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FLUORINATED SURFACTANTS

IN FIRE FIGHTING FOAMS:

ANY INPUT FOR WATER MIST TECHNOLOGY

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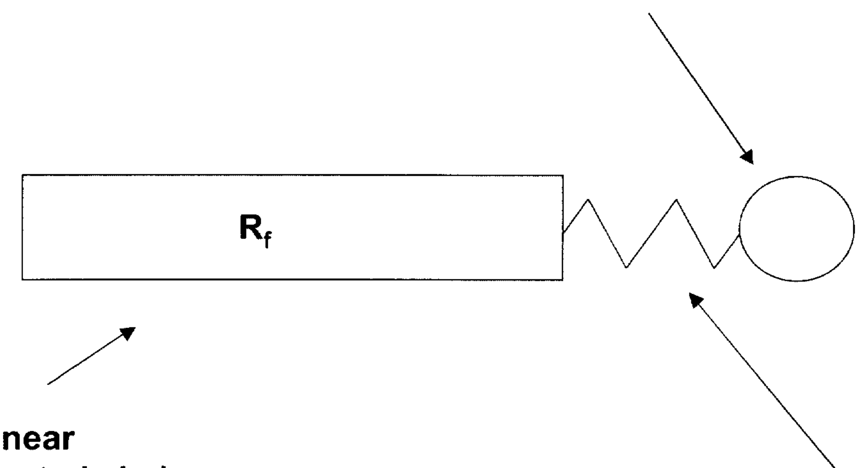
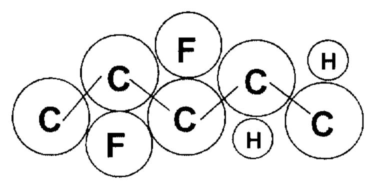
Structure of a fluorinated surfactant



Particularity of the perfluorinated chain

- Higher rigidity than a perhydrogenated chain : (radius of covalently bonded fluorine, only 0,72 Å → no steric stress)



- More hydrophobic than a perhydrogenated chain :

$$1\ CF_2 \Leftrightarrow 1.7\ CH_2$$

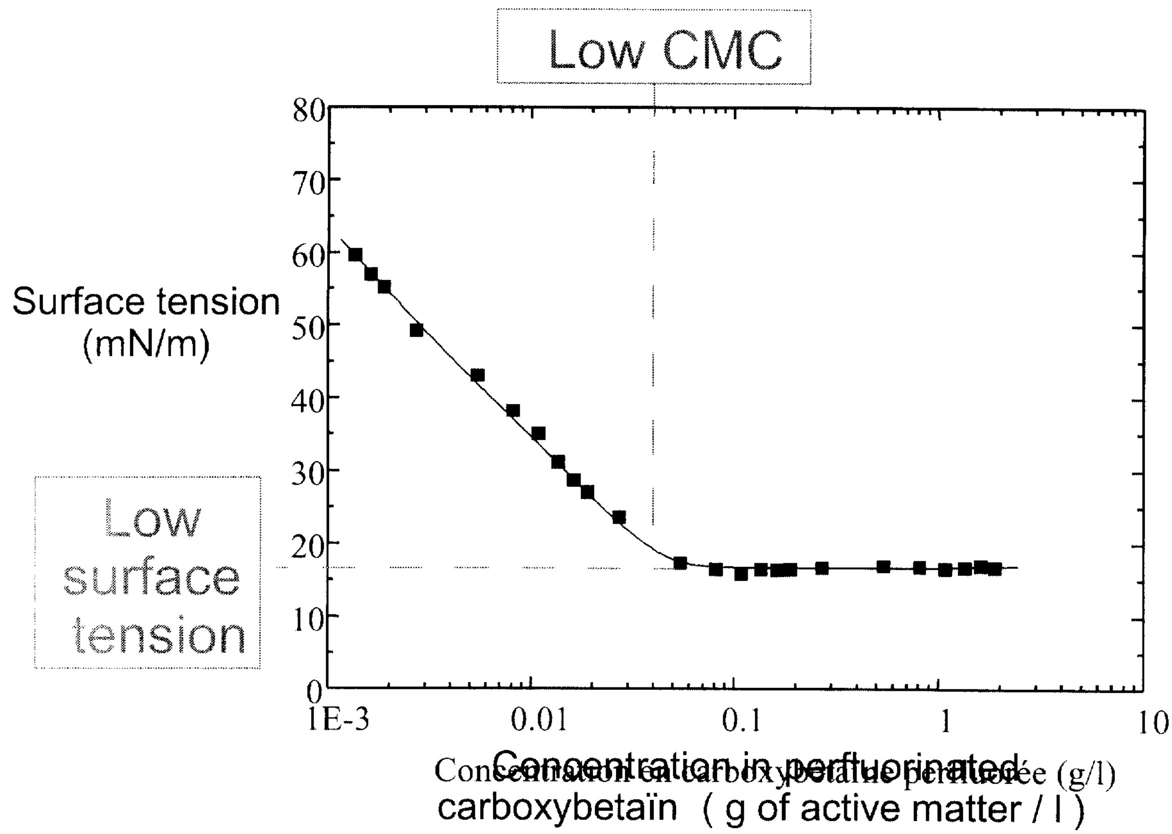
$$\text{Solubility of } CF_4 \text{ in water} = \frac{\text{Solubility of } CH_4 \text{ in water}}{7}$$

- Element with the Highest electronegativity

  ⇒ the valence electron is strongly attracted by the fluorine atome

⇒ Great thermal and chemical stability

Perfluorinated carboxybetaïn in aqueous solution



THERMAL STABILITY

Products	Charge	Loss of Mass (wt%)				
		100ÅC (212ÅF)	200ÅC (392ÅF)	300ÅC (572ÅF)	400ÅC (752ÅF)	500ÅC (932ÅF)
FORAFAC 1033	Anionic	0	56	94	96	98
FORAFAC 1176	Anionic	0	0	0	50	85
FORAFAC 1157	Amphoteric	0	0	87	95	100
FORAFAC 1183	Amphoteric	0	65	92	100	100

PARTICULARITY OF THE PERFLUORINATED CHAIN/ consequences on the surfactant properties

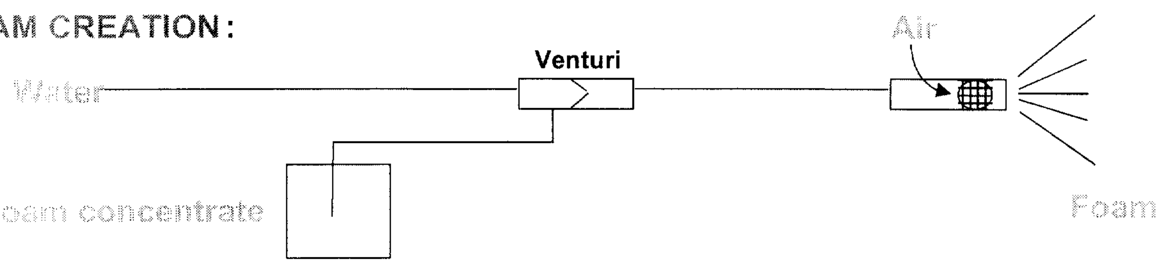
Property	**Type of surfactant**		
	Hydrocarbon	**Silicone**	**Fluorochemical**
Effectiveness (mN/m)	30 and up	20-35	16-20
Efficiency (weight percent)	0.5-5	0.1-0.5	0.01-0.05
Stability : Strong acid/alkaline Oxidising media Thermal	 Poor Poor Medium	 Medium Poor Medium	 Excellent Excellent Excellent
Activity in organic media	Poor to none	Medium-Good	Very good
Relative price index	1	About 10	About 100

USE OF AQUEOUS FOAM FOR FIRE FIGHTING
(SOLVENT FIRE)

FOAM used to :
- **Stop the vapor emission**
- **Prevent flames from heating the solvent**

REQUIRED PROPERTIES:
- **Thermal stability as high as possible**
- **Positive spreading coefficient on the solvent**

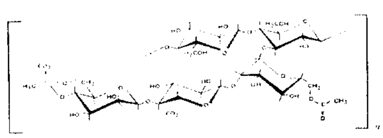
FOAM CREATION :



Composition of a foam concentrate

Hydrocarbon surfactant or protein →	**Foam formation**
FLUORINATED SURFACTANT →	Foam formation Spreading coefficient Thermal stability
Butylcarbytol →	**Foam stabilizer** **cosolvent for surfactants**
1,2 propane diol →	**Protection against freezing**
Polysaccharide →	**Formation of a precipitate at the solvent surface**

Mw ≈ $2{,}5.10^6$



Conditions for a water film formation at the hydrocarbon surface

➡ Spreading coefficient (SC) > 0

Hydrocarbon surface tension

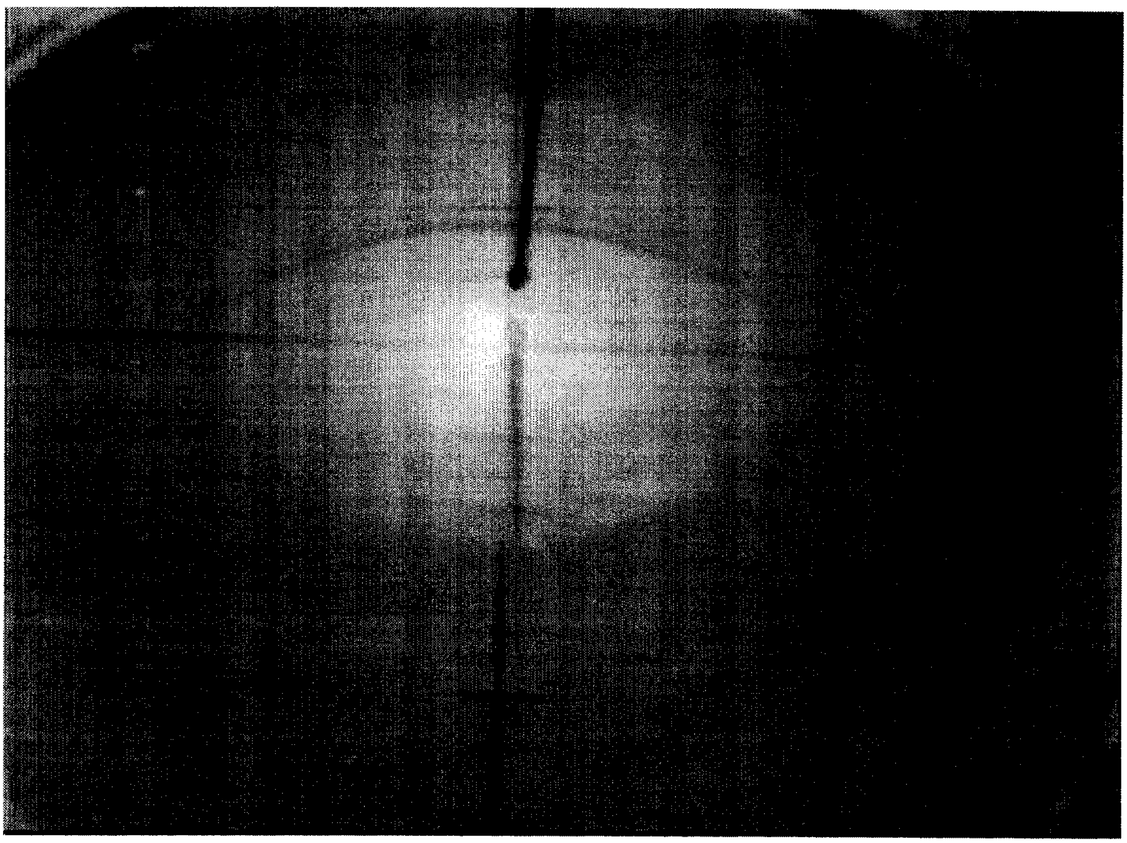
Diluted foam concentrate surface tension

Interfacial tension between diluted foam concentrate and hydrocarbon

$$\boxed{SC = \gamma_{HC} - (\gamma_{S} + \gamma_{I})}$$

Use of fluorinated surfactants in order to lower the surface tension of the diluted foam concentrate

Use of hydrocarbon surfactants in order to lower interfacial tension between diluted foam concentrate and hydrocarbon



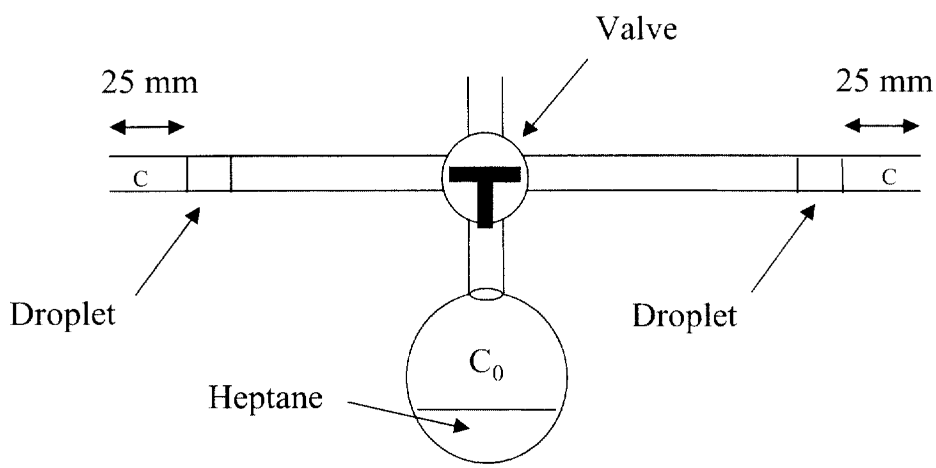
1 g/l of fluorinated carboxybetain

Cyclohexane alone

Effect of a film of water onto heptane's rate of evaporation: role of the surfactants

Goal : **Measurement of the heptane vapours going through :**
- **water**
- **Aqueous solution of fluorinated carboxybetain**
- **Aqueous solution of hydrocarbon surfactants**

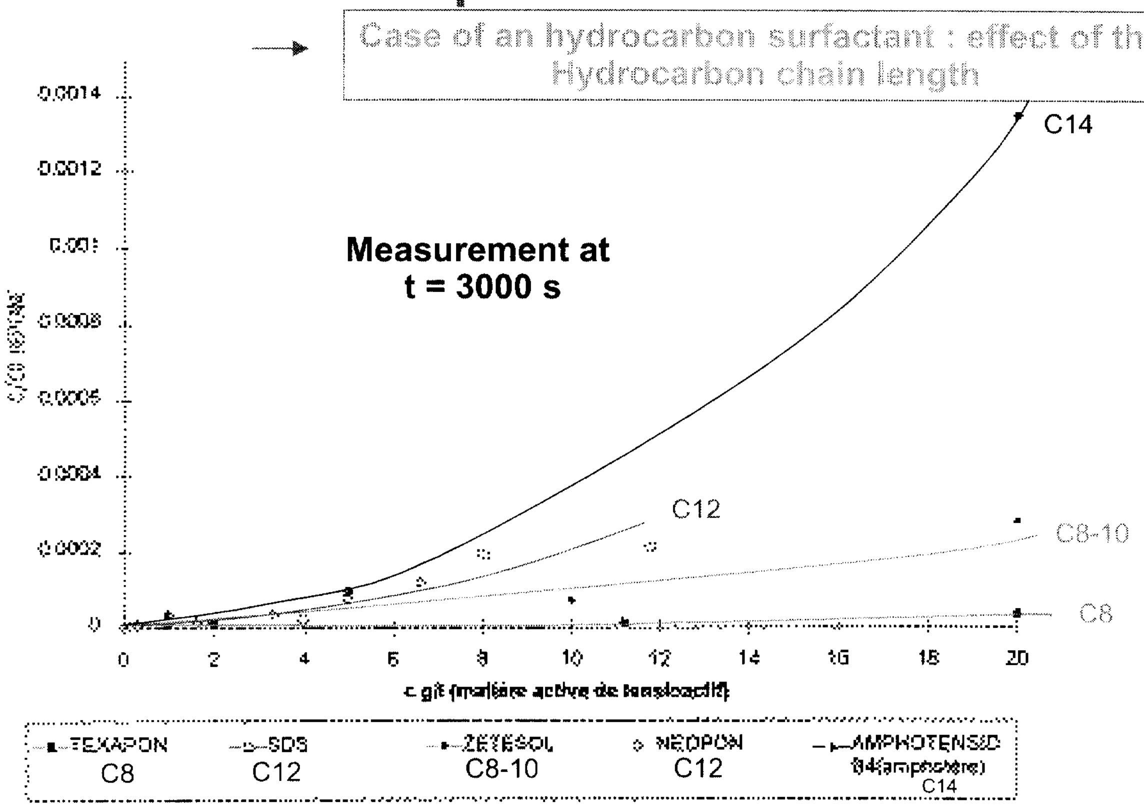
Experimental set up



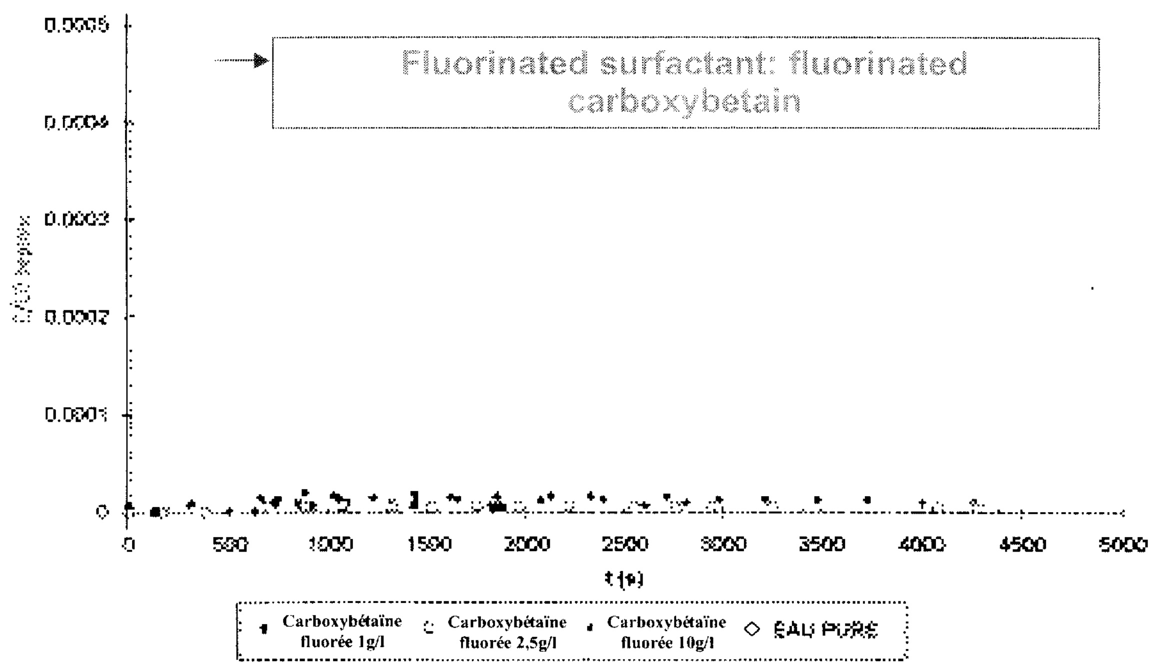
Effect of a film of water onto heptane's rate of evaporation: role of the surfactants

		Formule	CMC en g/l (*)
TENSIOACTIFS HYDROCARBONES ANIONIQUES	Octylsulfate TEXAPON 842	$C_8H_{17}SO_4Na$	20
	Laurylsulfate SDS	$C_{12}H_{25}SO_4Na$	2.4
	Alkylethersulfate en C_8-C_{10} ZETESOL ST	C_nH_{2n+1}-$(O$-$C_2H_4)_p$-SO_4Na (n = 8-10)	2
	Laurylethersulfate NEOPON LOS	$C_{12}H_{25}$-$(O$-$C_2H_4)_p$-SO_4Na (p ~ 2)	0.33
TENSIOACTIF HYDROCARBONE AMPHOTERE	N-alkylbétaine AMPHOTENSID B4	$C_{14}H_{29}$-$N^+(CH_3)_2$-CH_2COO^-	0,02
TENSIOACTIF FLUORE AMPHOTERE	**Fluorinated Carboxybetain**		0,06

Effect of a film of water onto heptane's rate of evaporation: role of the surfactants

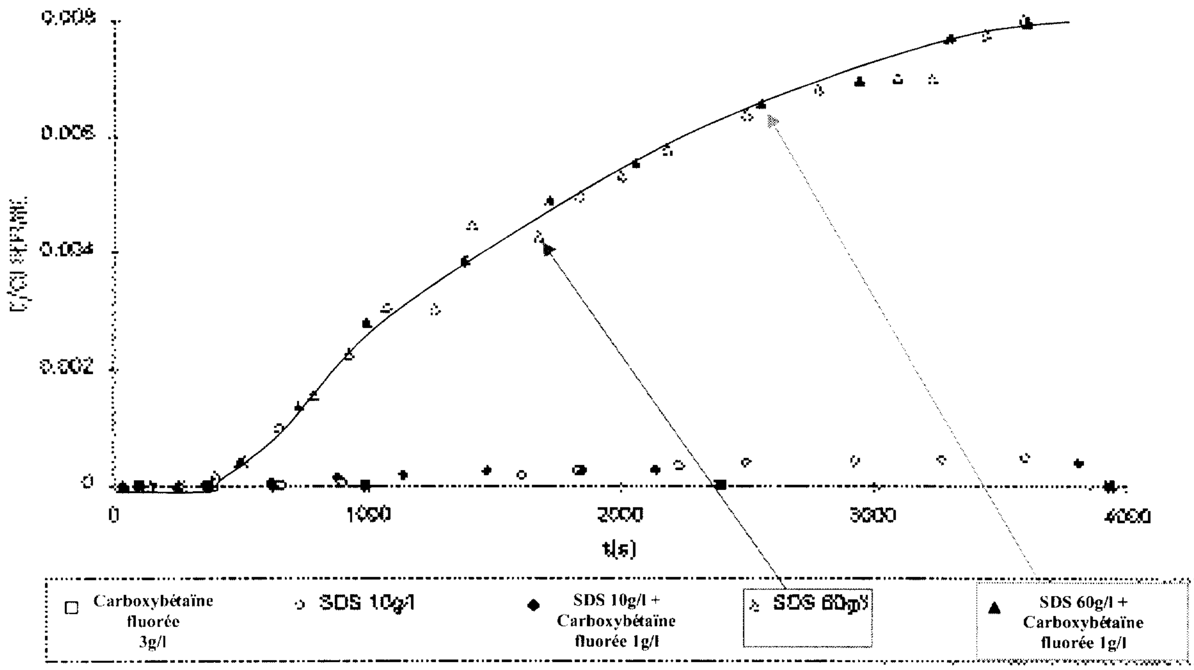


Effect of a film of water onto heptane's rate of evaporation: role of the surfactants



Effect of a film of water onto heptane's rate of evaporation: role of the surfactants

→ Mixture between hydrocarbon and fluorinated surfactant



Effect of a film of water onto heptane's rate of evaporation: role of the surfactants

→ CONCLUSION

-The amount of heptane going through a water droplet is not detectable

- The hydrocarbon surfactant has to be carefully chosen.

-Fluorinated surfactants do not participate to the heptane transfer through the water droplet

GENERAL CONCLUSION

➡Fluorinated surfactants have a high thermal and chemical stability

➡They give some very low surface tension values in water:
Lower droplet diameter ;
Improved spreading of droplet also on solid surfaces.

➡An appropriate formulation prevents the burn back