

# Influence of co-surfactant chain length on volume-induced electric percolation of n-heptane/water/AOT microemulsions

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## Introduction

The percolation of conductance is an interesting physical phenomenon in w/o microemulsion. At constant temperature after a threshold volume fraction of water, exhibit significant rise in the conductance.

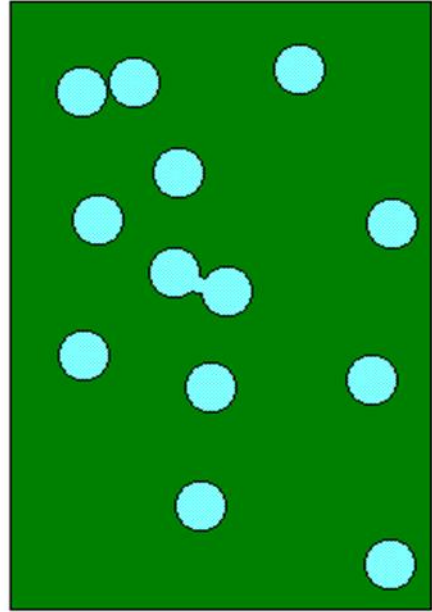


Fig 1: Before threshold volume fraction of water

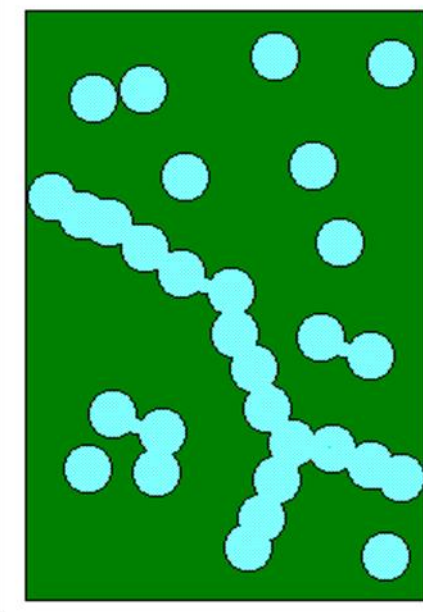
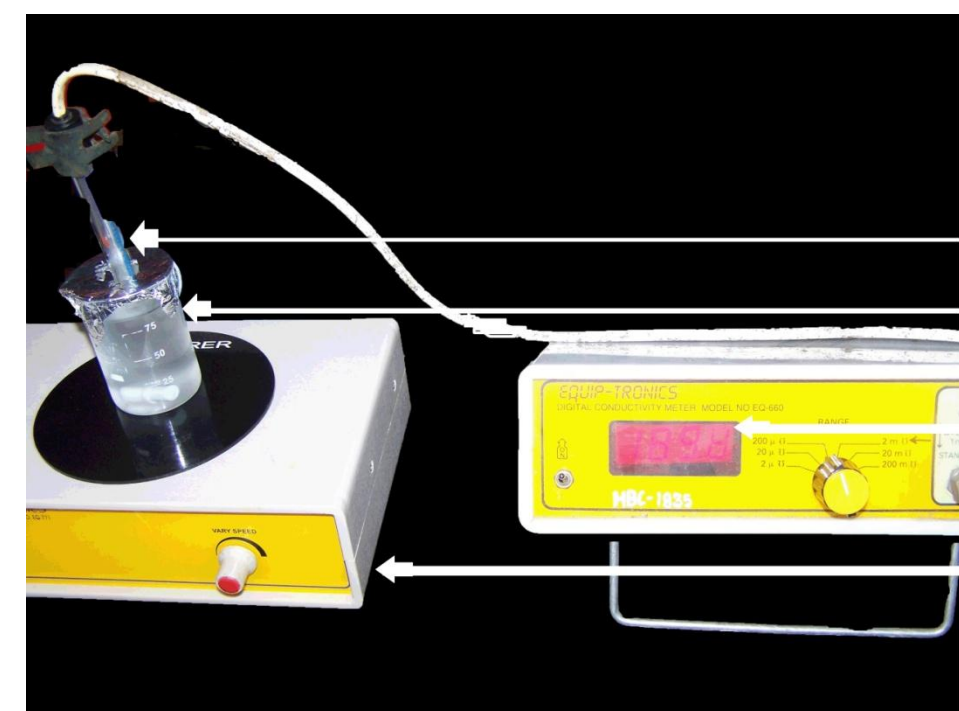


Fig 2: After threshold volume fraction of water

Though percolation in microemulsions has been studied in detail, the role of co-surfactant hydrophobicity and nature of electrolytes on energetics of percolation is seldom understood. In recent years, significant efforts have been made to understand the effect of co-surfactant and electrolytes on percolation phenomenon. [1].

In the current study, attempts have been made to identify the role of alkyl chain length of n-alcohols on percolation phenomenon using conductivity measurements. The system reported here is AOT/n-heptane/water microemulsion in the presence of alcohols as co-surfactants. The co-surfactant chain length dependence on percolation threshold, Scaling behavior and activation energy for percolation are determined.

## Experimental setup



Conductivity probe, calibrated with 0.01 M KCl solution to  $1413 \times 10^{-6}$  S  
System: Microemulsion of AOT/water/n-heptane + alcohols  
Conductivity meter from the Equip-Tronics the cell constant  $1.02 \text{ cm}^{-1}$   
Remi Cyclo Mixture CM 101, for homogenous mixing

Fig 3: setup of conductivity method used for study of the percolation phenomenon.

## Results

### 1. Effect of water content

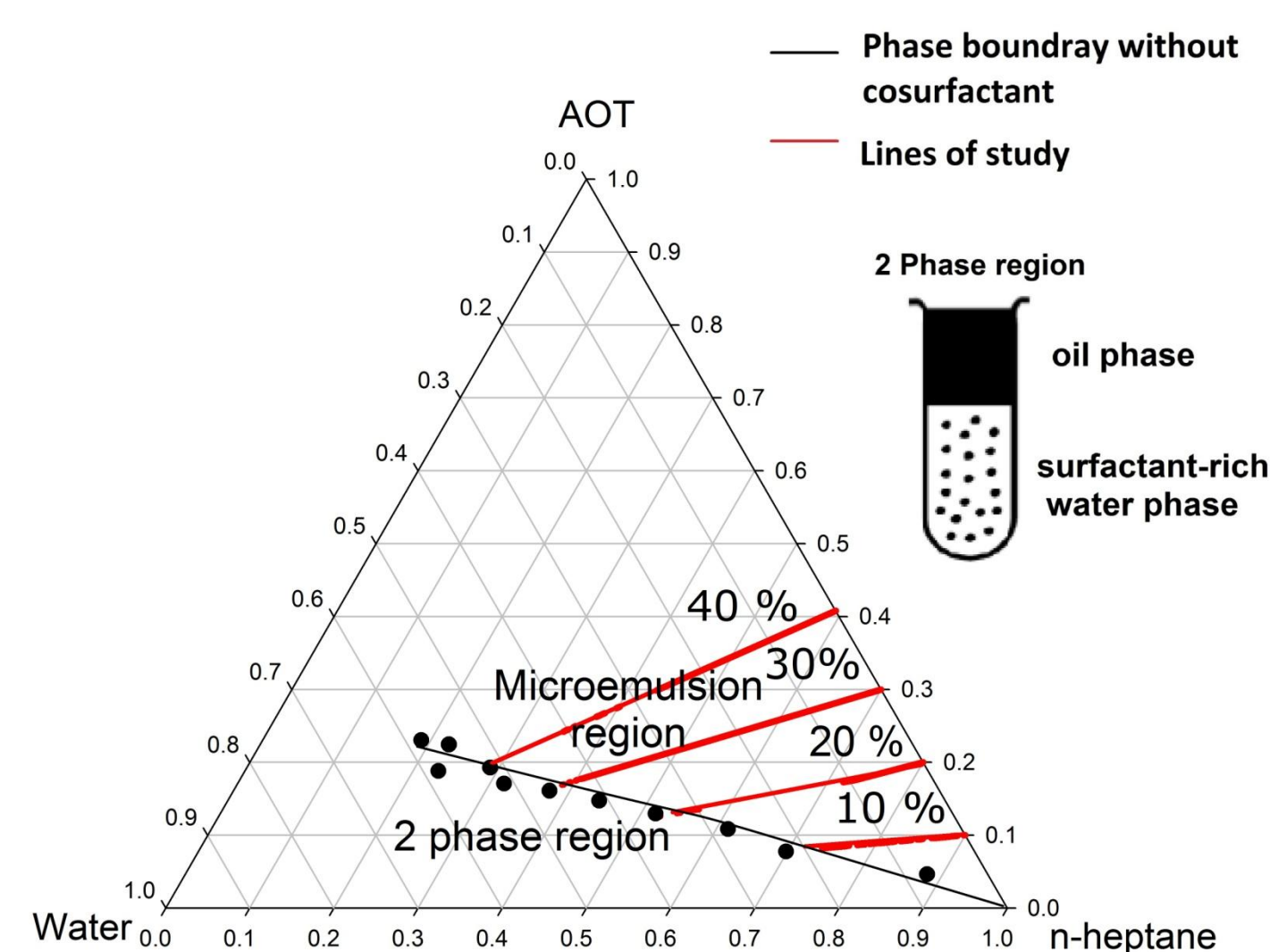


Fig 4: Phase boundary between microemulsion and 2 phase for different AOT concentrations.

Percolation phenomenon was studied along

- 10, 20, 30 and 40 w/w% of initial concentration of AOT in n-heptane.
- with water content as variable.

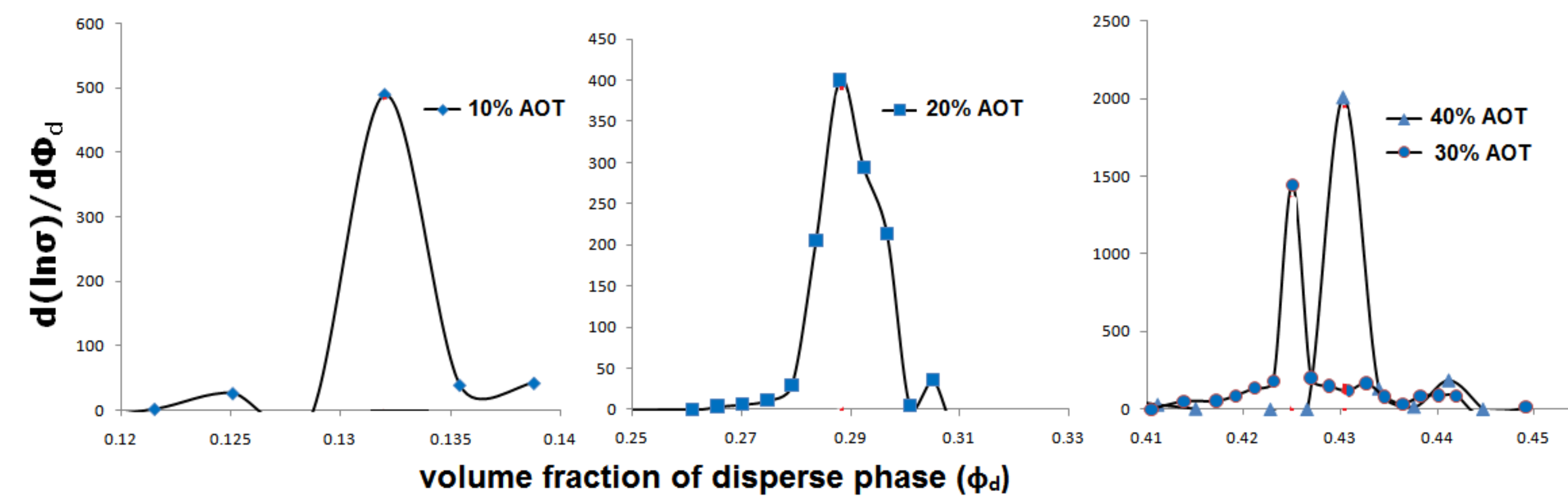


Fig 5: Differential variation in the conductivity of the system as a function of volume fraction of water at different AOT concentration.

The following equations were used to analyses of these graphs and results are shown in the Table 1.

1. Scaling equation:-

$$\sigma = K (\Phi_d - \Phi_d^t)^\alpha \quad \text{---- (1)}$$

2. Thermodynamic parameter:

$$\Delta G_{cl} = RT \ln (\Phi_d^t) \quad \text{---- (2)}$$

Where,

$\sigma$  = conductance of microemulsion system

$\Phi_d$  = volume fraction of disperse phase

$\Phi_d^t$  = volume fraction at the percolation threshold

$K$  = constant related to the specific conductance of dispersion

Table 1

Line of study	$(\Phi_d^t)$	$\alpha$	$\Delta G_{cl} / \text{kJmol}^{-1}$
10%	0.13	0.22	-5.17
20%	0.29	0.87	-3.13
30%	0.42	0.91	-2.19
40%	0.43	1.7	-2.14

### 2. Function of co-surfactant

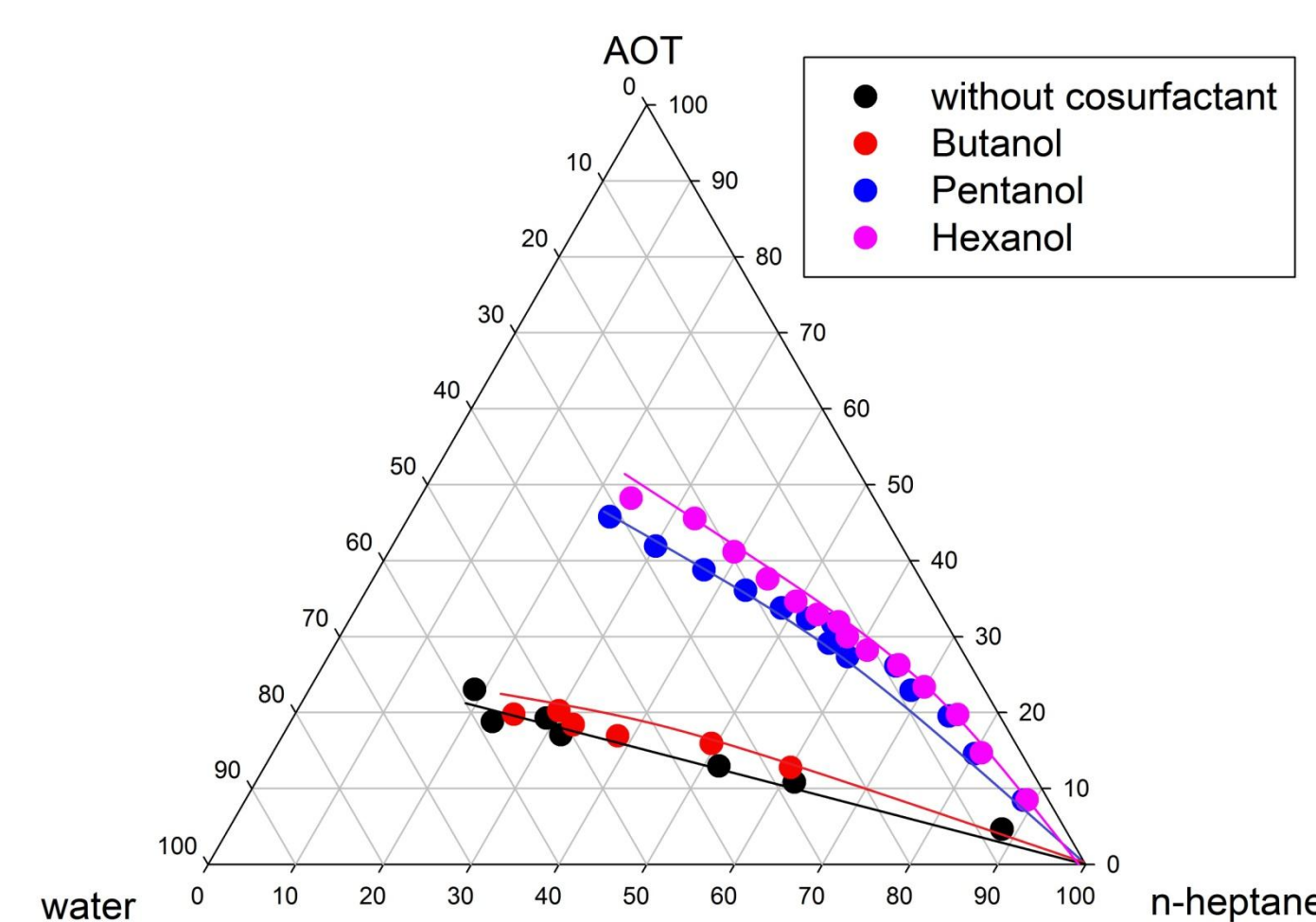


Fig 6 : Phase diagram in presence of alcohol as co-surfactant

Volume induced percolation was carried out at two concentrations of (AOT + alcohol) in heptane corresponding to 30% and 40% w/w, for various alcohols as co-surfactants by fixing the ratio of concentration of alcohol : AOT as 4:1 by moles.

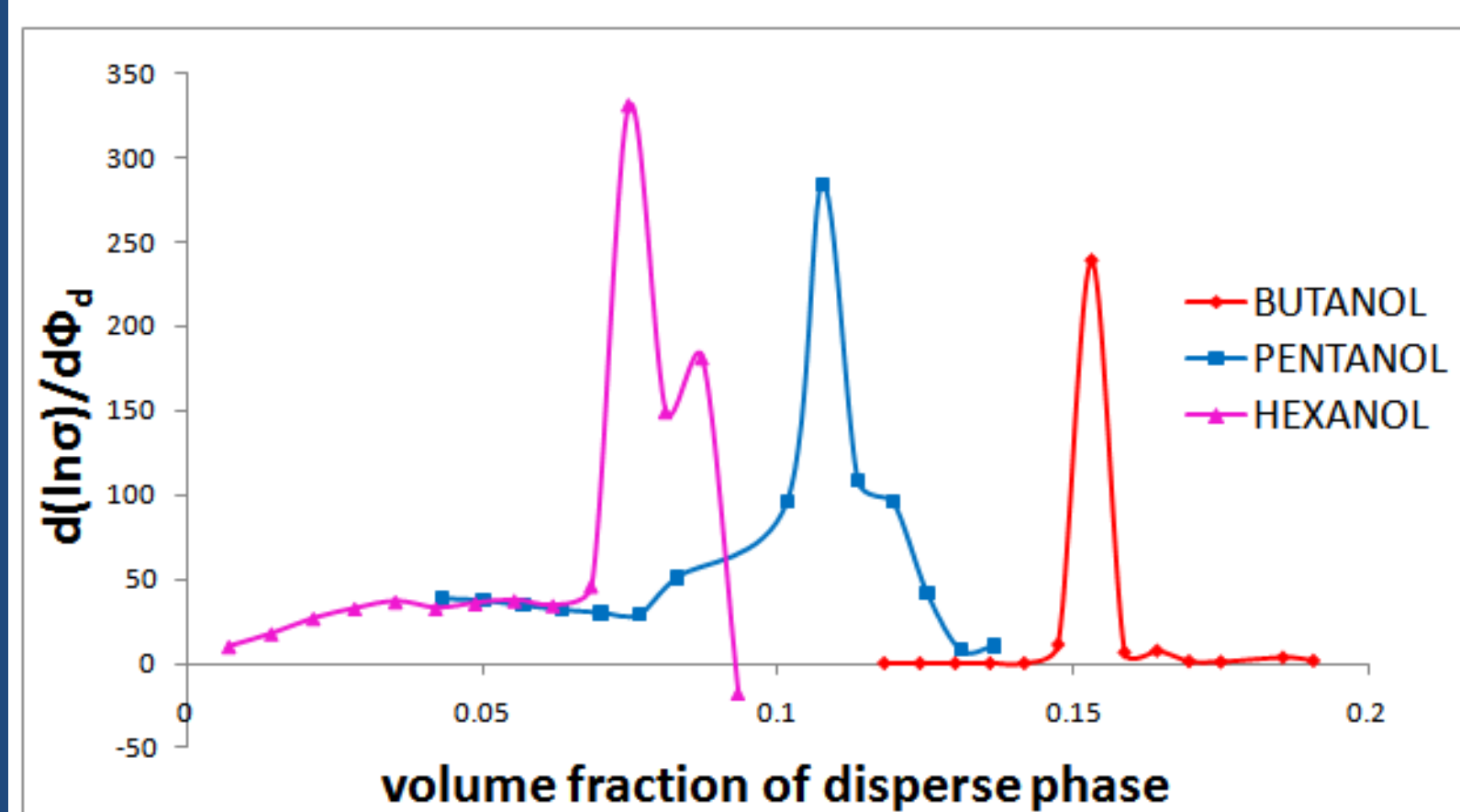


Fig 7 : Volume induced percolation for 40 w/w% of AOT + alcohol in heptane

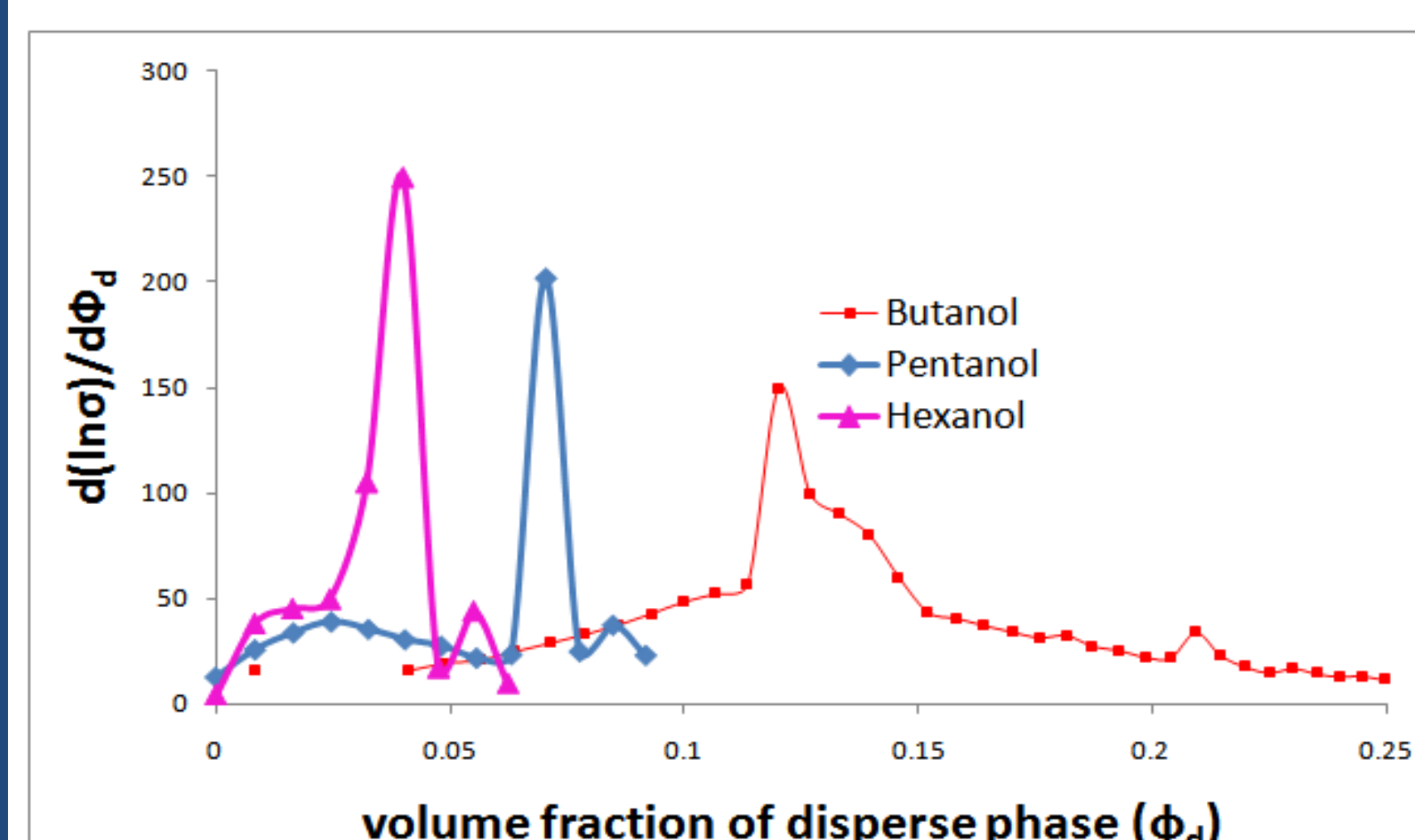


Fig 8: Volume induced percolation for 30 w/w% of AOT + alcohol in heptane

Both microemulsion phase boundary and percolation threshold are affected by changes in alcohols chain length (Fig 6,7,8).

Table 2

Alcohol	w/w ratio of AOT + alcohol in heptane	$\Phi_d^t$	$\alpha$	$\Delta G_{cl} / \text{kJmol}^{-1}$
Butanol	40%	0.15	0.33	-4.8
Pentanol	40%	0.11	0.43	-5.7
Hexanol	40%	0.07	0.64	-6.6
Butanol	30%	0.12	0.44	-5.4
Pentanol	30%	0.07	0.47	-6.7
Hexano1	30%	0.04	0.66	-8.1

### 3. Effect of mixed co-surfactant

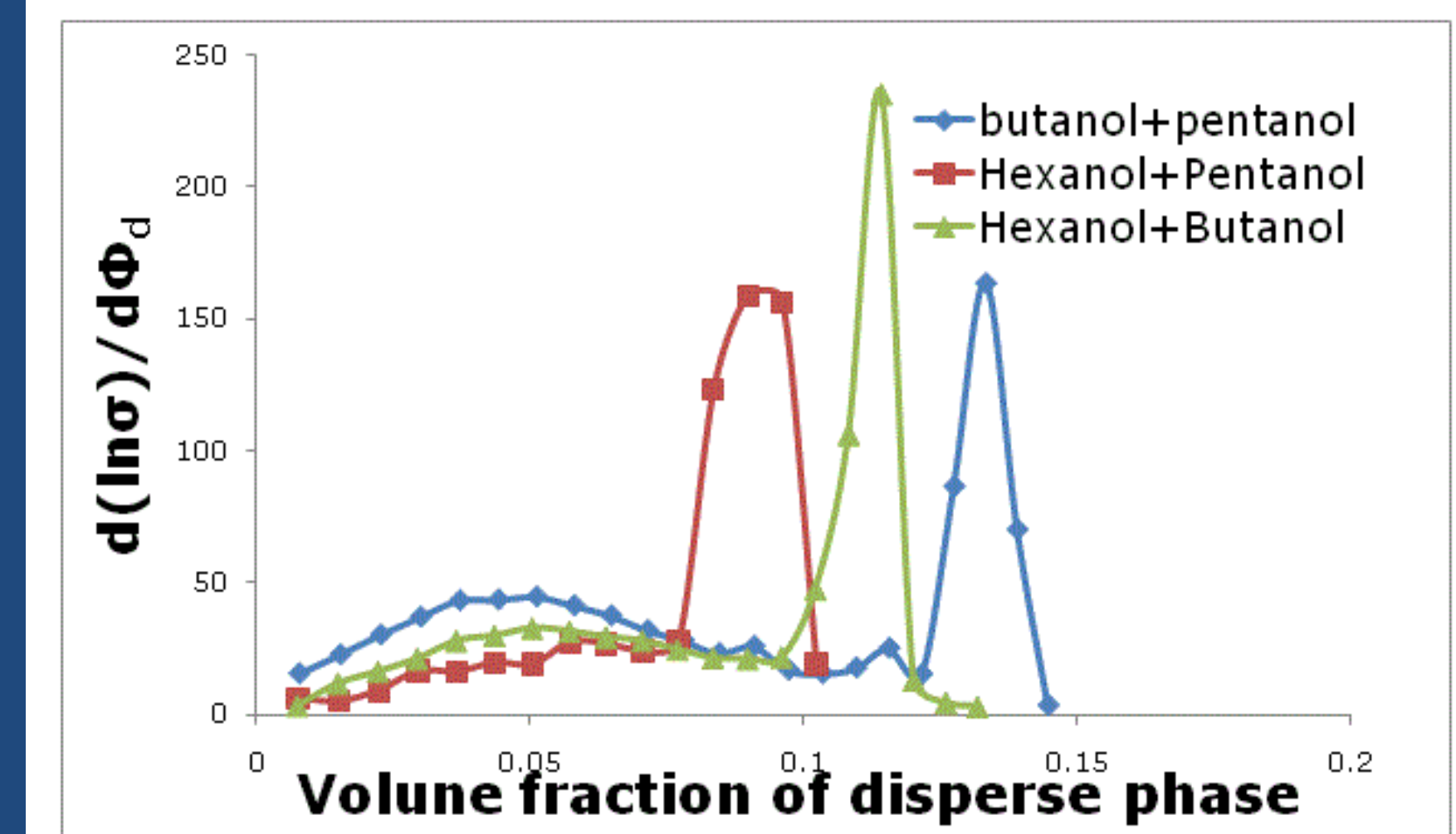


Fig 9: Differential variation in the conductivity of the system as a function of volume fraction of water at different (AOT + alcohols) concentrations

Similar experiments were repeated with binary mixed alcohols systems with initial concentration of (AOT + alcohols) in heptane = 40 % w/w. Results obtained are shown in Table 3.

Table 3

co-surfactant	$\Phi_d^t$	$\alpha$	$\Delta G_{cl} / \text{kJmol}^{-1}$
Butan-1-ol + Pentan-1-ol	0.13	0.19	-5.2
Butan-1-ol + Hexan-1-ol	0.11	0.08	-5.6
Pentan-1-ol + Hexan-1-ol	0.09	0.26	-6.1

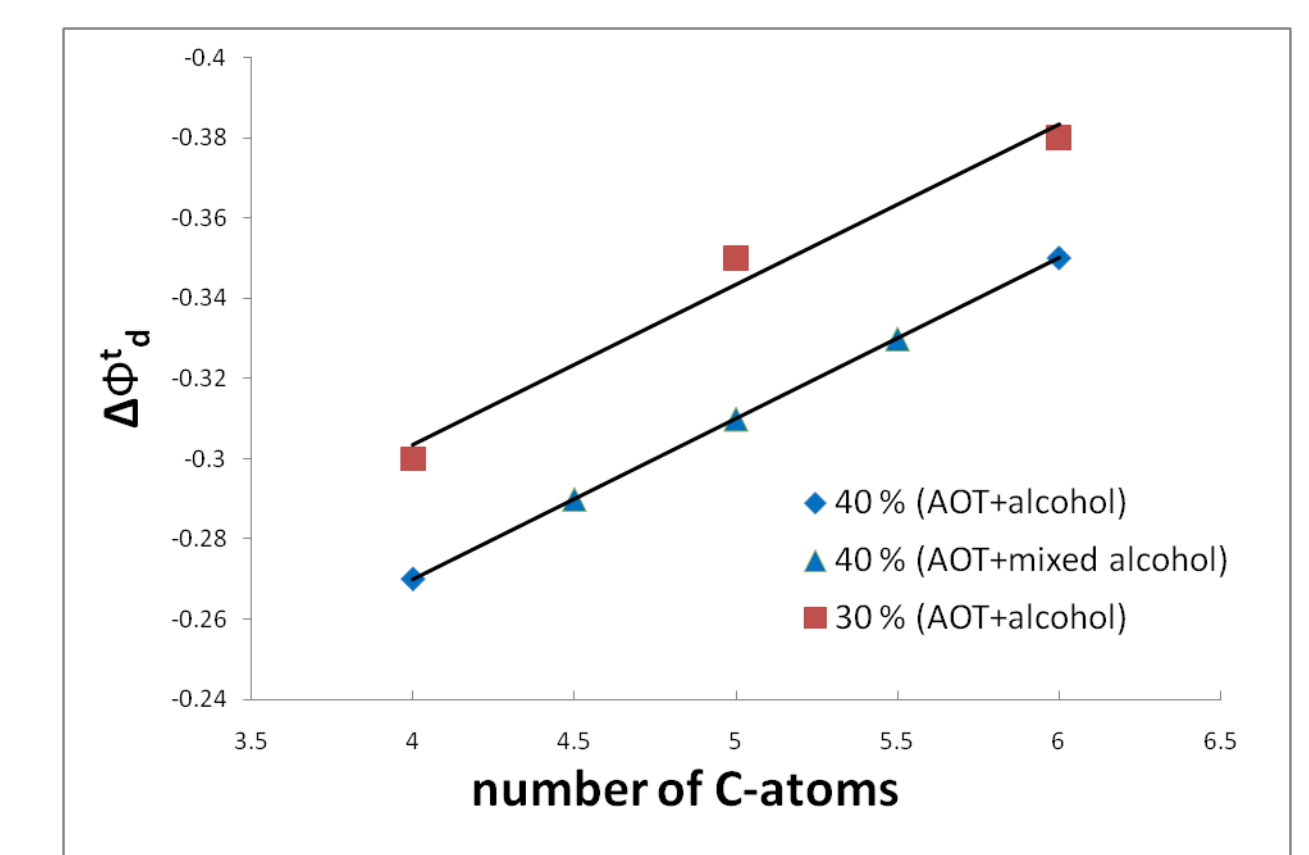


Fig 10: Variation of  $\Delta\Phi_d^t$  as a function of number of C-atoms in alcohol system

## Conclusions

1. Short chain alcohols such as butanol seldom affect the microemulsion phase boundary, long chain alcohols (pentanol and hexanol) significantly lowered water uptake in the microemulsion.
2. Alcohols decrease the percolation threshold of w/o microemulsion significantly.
3. Scaling laws of the percolation are obeyed by the system but the constant and exponents are different from the expected.
4. Percolation is more favored for the long C-chain alcohols.
5. A graph between number of C-atoms in alcohol and  $\Delta\Phi_d^t = \Phi_p^t - \Phi_a^t$  (where  $\Phi_p^t$  and  $\Phi_a^t$  are the threshold volume fraction in presence and absence of co-surfactant) shows a linear relationship. Interestingly this trend is also followed by mixed alcohol systems with their average number of C-atom.

## Reference

[1] S.K. Mehta, S. Shweta and K.K. Bhasin, J. Phys. Chem. B 109 (2005) 9751 – 9759

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