Final Conference - Malta

Characterisation and Impacts of LSFOs

Fanny CHEVER

18.11.25

WP3

Characterisation and Impacts

Objectives

- **Screen** and **characterise** new samples, **compare** with IMAROS samples
- **Understand** the market evolution since 2020
- **Improve** understanding of the properties of LSFOs, focusing on parameters affecting recovery and shoreline response
- **Get information** on the behaviour of LSFOs in marine and fresh waters
- **Get information** on behaviour and response options in Mediterranean area

WP3

Characterisation and Impacts

Tasks

- In-depth physical-chemical characterisation
- Oil weathering (5°C and 25°C, freshwater and seawater)
- Biodegradability
- Identification (CEN: European committee for standardization)
- Modelling

WP3

Characterisation and Impacts

Tasks

- In-depth physical-chemical characterisation
- Oil weathering (5°C and 25°C, freshwater and seawater)
- Biodegradability
- **Identification (CEN: European committee for standardization) → RBINS**
- Modelling

WP3

Characterisation and Impacts

Tasks

- In-depth physical-chemical characterisation
- Oil weathering (5°C and 25°C, freshwater and seawater)
- Biodegradability
- Identification (CEN: European committee for standardization)
- **Modelling → RWS / RBINS**

Samples

19

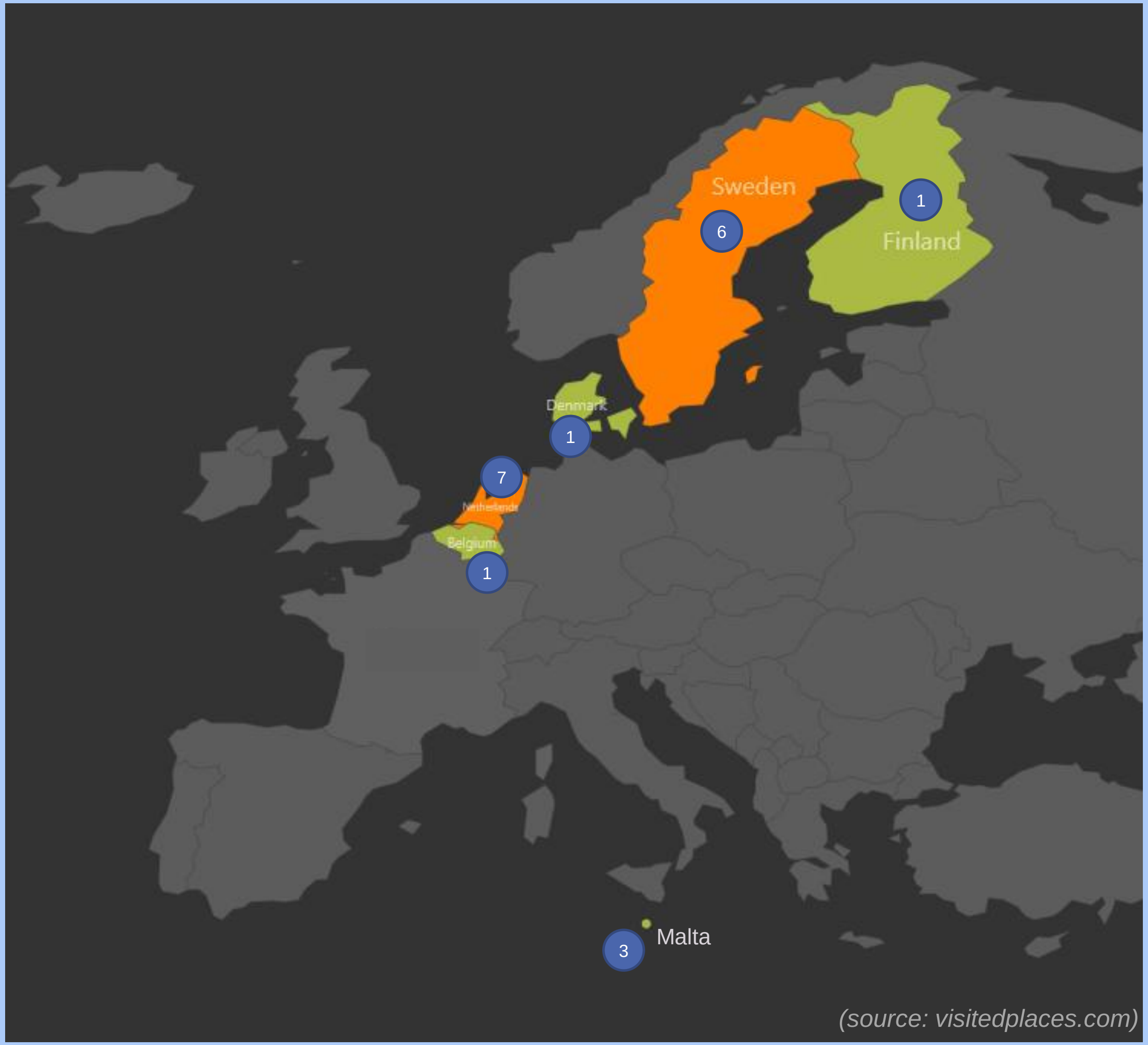
16 small, 3 large

- ❑ 6 countries (FI, SE, DK, NL, BE, MT)

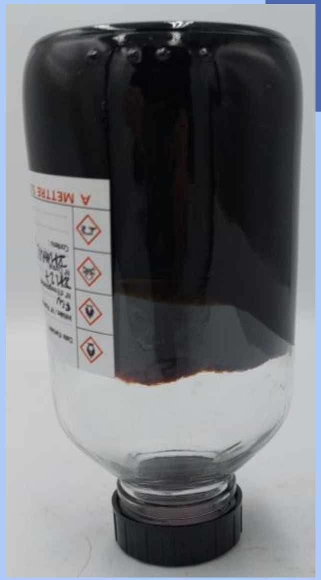
5 ULSFO

14 VLSFO

- ❑ Refineries or bunker companies



All black residual fuel oils



Visual aspect at ~20°C:
- 9 fluid
- 10 not fluid

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Comparison VPS PortStat (2024) and IMAROS 2 samples

VLSFO		VPS PortStats (2024)	IMAROS 2 samples			VPS PortStats (2024)	IMAROS 2 samples			VPS PortStats (2024)	IMAROS 2 samples
Density (kg/m3)	< 880			Vsicosity 50°C (Cst)	< 20		1	Pour Point (°C)	-5 - 0		3
	881 - 900				20 - 50		2		0 - 5		1
	901 - 920				51 - 80		1		5 - 10		**3**
	921 - 950		4		81 -180		4		10 - 15		2
	951 - 980		**9**		181 - 280		**5**		15 - 20		
	980 - 990				281 - 380				20 - 25		1
	> 991		1		>381		1		25 - 30		2
									> 30		1

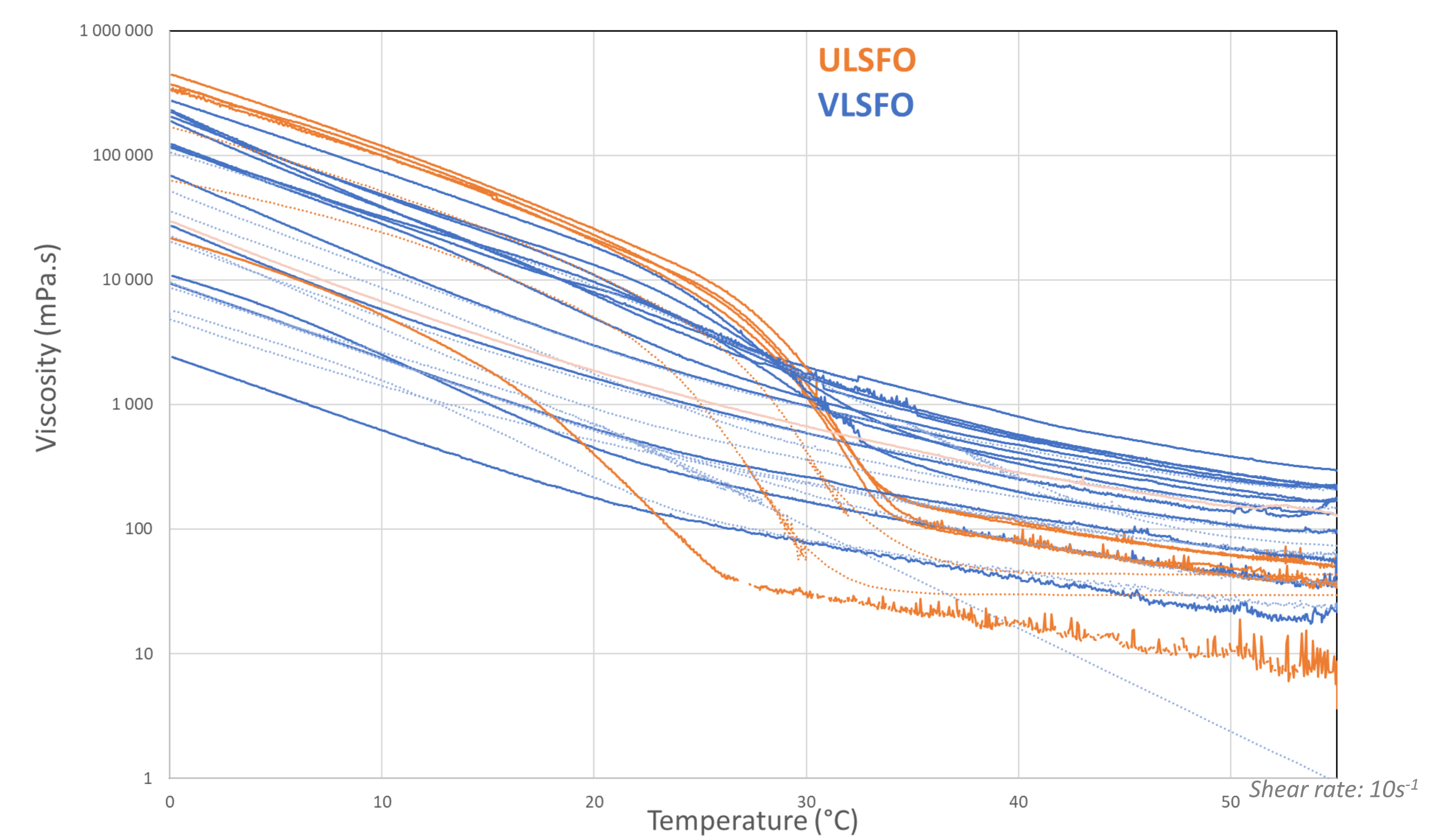
ULSFO		VPS PortStats (2024)	IMAROS 2 samples			VPS PortStats (2024)	IMAROS 2 samples			VPS PortStats (2024)	IMAROS 2 samples
Density (kg/m3)	< 880			Vsicosity 50°C (Cst)	< 20		1	Pour Point (°C)	-5 - 0		
	881 - 900		**5**		20 - 50		**2**		0 - 5		
	901 - 920				51 - 80		**2**		5 - 10		
	921 - 950				81 -180				10 - 15		
	951 - 980				181 - 280				15 - 20		1
	980 - 990				281 - 380				20 - 25		
	> 991				>381				25 - 30		
									> 30		**4**

- IMAROS 2 samples mainly representative of the market in 2024

Part I

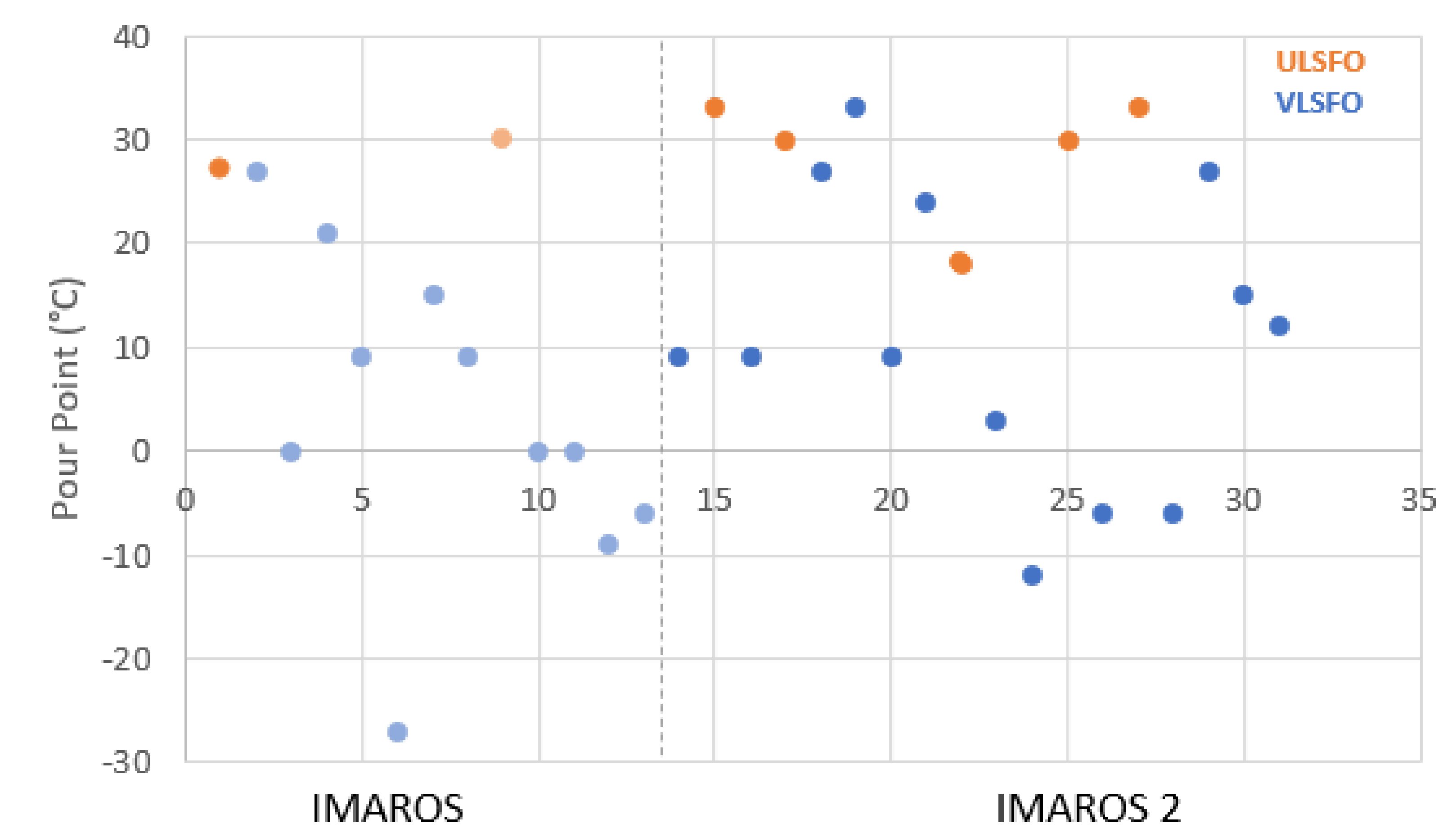
Screening of the fresh oils

Viscosity


ULSFO
VLSFO
1 000 000
100 000
10 000
1 000
100
10
1
Viscosity (mPa.s)
0
10
20
30
40
50
Temperature (°C)
Shear rate: 10s-1

Pour point

IMAROS 2 samples : -12°C to +33°C



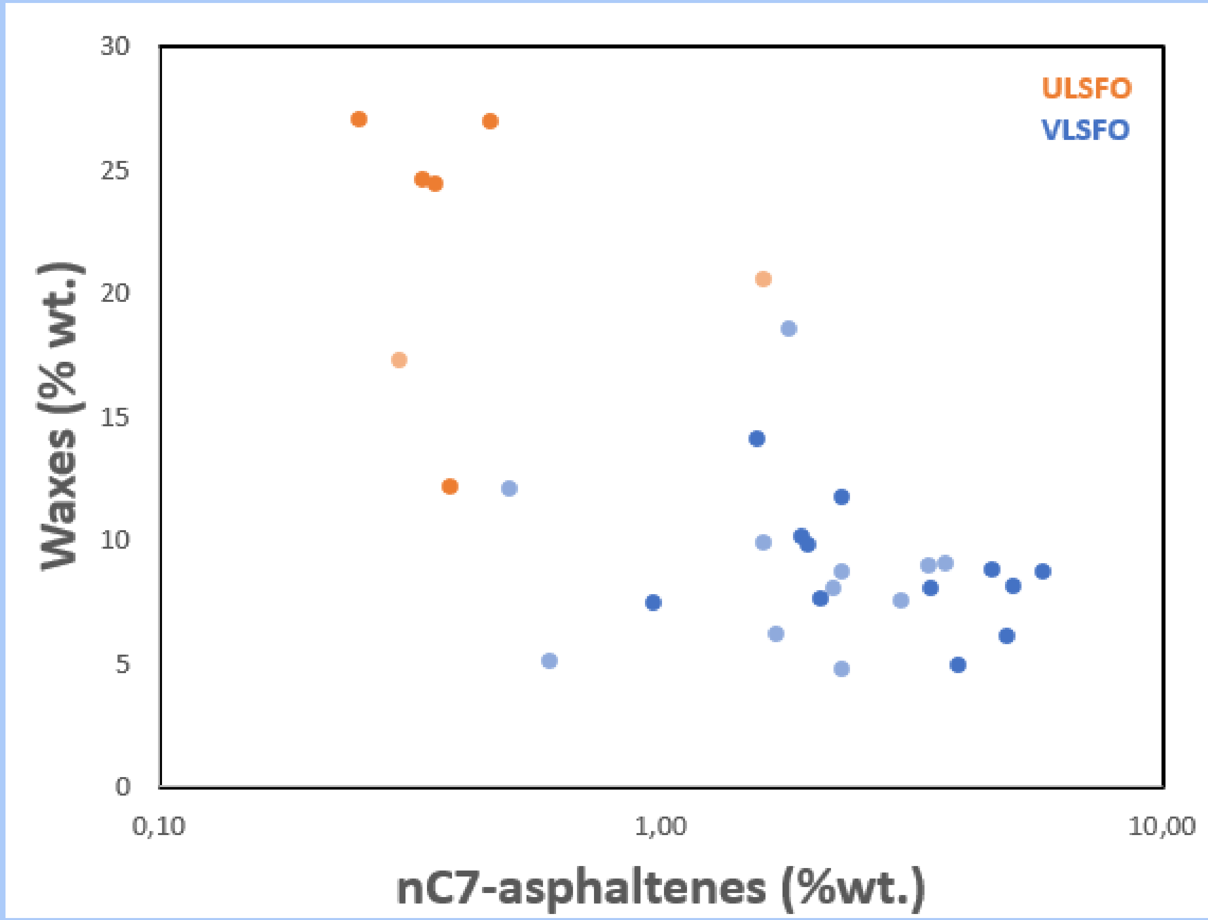
Pour point

	Pour point CoA (°C)	Pour point Cedre (°C) *ISO 3016 (ASTM 97)*	Init. measure Sintef (°C) *(ASTM D97)*	Min. pour point (°C)* *(ASTM D5853)*	Max. pour point (°C)* *(ASTM D5853)*	Max. pour point (next day)*
IM-27	**12**	9	21	9	24	21
IM-28	**27**	24	30	21	30	27
IM-29	**27**	18	21	15	21	24

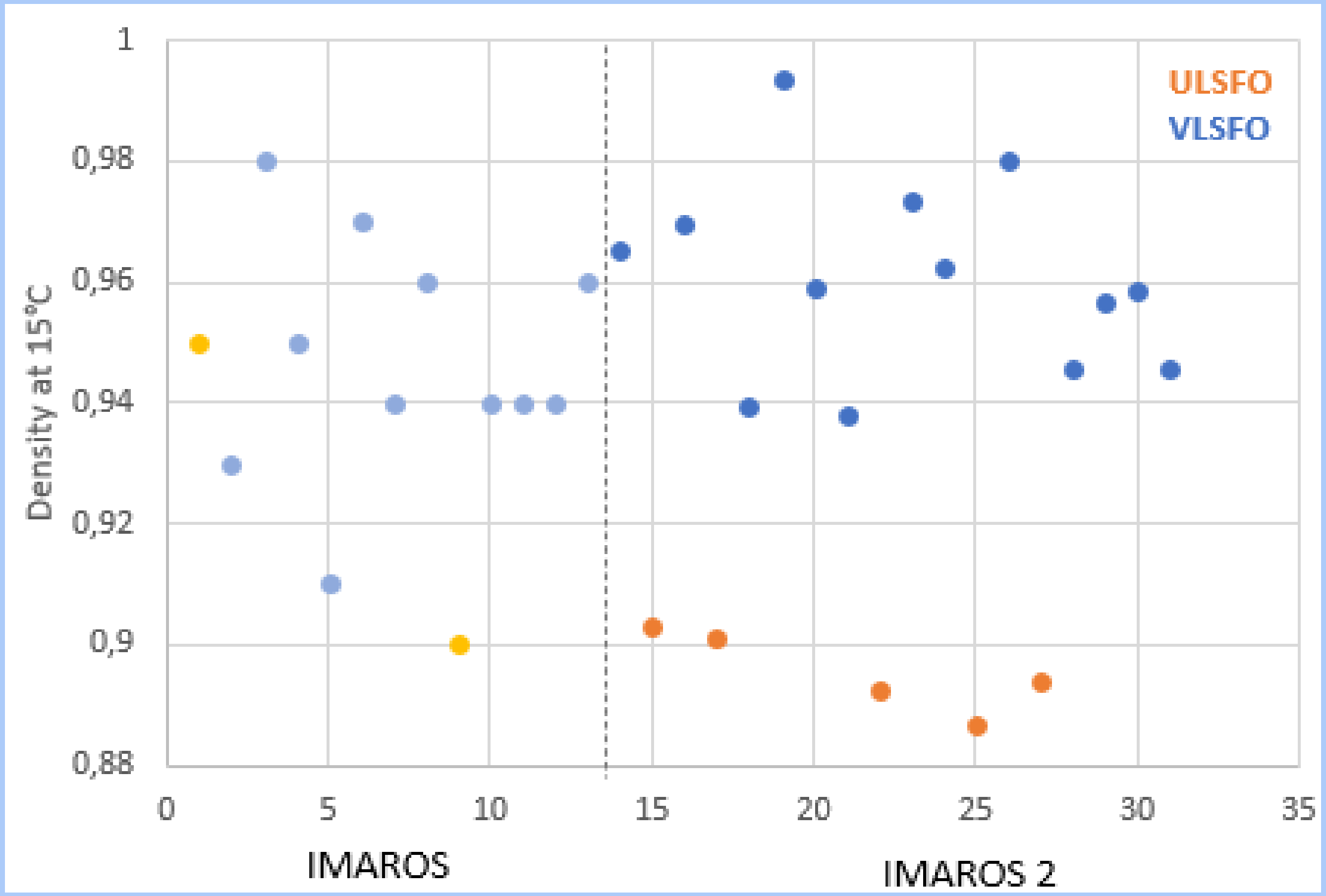
** source: SINTEF/Intertek*

- **ASTM D-5853** Standard Test Method for Pour Point of Crude Oils. The maximum and minimum pour point temperatures provide a temperature window where a crude oil, **depending on its thermal history**, might appear in the liquid as well as the solid state. The test method can be used to supplement other measurements of cold flow behaviour. **It is especially useful for the screening of the effect of wax interaction modifiers on the flow behaviour of crude oils**.

Waxes & Asphaltenes

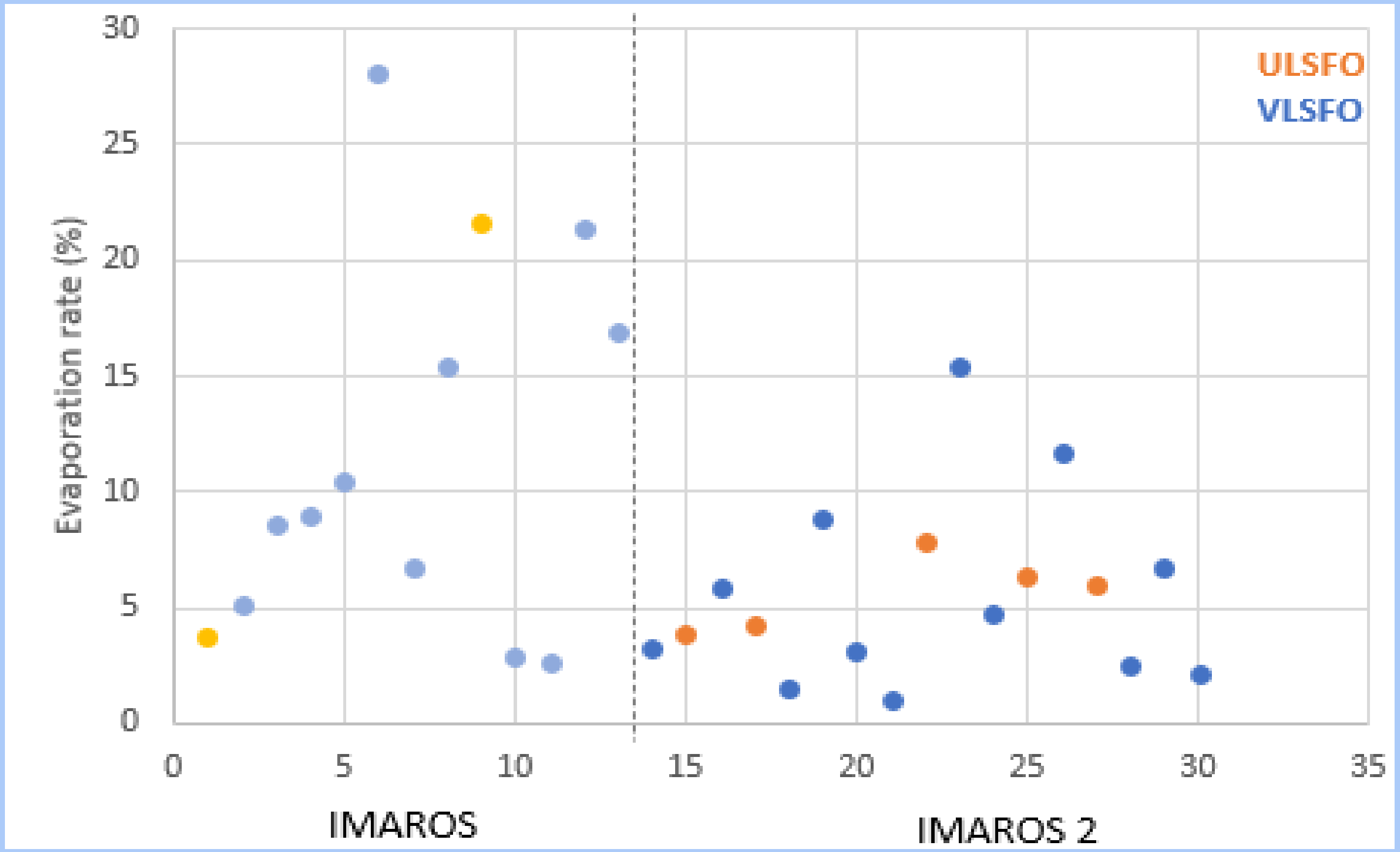


Density



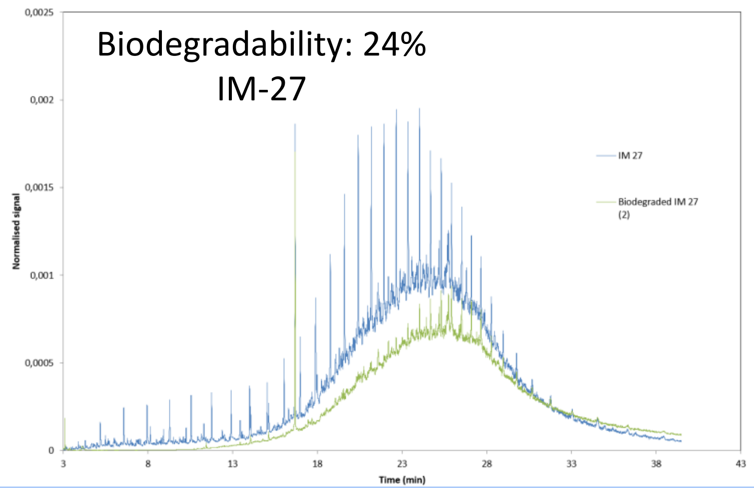
ULSFO
VLSFO
Density at 15°C
1
0,98
0,96
0,94
0,92
0,9
0,88
0
5
10
15
20
25
30
35
IMAROS
IMAROS 2

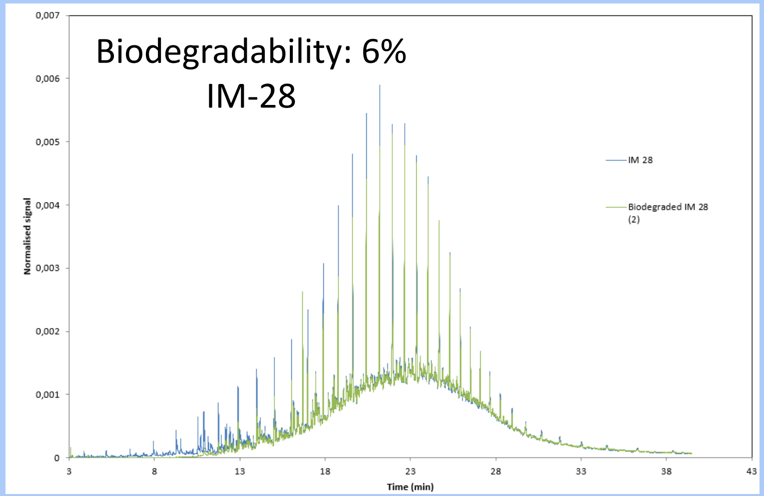
Evaporation

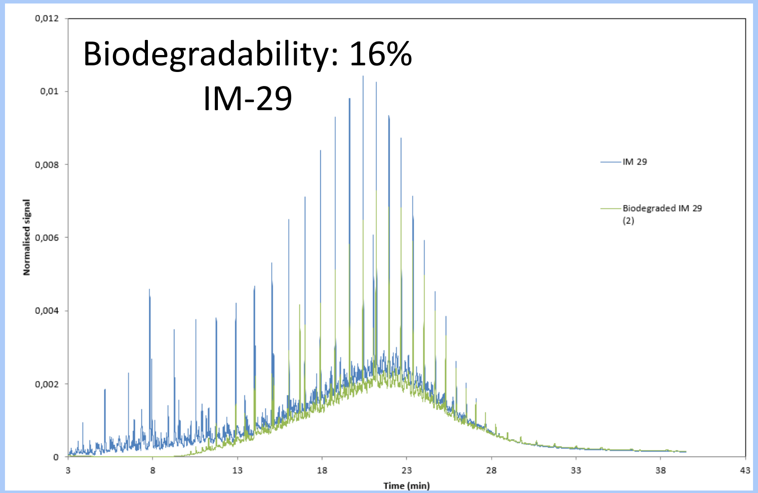


Biodegradability

protocol adapted from De Mello et al. (2007)







- Low biodegradability rates

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Cedre

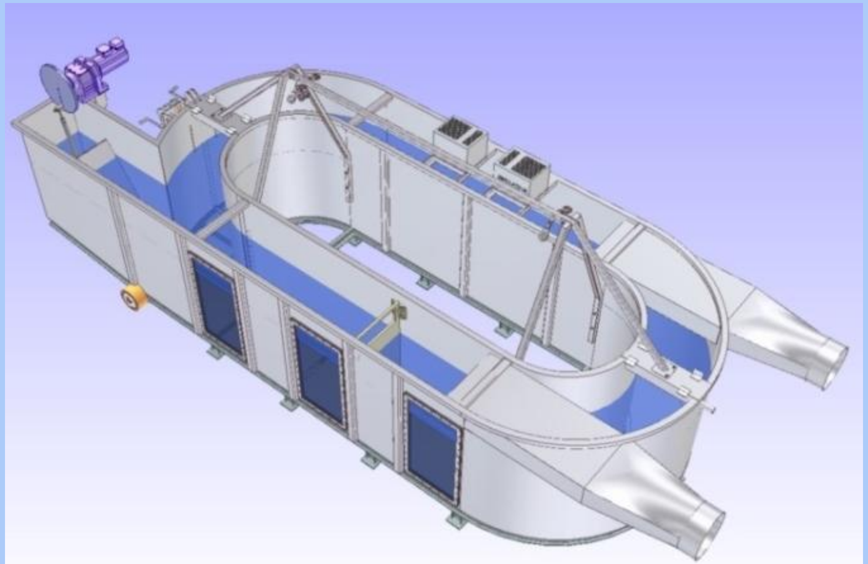
Part II

Weathering of the oils

Focus on the 3 Large Samples (IM-27, IM-28 and IM-29)

Weathering

	Visc. 50°C CoA from suppliers (mm^2/s)	Pour point Cedre (°C)	Density 15°C	Visc. 5°C ($10s^{-1}$, mPa.s)	Visc. 25°C ($10s^{-1}$, mPa.s)	Evaporation rate (% vol.)	Asphaltenes (%)	Waxes (%)
IM27 (VLSFO)	322	9	0.96	165 205	7 592	3	2.1	7.6
IM28 (VLSFO)	124	24	0.94	249 952	21 221	1	1.5	14.1
IM29 (ULSFO)	39	18	0.89	42 782	331	8	0.4	13.3



Polludrome®

For each oil, 3 conditions tested

- 5°C in seawater
- 5°C in freshwater
- 25°C in seawater

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Weathering – Global observations

At 5°C:

- 1st part:
  - Possible fragmentation (IM-28 and IM-29)
  - IM-27 and IM-28: oils stick to the walls, no floating oil for a time, can go up to 96h, need to be manually removed from the walls
  - IM-29: one big slick moving but that can hang the walls
- 2nd part:
  - IM-27: with time and emulsification, a slick reassembles and float again
  - IM-28: Stays stuck / no oil free
  - IM-29: The oil freely floats

Real environment: Slicks can either disseminate as small bullets or become even more compact, with slower emulsification process

At 25°C:

- IM-27, IM-28 and IM-29: Much more traditionnal behaviour

Effect of salinity/Freshwater: no major changes. Whatever the salinity, the oil will go in subsurface in case of agtation/turbulences

- IM-27, 5°C, SW

+1h

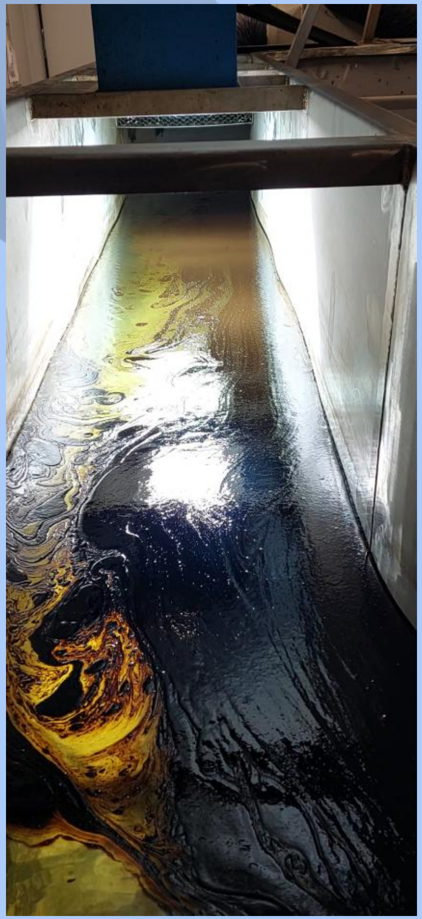
+53h

	Fresh oil	Weathered oil
Viscosity (mPa.s)	165 000	120 000
Density	0.96	0.99
Water content (%)	-	~40-60

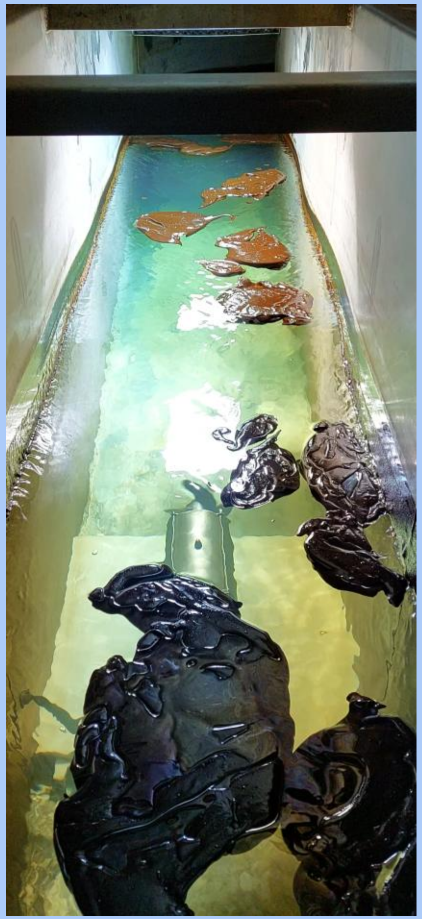
Compact slicks that do not spread

❑ IM-27, 25°C, SW

+1h



+168h



	Fresh oil	Weathered oil
Viscosity (mPa.s)	7 600	37 000
Density	0.95	0.98
Water content (%)	-	80

Much more fluid slick that spreads and emulsifies with time

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- IM-28, 5°C, SW

+1h

+144h

	Fresh oil	Weathered oil
Viscosity (mPa.s)	250 000	380 000
Density	0.94	0.97
Water content (%)	-	40

Solid / semi-solid slicks with granular aspect
May disseminate
Bullets can slowly emulsify

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Cedre

- IM-28, 25°C, SW

+2h

+168h

	Fresh oil	Weathered oil
Viscosity (mPa.s)	21 000	64 000
Density	0.930	0.998
Water content (%)	-	85

Solid / semi-solid slicks with granular aspect
May break easily
Lumps can emulsifiy with time

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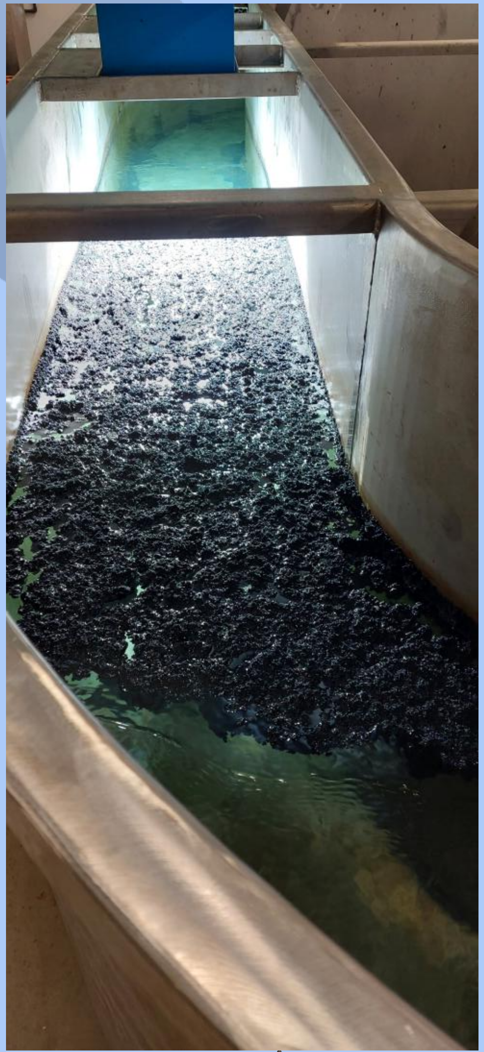
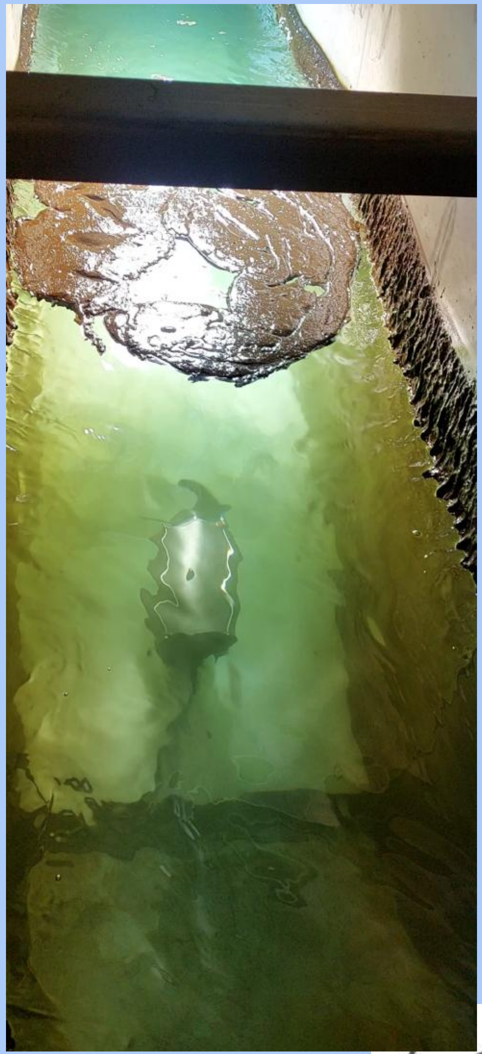
Cedre

- IM-29, 5°C, SW

+1h



+53h



	Fresh oil	Weathered oil
Viscosity (mPa.s)	43 000	65 000
Density	0.90	0.88
Water content (%)	-	50

Highly granular fragmented slick
May disseminate
Bullets can slowly emulsify

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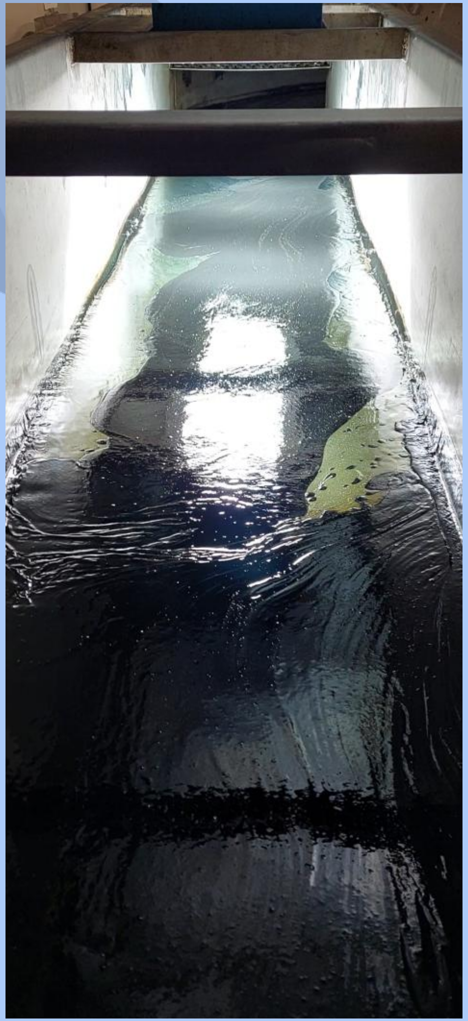
Cedre

- IM-29, 25°C, SW

+1h



+168h

	Fresh oil	Weathered oil
Viscosity (mPa.s)	331	8 400
Density	0.89	1.00
Water content (%)	-	90

Much more fluid slick that spreads and emulsifies with time

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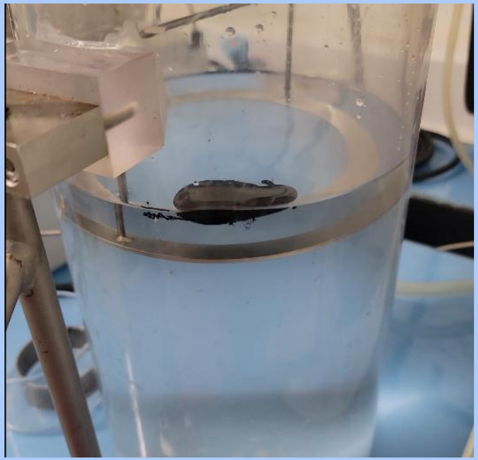
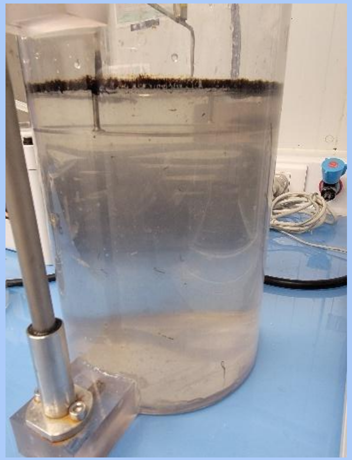
Cedre

Chemical dispersion – Fresh oils

IM-27



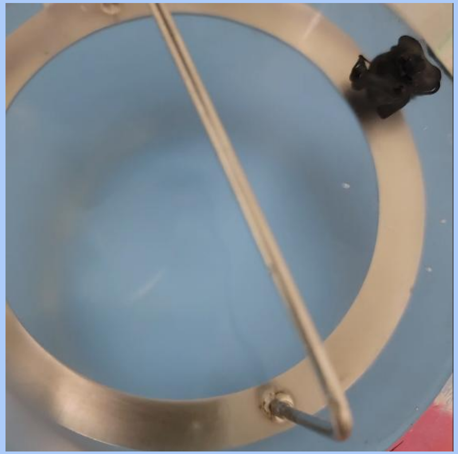
IFP test – 5°C



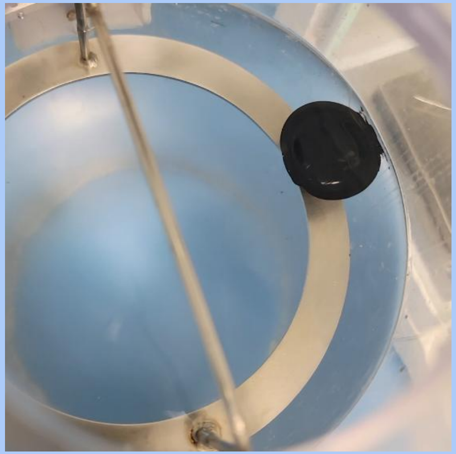
IFP test – 25°C

	Visc. 5°C ($10s^{-1}$, mPa.s)	Visc. 25°C ($10s^{-1}$, mPa.s)
IM27	165 205	7 592
IM28	249 952	21 221
IM29	42 782	331

IM-28

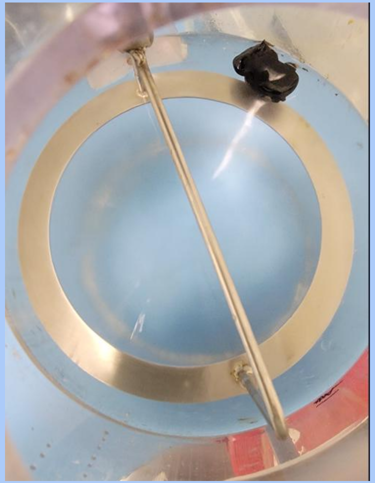


IFP test – 5°C

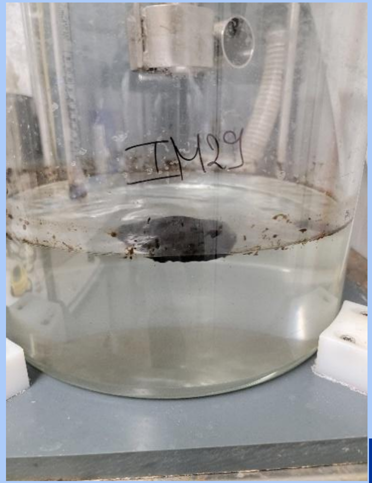


IFP test – 25°C

IM-29



IFP test – 5°C



MNS test – 25°C

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Cedre

Main conclusions & Elements for OSR techniques

- No flammability issues
- Persistent products (low evaporation)
- Floating oils
- Possible dissemination of the slicks in small bullets
- Emulsification at 25°C, limited at 5°C
- Chemical dispersion seems limited to some fresh oils (IMAROS samples)
- Based on viscosity measurements, recovery recommended even if challenged for some oils due to high pour points
- Visco-elastic behaviour cannot be reproduced during those trials

Thank you for your attention