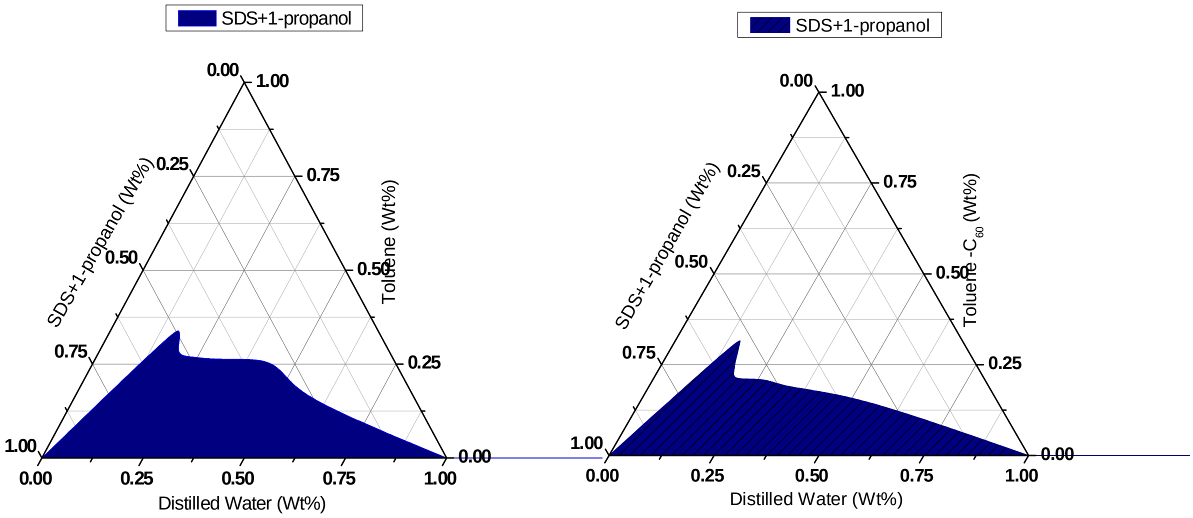


Figure 3.2.(c)1 and 2 Triangular phase diagram for SDS/1-propanol/toluene/ water in absence and in presence of [60] fullerene *

Table 3.2.(c).3 Area of microemulsion and emulsion for the system SDS/ 1-propanol/toluene /water in absence and in presence of [60] fullerene *

SDS/1-Propanol / Toluene /Water	Area under the curve (E) (cm^2)	Area above the curve (μE) (cm^2)	Total Area (cm^2)
Without C_{60}	39.5	79.5	119.0
With C_{60}	32.1	86.9	119.0

The microemulsion area above the curve for microemulsion system SDS/ 1-propanol/toluene / water found to be 79.5cm^2 and 86.9 cm^2 while emulsion area found 39.5cm^2 and 32.1 cm^2 without and with [60] fullerene respectively at 30^{0}C.

Table3.2.(c).4. Miscibility data of toluene in water with surfactant SDS and co-surfactant 1-butanol *

Water (ml)	Toluene (ml)	SDS (gm)	1-Butanol (ml)	Solution
1.0	0.3	0.0014	2.50	Clear
1.0	0.5	0.0014	3.26	Clear
1.0	0.7	0.0014	4.57	Clear
1.0	0.9	0.0014	5.83	Clear
1.0	1.1	0.0014	7.05	Clear
1.0	1.3	0.0014	8.00	Clear
1.0	1.5	0.0014	8.50	Clear
1.0	1.7	0.0014	7.30	Clear
1.0	1.9	0.0014	7.33	Clear
1.0	2.1	0.0014	7.30	Clear
1.0	2.3	0.0014	7.38	Clear
1.0	2.5	0.0014	7.40	Clear

Table3.2.(c).5. Miscibility data of solution of [60] fullerene-toluene in water with surfactant SDS and co-surfactant 1-butanol *

Water (ml)	Toluene+C_{60} (ml)	SDS (gm)	1-Butanol (ml)	Solution
1.0	0.3	0.014	1.6	Clear
1.0	0.5	0.014	2.16	Clear
1.0	0.7	0.014	3.2	Clear
1.0	0.9	0.014	4.12	Clear
1.0	1.1	0.014	5.85	Clear
1.0	1.3	0.014	6.36	Clear
1.0	1.5	0.014	7.57	Clear
1.0	1.7	0.014	8.15	Clear
1.0	1.9	0.014	8.59	Clear
1.0	2.1	0.014	8.15	Clear
1.0	2.3	0.014	8.13	Clear

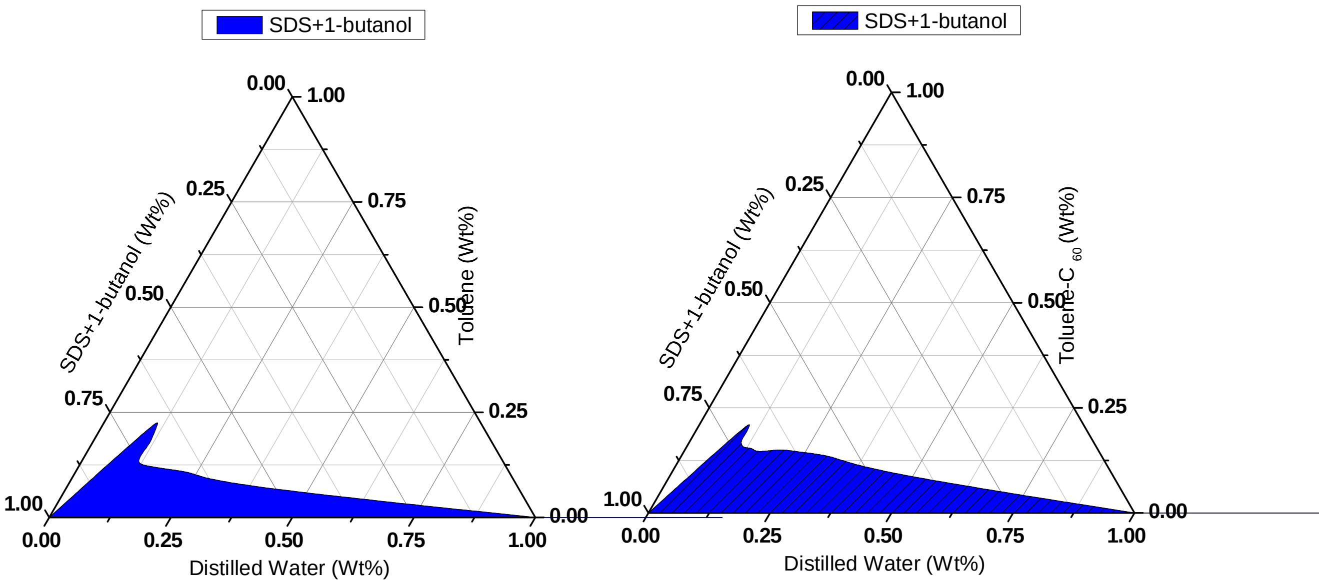


Figure 3.2.(c) 3 and 4 Triangular phase diagram for SDS/1-butanol/toluene/ water in absence and in presence of [60] fullerene *

Table3.2.(c).6. Area of microemulsion and emulsion for the system SDS/ 1-butanol/toluene /water in absence and in presence of [60] fullerene *

SDS/1-Butanol / Toluene / Water	Area under the curve (E) (cm^2)	Area above the curve (μE) (cm^2)	Total Area (cm^2)
Without C_{60}	15.2	103.8	119.0
With C_{60}	20.2	98.8	119.0

The microemulsion area above the curve for microemulsion system SDS-1-butanol-toluene/ water found to be 103.8 cm^2 and 98.8 cm^2 while emulsion area found 15.2cm^2 and 20.2cm^2 without and with [60] fullerene respectively at 30^0C.

Table3.2.(c).7. Miscibility data of toluene in water with surfactant SDS and co-surfactant 1-pentanol *

Water (ml)	Toluene (ml)	SDS (gm)	1-Pentanol (ml)	Solution
1.0	0.3	0.0014	8.91	Clear
1.0	0.5	0.0014	11.00	Clear
1.0	0.7	0.0014	12.19	Clear
1.0	0.9	0.0014	14.15	Clear
1.0	1.1	0.0014	14.62	Clear
1.0	1.3	0.0014	15.00	Clear
1.0	1.5	0.0014	15.61	Clear
1.0	1.7	0.0014	15.56	Clear
1.0	1.9	0.0014	15.00	Clear
1.0	2.1	0.0014	15.00	Clear
1.0	2.3	0.0014	14.04	Clear
1.0	2.5	0.0014	14.03	Clear

Table3.2.(c).8. Miscibility data of solution of [60] fullerene-toluene in water with surfactant SDS and co-surfactant 1-propanol *

Water (ml)	Toluene-C_{60} (ml)	SDS (gm)	1-Pentanol (ml)	Solution
1.0	0.3	0.0014	9.1	Clear
1.0	0.5	0.0014	10.86	Clear
1.0	0.7	0.0014	12.27	Clear
1.0	0.9	0.0014	13.29	Clear
1.0	1.1	0.0014	14.1	Clear
1.0	1.3	0.0014	14.98	Clear

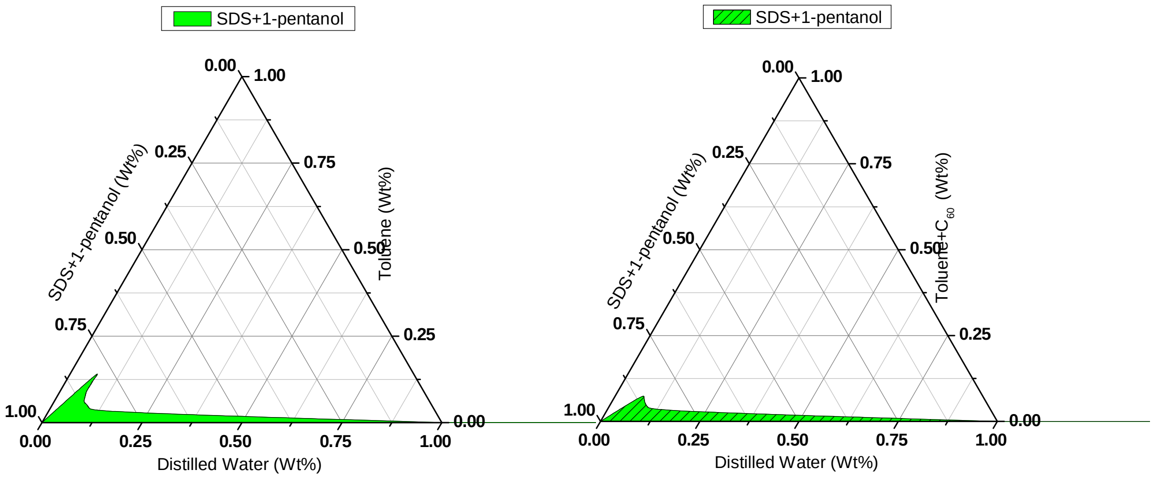


Figure 3.2.(c) 5 and 6 Triangular phase diagram for SDS/1-pentanol/toluene /water in absence and in presence of [60] fullerene *

Table3.2.(c).9. Area of microemulsion and emulsion for the system SDS/ 1-pentanol/toluene /water in absence and in presence of [60] fullerene *

SDS/1-Pentanol +/Toluene /Water	**Area under the curve (E) (cm^2)**	**Area above the curve (μE) (cm^2)**	**Total Area (cm^2)**
Without C_{60}	5.4	113.6	119.0
With C_{60}	4.9	114.1	119.0

The microemulsion area above the curve for microemulsion system SDS/ /toluene/ water found to be 113.6 cm^2 and 114.1cm^2 while emulsion area found 5.4 cm^2 and 4.9cm^2 without and with [60] fullerene respectively at 30^0C.

Table3.2.(c).10. Miscibility data of toluene in water with surfactant SDS and co-surfactant 1-hexanol *

Water (ml)	Toluene (ml)	SDS (gm)	1-Hexanol (ml)	Solution
1.0	0.3	0.0014	14.03	Clear
1.0	0.5	0.0014	15.91	Clear
1.0	0.7	0.0014	17.74	Clear
1.0	0.9	0.0014	19.61	Clear
1.0	1.1	0.0014	21.10	Clear

Table3.2.(c).11. Miscibility data of solution of [60] fullerene-toluene in water with surfactant SDS and co-surfactant 1-hexnol *

Water (ml)	Toluene-C_{60} (ml)	SDS (gm)	1-Hexanol (ml)	Solution
1.0	0.3	0.0014	15.98	Clear
1.0	0.5	0.0014	17.6	Clear
1.0	0.7	0.0014	19.22	Clear
1.0	0.9	0.0014	20.06	Clear
1.0	1.1	0.0014	20.08	Clear

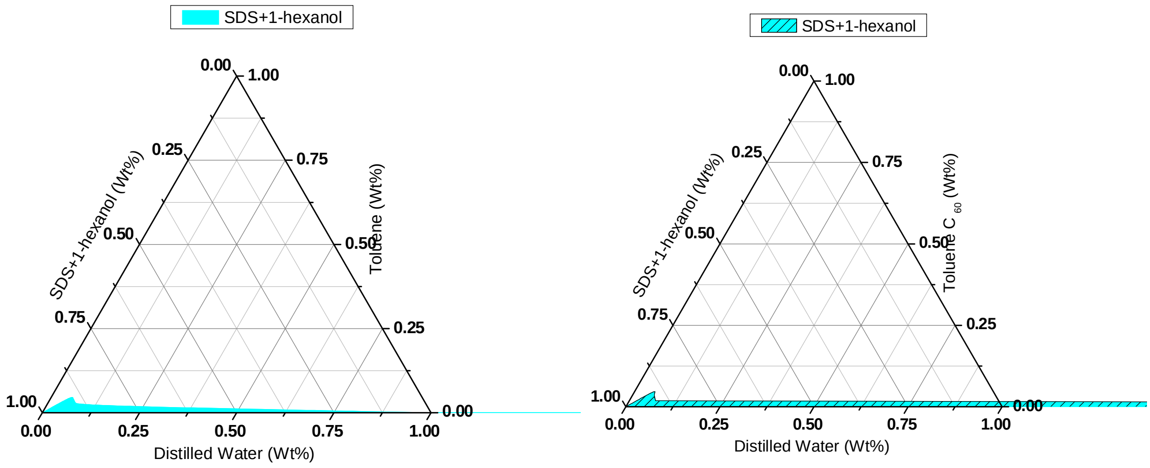


Figure 3.2.(c) 7 and 8. Triangular phase diagram for SDS/1-hexanol/toluene/water in absence and in presence of [60] fullerene *

Table3.2.(c).12. Area of microemulsion and emulsion for the system SDS/ 1-hexanol/toluene /water in absence and in presence of [60] fullerene *

SDS/1-Hexanol / Toluene /Water	Area under the curve (E) (cm^2)	Area above the curve (μE) (cm^2)	Total Area (cm^2)
Without C_{60}	3.2	115.8	119.0
With C_{60}	4.3	114.7	119.0

The microemulsion area above the curve for microemulsion system SDS/ 1-hexanol/toluene / water found to be 115.8cm^2 and 114.7cm^2 while emulsion area found 3.2 cm^2 and 4.3 cm^2 without and with [60] fullerene respectively at 30^0C.

Table3.2.(c).13. Miscibility data of toluene in water with surfactant SDS and co-surfactant 1-octanol *

Water (ml)	**Toluene (ml)**	**SDS (gm)**	**1-Octanol (ml)**	**Solution**
1.0	0.3	0.0014	18.0	Clear
1.0	0.5	0.0014	21.62	Clear
1.0	0.7	0.0014	27.0	Clear

Table3.2.(c).14. Miscibility data of solution of [60] fullerene -toluene in water with surfactant SDS and co-surfactant 1-octanol *

Water (ml)	**Toluene-C_{60} (ml)**	**SDS (gm)**	**1-Octanol (ml)**	**Solution**
1.0	0.3	0.0014	25.08	Clear
1.0	0.5	0.0014	26.7	Clear
1.0	0.7	0.0014	29.2	Clear

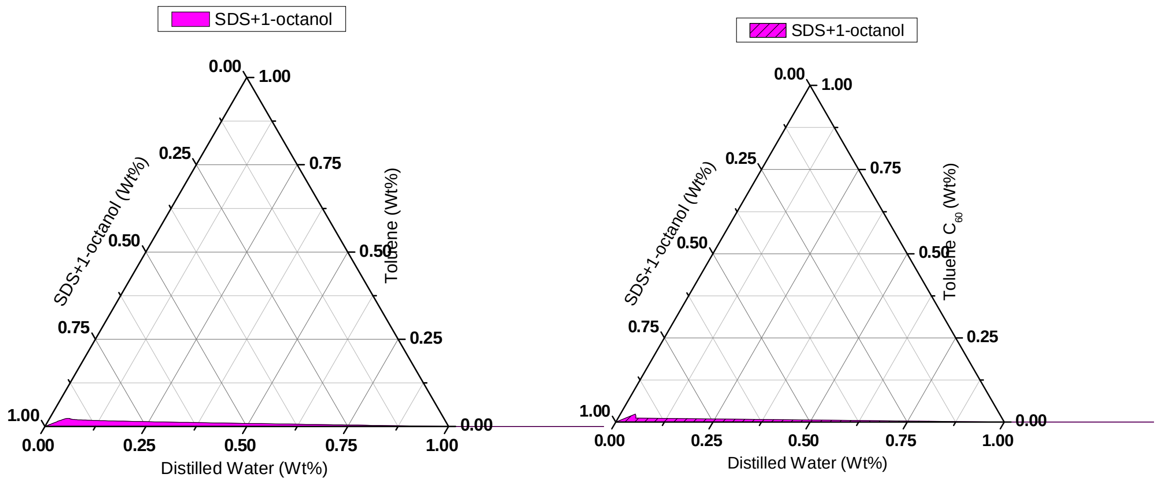


Figure 3.2.(c) 9 and 10 Triangular phase diagram for SDS/1-octanol/toluene/ water in absence and in presence of [60] fullerene *

Table3.2.(c).15. Area of microemulsion and emulsion for the system SDS/ 1-octanol/toluene / water in absence and in presence of [60] fullerene *

SDS/1-Octanol Toluene /Water	Area under the curve (E) (cm^2)	Area above the curve (µE) (cm^2)	Total Area (cm^2)
Without C_{60}	1.6	117.4	119.0
With C_{60}	1.8	117.2	119.0

The microemulsion area above the curve for microemulsion system SDS/ 1-octanol/toluene / water found to be 117.4 cm^2 and 117.2 cm^2 while emulsion area found 1.6cm^2 and 1.8 cm^2 without and with [60] fullerene respectively at 30^0C.

Table3.2.(c).16. Summary of area using SDS:

SDS / Toluene / Water		Area under the curve (E) (cm^2)	Area above the curve (μE) (cm^2)	Total Area (cm^2)
1- Propanol	Without C_{60}	39.5	79.5	119.0
1-Propanol	With C_{60}	32.1	86.9	119.0
1-Butanol	Without C_{60}	15.2	103.8	119.0
1-Butanol	With C_{60}	20.2	98.8	119.0
1-Pentanol	Without C_{60}	5.4	113.6	119.0
1-Pentanol	With C_{60}	4.9	114.1	119.0
1-Hexanol	Without C_{60}	3.2	115.8	119.0
1-Hexanol	With C_{60}	4.3	114.7	119.0
1-Octanol	Without C_{60}	1.6	117.4	119.0
1-Octanol	With C_{60}	1.8	117.2	119.0

The microemulsion area increases as 1-propanol and 1- pentanol are used as co-surfactant in the above system in presence of [60] fullerene but it decreases from 1-hexanol to 1-octanol than in absence of [60] fullerene.

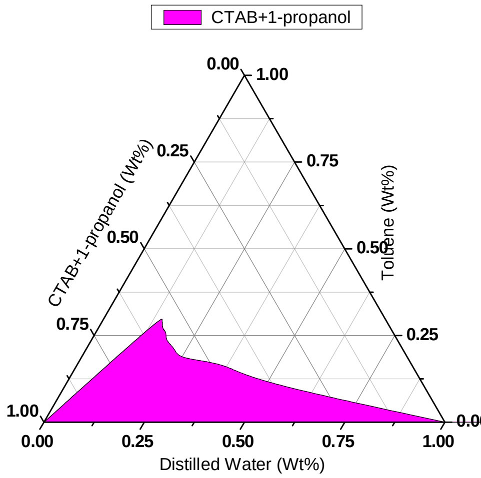
Using 1-propanol as co-surfactant microemulsion area measured was 79.5 cm^2 and using 1-octanol as co-surfactant it was 117.4 cm^2 in absence of [60] fullerene. While using 1-propanol as co-surfactant microemulsion area measured was 86.9cm^2 and using 1-octanol as co-surfactant it was 117.2 cm^2 in presence of [60] fullerene.

Table3.2.(d).1. Miscibility data of toluene in water with surfactant CTAB and co-surfactant 1-propanol *

Water (ml)	Toluene (ml)	CTAB (gm)	1-Propanol (ml)	Solution
1.0	0.3	0.0017	1.14	Clear
1.0	0.5	0.0017	1.51	Clear
1.0	0.7	0.0017	2.23	Clear
1.0	0.9	0.0017	2.95	Clear
1.0	1.1	0.0017	3.2	Clear
1.0	1.3	0.0017	3.55	Clear
1.0	1.5	0.0017	3.89	Clear
1.0	1.7	0.0017	4.0	Clear
1.0	1.9	0.0017	4.35	Clear
1.0	2.1	0.0017	4.54	Clear
1.0	2.3	0.0017	4.68	Clear
1.0	2.5	0.0017	4.88	Clear

Table3.2.(d).2. Miscibility data of solution of [60] fullerene-toluene in water with surfactant CTAB and co-surfactant 1-propanol *

Water (ml)	Toluene-C_{60} (ml)	CTAB gm	1-Propanol (ml)	Solution
1.0	0.3	0.0017	1.27	Clear
1.0	0.5	0.0017	1.91	Clear
1.0	0.7	0.0017	2.59	Clear
1.0	0.9	0.0017	3.03	Clear
1.0	1.1	0.0017	3.4	Clear
1.0	1.3	0.0017	3.7	Clear
1.0	1.5	0.0017	3.89	Clear
1.0	1.7	0.0017	4.18	Clear
1.0	1.9	0.0017	4.38	Clear
1.0	2.1	0.0017	4.72	Clear
1.0	2.3	0.0017	5.07	Clear
1.0	2.5	0.0017	5.38	Clear



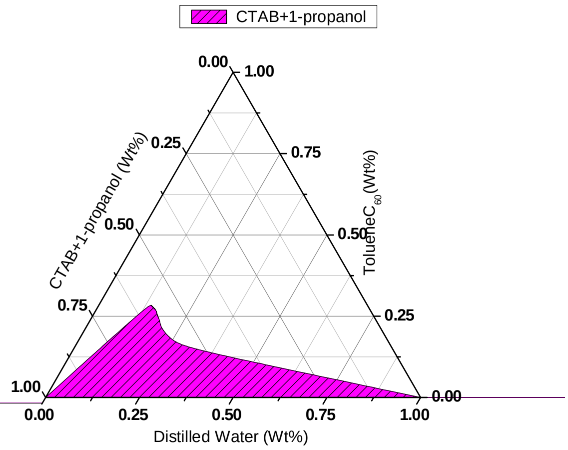


Figure 3.2.(d)1 and 2. Triangular phase diagram for CTAB/1-propanol/toluene/ water in absence and in presence of [60] fullerene *

Table3.2.(d).3. Area of microemulsion and emulsion for the system CTAB/ 1-propanol/toluene / water in absence and in presence of [60] fullerene *

CTAB/1-Propanol / Toluene /Water	**Area under the curve (E) (cm^2)**	**Area above the curve (μE) (cm^2)**	**Total Area (cm^2)**
Without C_{60}	28.9	90.1	119.0
With C_{60}	25.3	93.7	119.0

The microemulsion area above the curve for microemulsion system CTAB/ 1-propanol/toluene/ water found to be 90.1cm^2 and 93.7 cm^2 while emulsion area found to be 28.9cm^2 and 25.3 cm^2 without and with [60] fullerene respectively at 30^0C.

Table3.2.(d).4. Miscibility data of toluene in water with surfactant CTAB and co-surfactant 1-butanol *

Water (ml)	Toluene (ml)	CTAB (gm)	1-Butanol (ml)	Solution
1.0	0.3	0.0017	4.43	Clear
1.0	0.5	0.0017	5.26	Clear
1.0	0.7	0.0017	6.52	Clear
1.0	0.9	0.0017	6.92	Clear
1.0	1.1	0.0017	7.23	Clear
1.0	1.3	0.0017	8.03	Clear
1.0	1.5	0.0017	8.37	Clear
1.0	1.7	0.0017	8.6	Clear
1.0	1.9	0.0017	8.83	Clear
1.0	2.1	0.0017	9.97	Clear
1.0	2.3	0.0017	9.98	Clear
1.0	2.5	0.0017	9.90	Clear

Table3.2.(d).5. Miscibility data of solution of [60] fullerene-toluene in water with surfactant CTAB and co-surfactant 1-butanol *

Water (ml)	**Toluene- C_{60} (ml)**	**CTAB (gm)**	**1-Butanol (ml)**	**Solution**
1.0	0.3	0.0017	5.25	Clear
1.0	0.5	0.0017	5.83	Clear
1.0	0.7	0.0017	6.38	Clear
1.0	0.9	0.0017	7.0	Clear
1.0	1.1	0.0017	7.2	Clear
1.0	1.3	0.0017	7.43	Clear
1.0	1.5	0.0017	7.6	Clear
1.0	1.7	0.0017	7.97	Clear
1.0	1.9	0.0017	8.19	Clear
1.0	2.1	0.0017	9.20	Clear
1.0	2.3	0.0017	8.80	Clear
1.0	2.5	0.0017	8.96	Clear

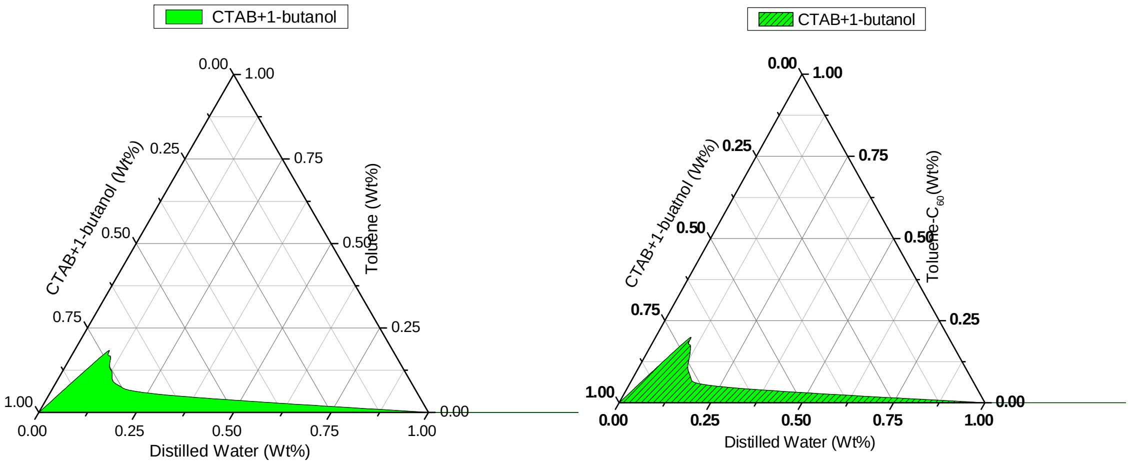


Figure 3.2.(d) 3 and 4 Triangular phase diagram for CTAB/1-butanol/toluene/water in absence and in presence of [60] fullerene *

Table3.2.(d).6. Area of microemulsion and emulsion for the system CTAB/ 1-butanol/toluene / water in absence and in presence of [60] fullerene *

CTAB/1-Butanol /Toluene / Water	Area under the curve (E) (cm^2)	Area above the curve (μE) (cm^2)	Total Area (cm^2)
Without C_{60}	10.5	108.5	119.0
With C_{60}	10.3	108.7	119.0

The microemulsion area above the curve for microemulsion system CTAB/ 1-butanol/toluene / water found to be 108.5 cm^2 and 108.7cm^2 while emulsion area found 10.5cm^2 and 10.3 cm^2 without and with [60] fullerene respectively at 30^0C.

Table3.2.(d).7. Miscibility data of toluene in water with surfactant CTAB and co-surfactant 1-pentanol *

Water (ml)	Toluene (ml)	CTAB (gm)	1-Pentanol (ml)	Solution
1.0	0.3	0.0017	7.00	Clear
1.0	0.5	0.0017	9.65	Clear
1.0	0.7	0.0017	11.31	Clear
1.0	0.9	0.0017	12.10	Clear
1.0	1.1	0.0017	13.08	Clear
1.0	1.3	0.0017	14.07	Clear
1.0	1.5	0.0017	15.45	Clear
1.0	1.7	0.0017	17.54	Clear

Table3.2.(d).8. Miscibility data of solution of [60] fullerene-toluene in water with surfactant CTAB and co-surfactant 1-pentanol *

Water (ml)	Toluene-C_{60} (ml)	CTAB (gm)	1-Pentanol (ml)	Solution
1.0	0.3	0.0017	10.71	Clear
1.0	0.5	0.0017	11.53	Clear
1.0	0.7	0.0017	12.31	Clear
1.0	0.9	0.0017	13.21	Clear
1.0	1.1	0.0017	14.14	Clear
1.0	1.3	0.0017	15	Clear
1.0	1.5	0.0017	15.5	Clear

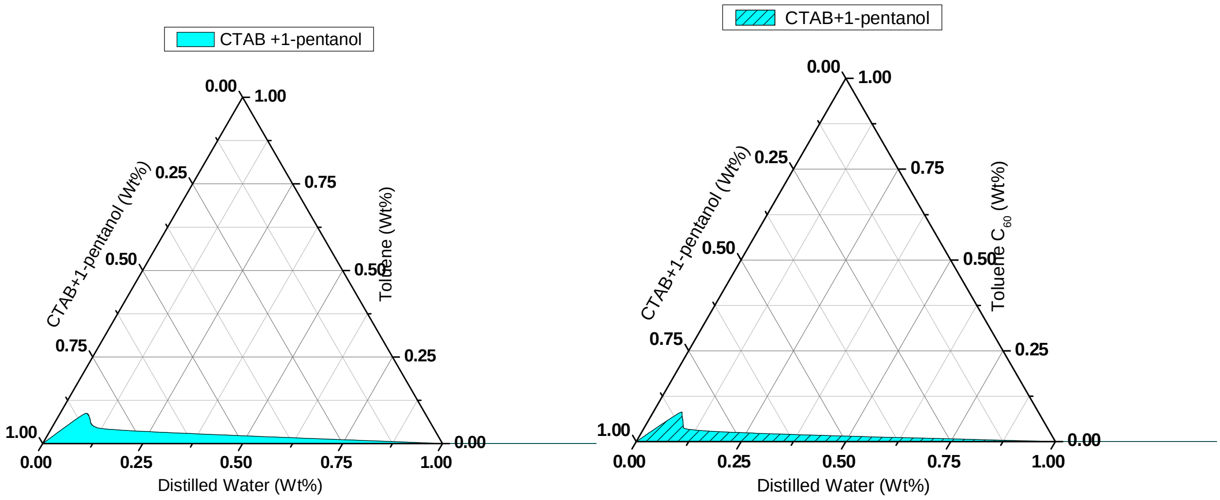


Figure 3.2.(d)5 and 6 Triangular phase diagram for CTAB/1-pentanol/toluene / water in absence and in presence of [60] fullerene *

Table3.2.(d).9. Area of microemulsion and emulsion for the system CTAB/ 1-pentanol/toluene / water in absence and in presence of [60] fullerene *

CTAB/1-Pentanol / Toluene / Water	Area under the curve (E) (cm^2)	Area above the curve (µE) (cm^2)	Total Area (cm^2)
Without C_{60}	3.2	115.8	119.0
With C_{60}	4.3	114.7	119.0

The microemulsion area above the curve for microemulsion system CTAB/ 1-butanol/toluene / water found to be 115.8 cm^2 and 114.7cm^2 while emulsion area found 3.2cm^2 and 4.3 cm^2 without and with [60] fullerene respectively at 30^0C.

Table3.2.(d).10. Miscibility data of solution of toluene in water with surfactant CTAB and co-surfactant 1-hexanol *

Water (ml)	Toluene (ml)	CTAB (gm)	1-Hexanol (ml)	Solution
1.0	0.3	0.0017	12.37	Clear
1.0	0.5	0.0017	15.00	Clear
1.0	0.7	0.0017	18.00	Clear

Table3.2.(d).11. Miscibility data of solution of [60] fullerene-toluene in water with surfactant CTAB and co-surfactant 1-hexanol *

Water (ml)	Toluene-C_{60} (ml)	CTAB (gm)	1-Hexanol (ml)	Solution
1.0	0.3	0.0017	14.0	Clear
1.0	0.5	0.0017	17.0	Clear
1.0	0.7	0.0017	19.2	Clear

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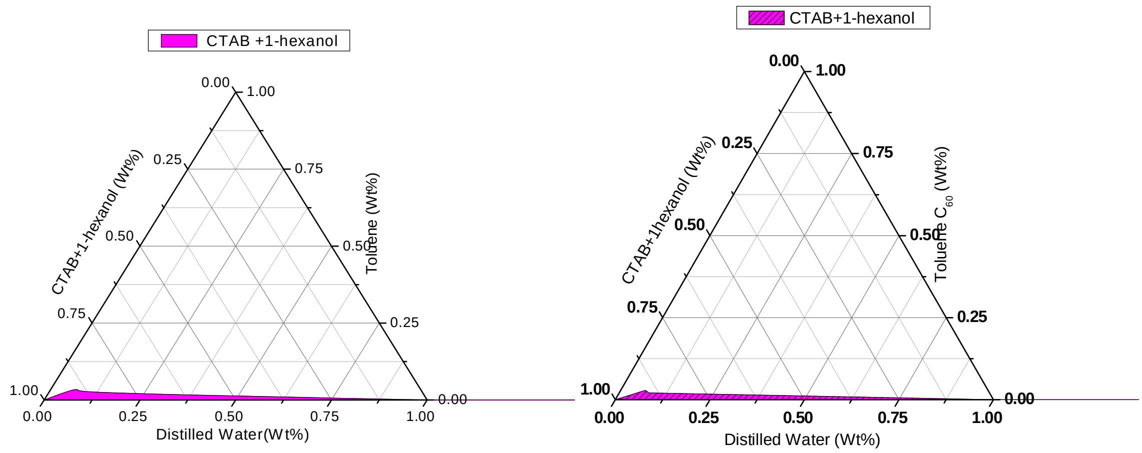


Figure 3.2.(d)7and 8 Triangular phase diagram for CTAB/1-hexanol/toluene/ water in absence and in presence of [60] fullerene *

Table3.2.(d).12. Area of microemulsion and emulsion for the system CTAB/ 1-hexanol/toluene / water in absence and in presence of [60] fullerene *

CTAB/1-Hexanol/ Toluene/Water	Area under the curve (E) (cm^2)	Area above the curve (μE) (cm^2)	Total Area (cm^2)
Without C_{60}	3.7	115.3	119.0
With C_{60}	3.8	115.2	119.0

The microemulsion area above the curve for microemulsion system CTAB-1-Hexanol-toluene / water found to be 115.3 cm^2 and 115.2 cm^2 while emulsion area found 3.7 cm^2 and 3.8 cm^2 without and with [60] fullerene respectively at 30^0C.

Table3.2.(d).13. Summary of area using CTAB:

CTAB / Toluene / Water		Area under the curve (E) (cm^2)	Area above the curve (μE) (cm^2)	Total Area (cm^2)
1- Propanol	Without C_{60}	28.9	90.1	119.0
1-Propanol	With C_{60}	25.3	93.7	119.0
1-Butanol	Without C_{60}	10.5	108.5	119.0
1-Butanol	With C_{60}	10.3	108.7	119.0
1-Pentanol	Without C_{60}	3.2	115.8	119.0
1-Pentanol	With C_{60}	4.3	114.7	119.0
1-Hexanol	Without C_{60}	3.7	115.3	119.0
1-Hexanol	With C_{60}	3.8	115.2	119.0

The microemulsion area increases as 1-propanol and 1- butanol are used as co-surfactants in the system in presence of [60] fullerene but it decreases from 1-pentanol to 1-octanol than in absence of [60] fullerene.

Using 1-propanol as co-surfactant microemulsion area measured was 88.9 cm^2 and using 1-octanol as co-surfactant it was 117.5 cm^2 in absence of [60] fullerene. While using 1-propanol as co-surfactant microemulsion area measured was 89.9cm^2 and using 1-octanol as co-surfactant it was 116.7 cm^2 in presence of [60] fullerene.

The monophasic area of the microemulsion increases for 1-propanol co-surfactant in presence of [60] fullerene for both nonionic and ionic surfactants used. Similar trend was observed for 1-butanol and 1-pentanol co-surfactants. But the monophasic i.e. microemulsion area decreases slightly in presence of [60] fullerene in presence of 1-hexanol and 1-octanol co-surfactants. Thus we can see that area of microemulsion increases in presence of [60] fullerene for the alcohols n=1,2,3,4,5 than without [60] fullerene. However a reverse trend is observed for 1-hexanol and 1-octanol co-surfactants. 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 if [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.

According to the results summarized, the structure of the surfactants, hydrophobicity of [60] fullerene and chemical nature of solvent with co-surfactant seems to influence the formation of microemulsion. The structure of co-surfactant also has remarkable influence on the phase behavior of microemulsion. The polar interior of reverse micellar aggregates formed of nonionic surfactants may structurally be similar more to the interior of normal micelles in aqueous solution than that of reverse micelles formed of ionic surfactants. The aggregation mainly depends on a balanced interaction between the polar chain of the surfactant and the solvent.

The chain length-dependent effect of alcohols and the role of alcohols in the formation of inverse microemulsions is very important. As linear alcohols n=2 to n=6 are adsorbed at the interface as well as due to their polar nature may be located in between the polar heads of surfactant or may be miscible with water present in the centre of reverse micelle. Because of their short chain co-surfactants like linear alcohols n=2 to n=6 may pull apart surfactant molecules by not providing equivalent interaction. As a result the solubilization is low. But due to the negative charge present on the clusters of [60]fullerene it shows more solubilization i.e. higher microemulsion area than alcohols n=6 to n=8. Also the more solubility of [60] fullerene in higher alcohols also affects on the monophasic microemulsion region.

For co-surfactants (1-alkanol) from n=3 and n=4 less region was found to solubilize hydrophobic [60]fullerene that is at outer site towards the non polar tail ends. So, smaller microemulsion area was observed due to the solubilized system at the tail ends.

While more microemulsion area was found using co-surfactants (1-alkanol) n=5, n=6 and n=8 to solublise [60] fullerene as due to the increase in the hydrophobic nature of the centre of reverse micelle. Similarly co-surfactant may be placed in between the polar heads of surfactants as well as the tail side of the surfactants. Therefore more microemulsion region was found in between the polar heads and hydrophobic tails of the surfactants to solublise [60] fullerene.

3.3. Critical reverse micelle formation [C_{rmc}]

The critical reverse micelle concentration C_{rmc} was determined by iodine solubilization method, as [60] fullerene has very poor aqueous solubility and is a non polar molecule similar to iodine. [60] fullerene-highly hydrophobic and non polar molecule, formed a reverse micelle complex with Tween 80, Triton X 100, SDS and CTAB in toluene. The λ_{max} of pure [60] fullerene (1.39 x 10-4 M) solution was observed at 312nm. The absorbance at new λ_{max} i.e. at 334 nm versus concentrations of all the [60] fullerene/SDS solutions was plotted. The change in the absorbance values with concentration was not linear but showed a distinct break point. This break point is the C_{rmc} of reverse micellisation at that temperature. Thermodynamic quantities like the standard free energy, enthalpy and entropy of reverse micellisation were calculated using following equations from the values of C_{rmc} of[60] fullerene solution with Tween 80 and Triton X 100 ,SDS and CTAB at 30ºC and 40ºC.

$$\Delta G^{\circ}_{rm} = RT \ln (C_{rmc})$$

$$\Delta H^{\circ}_{rm} = -RT^2 d \ln (C_{rmc}) / dT$$

$$\Delta S^{\circ}_{rm} = (\Delta H^{\circ}_{rm} - \Delta G^{\circ}_{rm}) / T$$

- **UV-VIS Spectra**

The λ_{max} of [60] fullerene in toluene (non-polar solvent) was observed at 335nm For various surfactants UV-VIS spectra are shown in Figure 3.3.(a-d). As expected the absorbance of surfactant solution with [60] fullerene in toluene is lower than that of pure [60] fullerene in toluene in all the four systems.

The λmax for [60] fullerene in at 30^0C was observed at 334 nm. Similarly λmax for Triton X 100-[60] fullerene in toluene at 30^0C was observed at 338 nm. The λ_{max} for Tween 80 -[60]fullerene in toluene at 30^0C was observed at 332nm.The λ_{max} for CTAB [60]fullerene in toluene at 30^0C was observed at around 334 nm. This is in agreement of previous results published. The small shift in maximum wavelength of Tween 80,Triton X 100,SDS and CTAB –[60] fullerene in toluene systems may be due to the interactions held in between [60] fullerene and surfactant molecules.

It is reported that in solutions sodium dodecyl sulfate, the characteristic band is widened and shifted bathochromically toward 339 nm, a different trend was observed in our system as toluene solution contain [60]fullerene. Similarly for Triton X 100 solution in [60] fullerene toluene shows little bathochromic shift at 338 nm. Eastoe et al. observed similar results with the proper ratio of C_{60} to reduced Triton X-100. So the bathochromic shift of the characteristic band complement the expanded fullerene particles not only in pure water, but also in organized solutions.

In solutions of Tween 80 sharp 330 nm bands are hypsochromically shifted against that in toluene as per previous findings, similar trend was observed for solutions of Tween 80 and CTAB in [60]fullerene in toluene. In which hypsochromic shift at 332 nm for Tween 80 was observed.

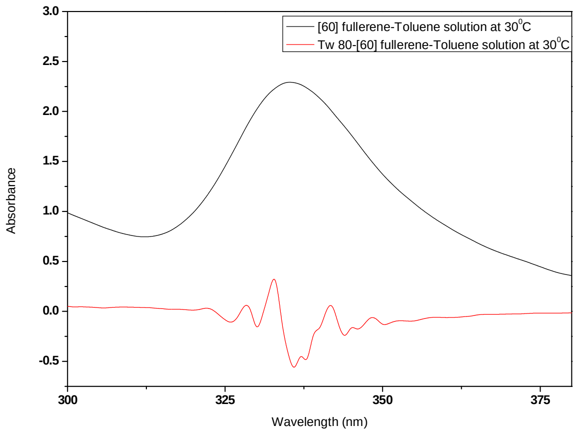


Figure 3.3.a. UV-visible spectrum of [60] fullerene solution and Tween 80-[60] fullerene solution at 30^0C.

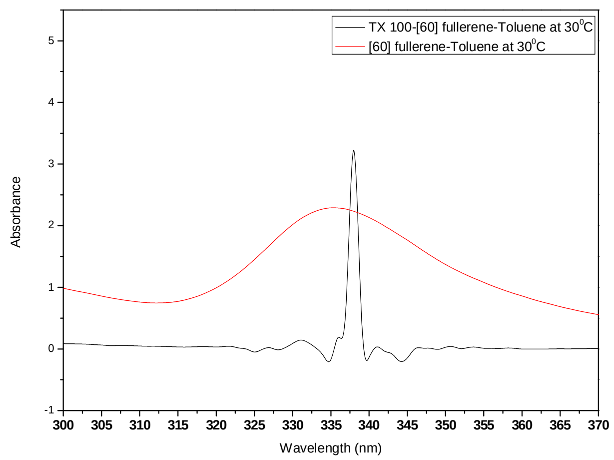


Figure 3.3.b. UV-visible spectrum of [60] fullerene solution and Triton X 100-[60] fullerene solution at 30^0C

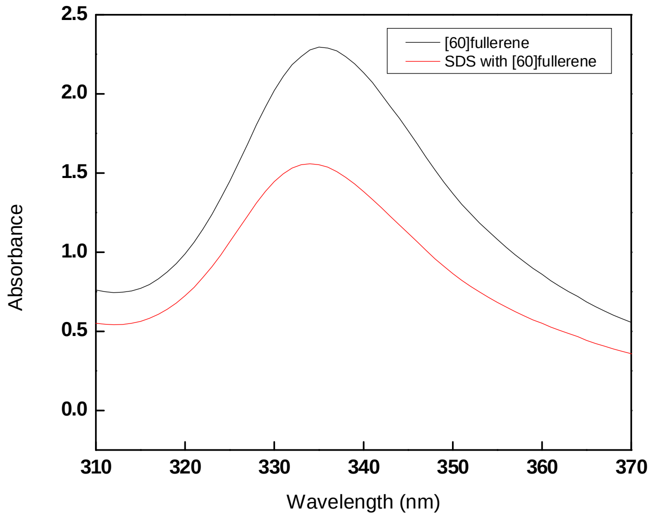


Figure 3.3. c. UV-visible spectrum of [60] fullerene solution and SDS-[60] fullerene solution at 30^0C.

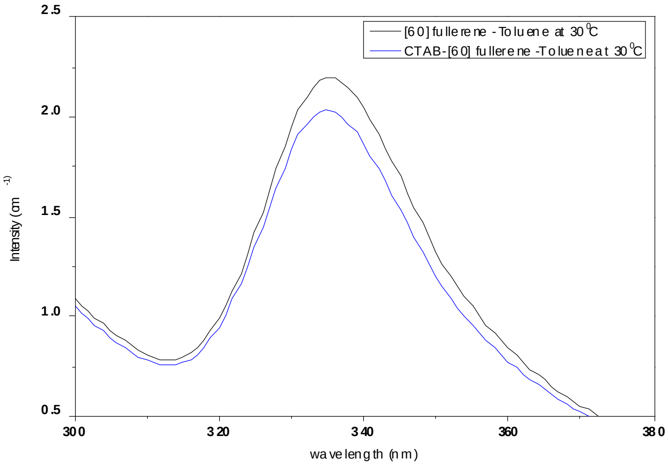
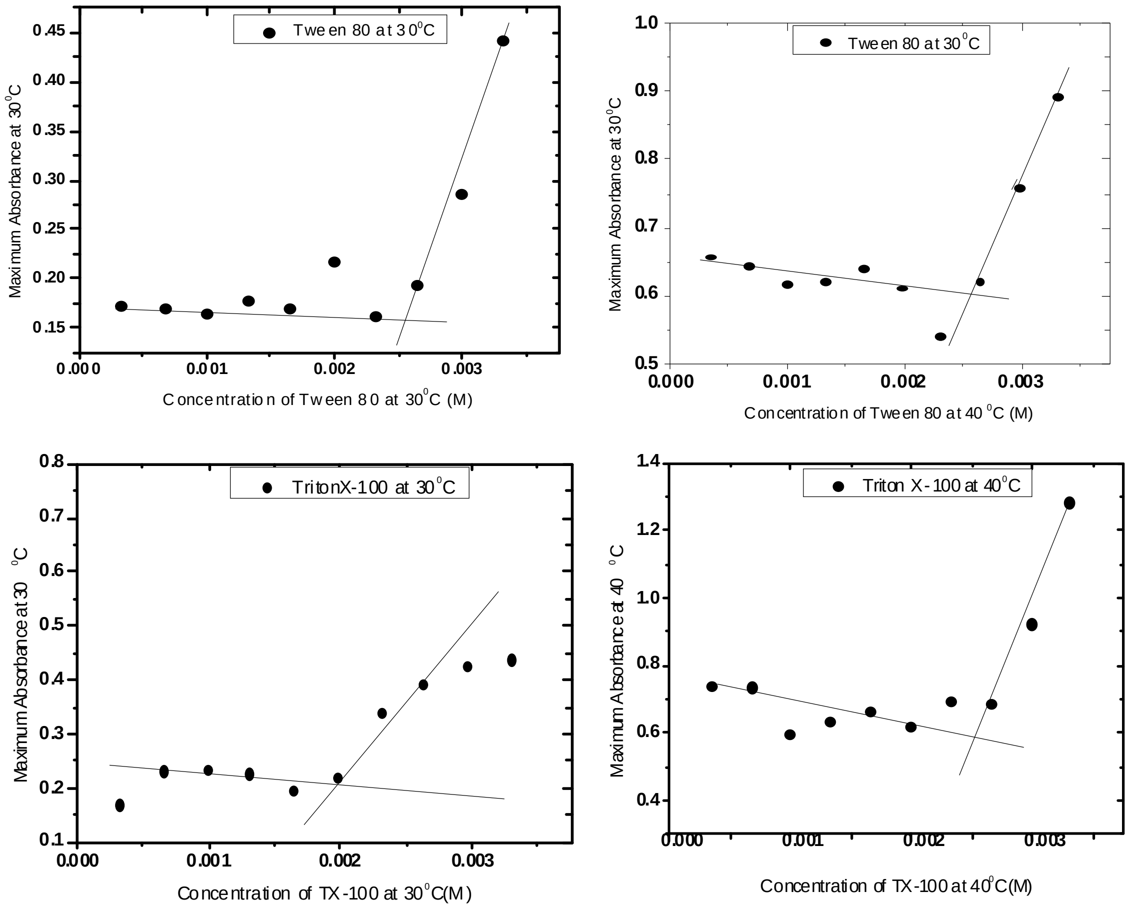


Figure 3.3.d. UV-visible spectrum of [60] fullerene solution and CTAB-[60] fullerene solution at 30^{0}C



Figures 3.4.a.i and 3.4.a.ii as well as 3.4.b .i and 3.4.b.ii Critical reverse micelle for Tween 80-[60] fullerene solution and Triton X-100-[60] fullerene solution at 30^{0}C and 40^{0}C respectively

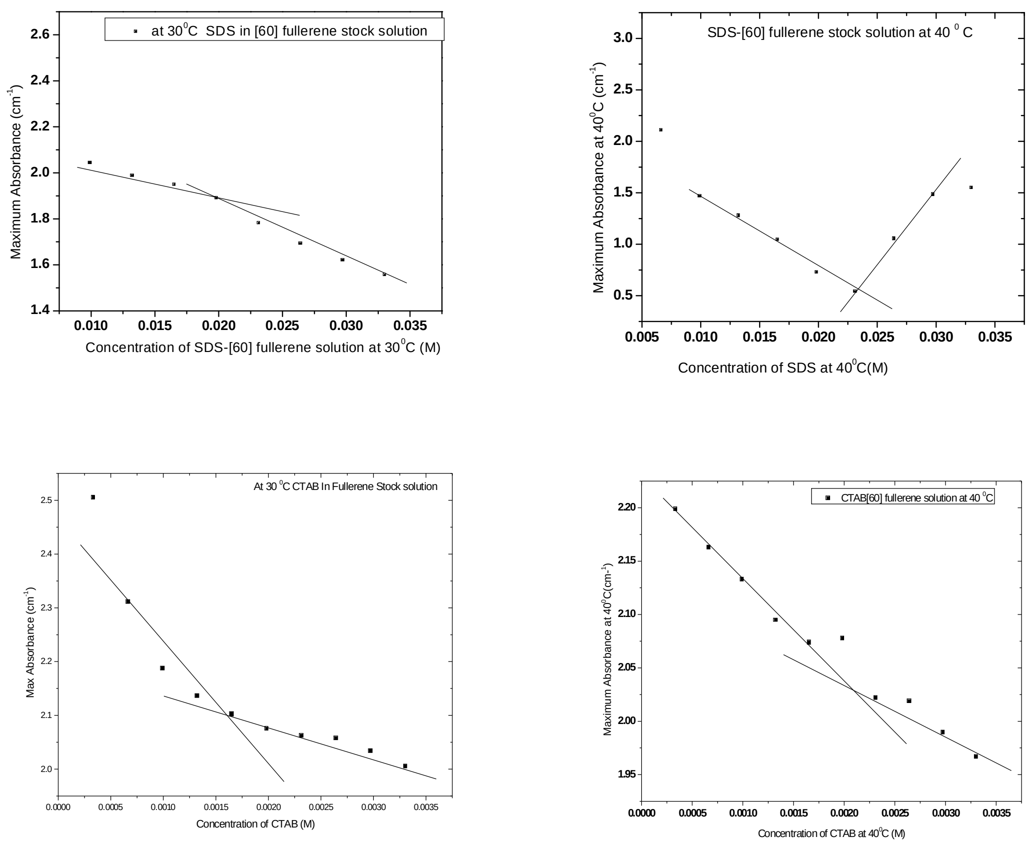
The change in the absorbance values with concentration was not linear but it showed a distinct break point. This break point is C_{rmc} of reverse micellisation at corresponding temperature. From The sharp slope and low C_{rmc} values of this non ionic surfactants at 30°C than 40°C was due to the effect of stability of micelle at higher temperatures.

Table3.4.1. Thermodynamic properties of solution of [60] fullerene-toluene in water with non ionic surfactants Tween 80 and Triton X 100.

Surfactant	**C_{rmc} mM/dm^3**		**-ΔG°$_{rm}$ kJ/mol**		**-ΔH°$_{rm}$ kJ/mol**		**ΔS°$_{rm}$ kJ/mol**	
	30 °C	**40 °C**	**30 °C**	**40 °C**	**30 °C**	**40 °C**	**30 °C**	**40 °C**
Tween 80	0.00253	0.00259	15.06	15.49	2.06	2.199	0.0429	0.0425
Triton X - 100	0.00199	0.00254	15.68	15.59	17.55	18.73	-0.00617	-0.0100

Critical reverse micelle value for Tween 80-[60] fullerene solution obtained was $2.5*10^{-3}$ mM /dm^3 at 30^{0}C while critical reverse micelle value for Tween80-[60] fullerene-toluene solution obtained was $2.6*10^{-3}$ mM /dm^3 at 40^{0}C. Critical reverse micelle value for Triton X 100-[60] fullerene-toluene solution obtained was $1.9*10^{-3}$ mM /dm^3 at 30^{0}C. Critical reverse micelle value for Triton X 100-[60] fullerene-toluene solution obtained was $2.5*10^{-3}$ mM /dm^3 at 40^{0}C. C_{rmc} increases as temperature increases in case of Trion X 100 but negligible change in the value of C_{rmc} of Tween 80 was observed at higher temperature. The thermodynamic properties (ΔG°, ΔH° and ΔS°) of reverse micellisation of Tween 80 and Triton X 100 in toluene- [60] fullerene solution at 30ºC and 40ºC were calculated and the results show that though there is significant change in the overall ΔG°, there was significant decrease in the enthalpic interactions with a corresponding decrease in the entropy for reverse micellization in toluene in case of Triton X 100. For Tween 80 no significant change in ΔG^0 was observed compared to Triton X 100 surfactant. The values of ΔG°, ΔH° and ΔS° are negative indicating the spontaneous and exothermic formation of a reverse micelle.

The value of ΔG° changes from 15.06 kJ/mol to 15.49 kJ/mol as temperature rises from 30ºC to 40ºC for Tween 80. The value of ΔS° changes from 0.0429kJ/mol to 0.0425 kJ/mol as temperature rises from 30ºC to 40ºC for Tween 80. The values of enthalpies in Tween 80-[60] fullerene-toluene solution ΔH° showed decrease from 2.06kJ/mol to 2.199 kJ/mol as temperature rises from 30ºC to 40ºC. The value of ΔG° changes from 15.68kJ/mol to 15.59 kJ/mol as temperature rises from 30ºC to 40ºC for Triton X 100. The value of ΔS° decreases from0.00617 kJ/mol to0.0100 kJ/mol as temperature rises from 30ºC to 40ºC for Triton X 100. The values of enthalpies in Triton X 100-[60] fullerene-toluene solution ΔH° showed decrease from 17.55kJ/mol to 18.73 kJ/mol as temperature rises from 30ºC to 40ºC.



Figures 3.4.c .i and 3.4.c.ii 3.4.d.i and 3.4.d.ii Critical reverse micelle for SDS-[60] fullerene solution and CTAB-[60] fullerene solution at 30^0C and 40^0C respectively

The change in the absorbance values with concentration was not linear but it showed a distinct break point. This break point is C_{rmc} of reverse micellisation at corresponding temperature. From The sharp slope and low C_{rmc} values of this ionic surfactants at 30°C than 40°C was due to the effect of stability of micelle at higher temperature.

Table3.4.2. Thermodynamic properties of solution of [60] fullerene-toluene in water with surfactants SDS and CTAB

Surfactant	C_{rmc} mM/dm^3		$-\Delta G°_{rm}$ kJ/mol		$-\Delta H°_{rm}$ kJ/mol		$\Delta S°_{rm}$ kJ/mol	
	30 °C	**40 °C**	**30 °C**	**40 °C**	**30 °C**	**40 °C**	**30 °C**	**40 °C**
SDS	0.0201	0.0234	15.27	15.61	6.64	7.91	0.0098	0.0057
CTAB	0.0016	0.0021	16.19	16.04	19.75	21.079	-0.0117	-0.0161

Critical reverse micelle value for SDS-[60] fullerene solution obtained was $2.0*10^{-2}$ mM/dm^3 at 30^{0}C while critical reverse micelle value for SDS-[60] fullerene-toluene solution obtained was $2.34*10^{-2}$ mM/dm^3 at 40^{0}C. Critical reverse micelle value for CTAB-[60] fullerene-toluene solution obtained was $1.6*10^{-3}$ mM/dm^3 at 30^{0}C. Critical reverse micelle value for CTAB-[60] fullerene-toluene solution obtained was $2.1*10^{-3}$ mM/dm^3 at 40^{0}C. This showed an increase in value of C_{rmc} as temperature increases like CMC. Similar trend was observed as in SDS-[60] fullerene-toluene solution. The obtained results are in agreement of the previous data published.

The thermodynamic properties (ΔG°, ΔH° and ΔS°) of reverse micellisation of SDS and CTAB in toluene-[60] fullerene solution at 30ºC and 40ºC were calculated and the results showed that overall ΔG° changes slightly, there was significant decrease in the enthalpic interactions with a corresponding increase in the entropy for reverse micellization in toluene. The value of ΔG° changes from 15.27kJ/mol to 15.61 kJ/mol as temperature rises from 30ºC to 40ºC for SDS. The value of ΔS° increases from 0.0098 kJ/mol to 0.0057 kJ/mol as temperature rises from 30ºC to 40ºC for SDS. The values of enthalpies in SDS-[60] fullerene-toluene solution ΔH° showed decrease from 6.64kJ/mol to 7.91 kJ/mol as temperature rises from 30ºC to 40ºC.

The value of ΔG° changes from 16.19 kJ/mol to 16.04 kJ/mol as temperature rises from 30ºC to 40ºC for CTAB. The value of ΔS° decreases from 0.0117 kJ/mol to 0.0161 kJ/mol as temperature rises from 30ºC to 40ºC for CTAB. The values of enthalpies in CTAB-[60] fullerene toluene solution ΔH° showed decrease from 19.75kJ/mol to 21.08 kJ/mol as temperature rises from 30ºC to 40ºC.

The values of ΔG°, ΔH° and ΔS° are negative indicating the spontaneous nature at low temperatures and exothermic formation of a reverse micelle.

This hydrophobic, non polar [60]fullerene forms the reverse micelle with SDS in toluene in presence of ethanol. As shown in Figures 3.4.(a)(b)(c)(d) the reverse micelle of [60]fullerene can be explained on the basis of different possibilities with the spherical or lamellar structures. Due to the ionic nature of SDS, micelles are formed with [60]fullerene partially getting entrapped into hydrophobic part of micelle and the micelle is also stabilized by the negatively charged surface of [60]fullerene clusters by electrostatic repulsion between the negatively charged exterior of [60]fullerene aggregates and the polar heads of SDS.

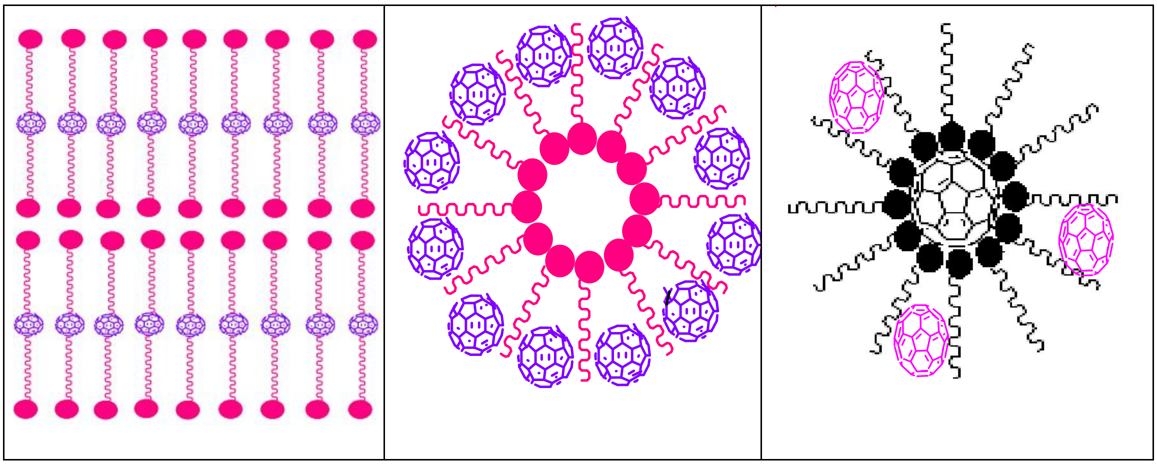


Figure 3. 4. a, b and c Possible reverse micelle structures for non ionic and ionic Surfactants in [60] fullerene solution

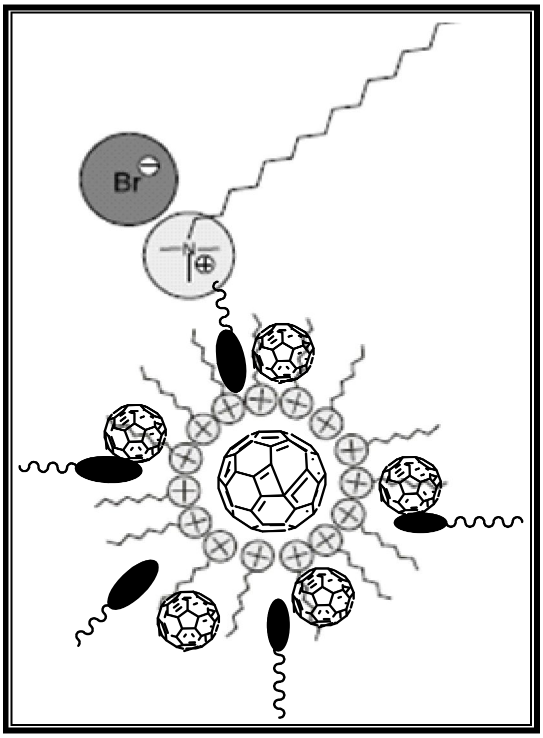


Figure 3.4.d. Schematic representation of water-in-oil reverse micelles cationic surfactant salt CTAB (Cetyltrimethylammonium bromide)

As hydrophobic molecule should be located within the micellar hydrocarbon core, while charge transfer interactions of highly electron accepting [60] fullerene may lead to place its site near the hydrophobic portion of micelle. It may be considered that fullerene molecule may exhibit as partly solubilized molecule within surfactant micelle and partly as a stabilized species by the surfactant. Such a dual state may be exhibited in nonionic surfactant (Tween 80 and Triton X 100) microemulsion systems showing w/o microemulsion, in which [60] fullerene forms reverse micelle on inverse micelle structure.

3.4. Fluorescence Spectra of [60] fullerene-toluene solution/Water/surfactant/ 1-alkanol (co-surfactant) microemulsion system

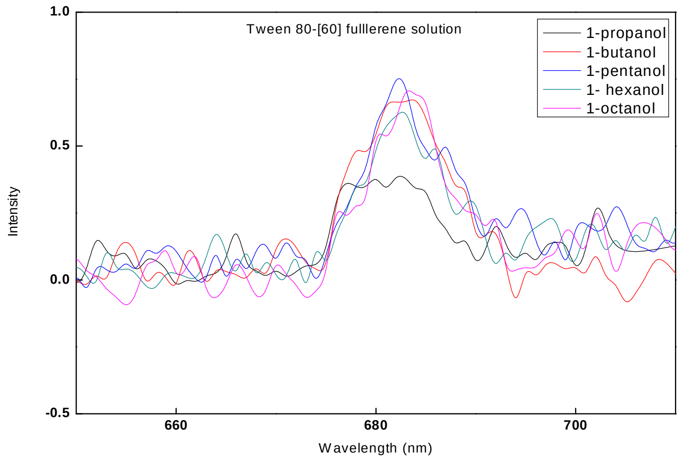


Figure3.5.a. Fluorescence spectra of [60] fullerene-toluene solution/Water/Tween80/ 1-alkanol (co-surfactant) microemulsion system.

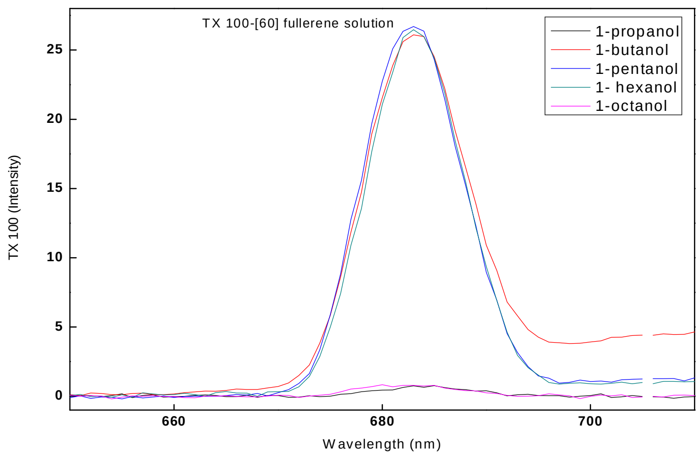


Figure3.5. b. Fluorescence spectra of [60] fullerene-toluene solution/water/ Triton X 100/1-alkanol (co-surfactant) microemulsion system

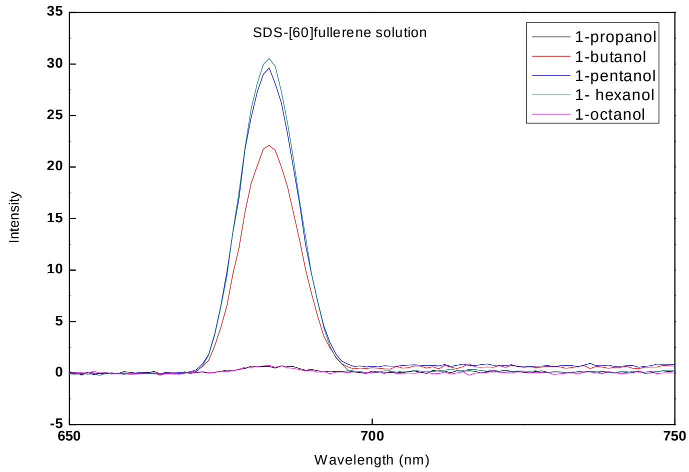


Figure 3.5.c. Fluorescence spectra of [60] fullerene-toluene solution/water/SDS/ 1-alkanol (co-surfactant) microemulsion system

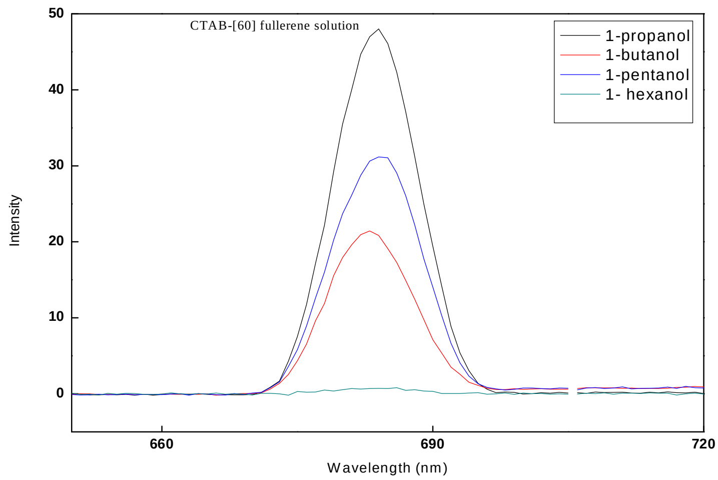


Figure 3.5.d. Fluorescence spectra of [60] fullerene-toluene solution/water/CTAB/ 1-alkanol (co-surfactant) microemulsion system

Fluorescence study of microemulsion systems with Tween 80, Triton X 100, SDS and CTAB were carried out at 340 nm excitation. Photophysical properties of fullerenes have been extensively studied but in this work we attempted to study photophysical properties of microemulsion systems containing [60] fullerene at room temperature. As reported previously [60] fullerene give peaks at 525 and 700 nm at 400 nm excitation at room temperature in toluene solvent. For which observed fluorescence of C_{60} -toluene solution is weak and broad at room temperature. This interprets that the high icosahedral symmetry of C_{60} is nearly maintained due to the weak interaction between C_{60} molecules and toluene molecules. Figure 3.5.a,b,c and d shows the fluorescence spectra for microemulsion system [60] fullerene-toluene/water with surfactants Tween 80, Triton X 100,SDS and CTAB respectively adding different co-surfactants 1-alkanols at room temperature.i.e.at 30^0C. Our results illustrate that [60] fullerene-toluene solution gives peak at 700nm at room temperature which is in agreement of previous results given by Kim et al and Y Zhao et al.

Figure 3.5.a displays the weak and broad fluorescence spectra of [60] fullerene /toluene/water with Tween 80 and 1-alkanols shows peak at 682 nm. It can be seen from the spectra as nature of co-surfactants changes to more polar i.e. from 1-octanol to 1-propanol intensity of peaks decreases. Figure 3.5.b displays the sharp and strong fluorescence spectra of [60] fullerene toluene-Water with Triton X 100-1-alkanols shows peak at 683 nm. Figure 3.5.c displays the sharp and strong fluorescence spectra of [60] fullerene toluene-Water with SDS-1-alkanols shows peak at 685 nm. Figure 3.5.d displays the sharp and strong fluorescence spectra of [60] fullerene toluene-Water with CTAB -1-alkanols shows peak at 684 nm. The intensity of fluorescence for C_{60} is increased in order of the co-surfactants along with fine fluorescence structures for C_{60}. This shows that the solute–solvent interaction is stronger which results in higher distortion in the symmetry of [60] fullerene molecule. The solvents having effective electron donor capacity shows comparatively strong interaction with fullerenes due to formation of the charge transfer adduct, which could highly distort the molecular symmetry and lead to the strong and well-resolved fluorescence.