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The effect of water ingress on environmentally adapted greases

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Introduction

- Protect and improve our environment with lubricating grease
- Provide acceptable or better performance than before
- Combine environmental focus with governmental and international regulations
- Show off this with ”green labels”
- Keep in place if it is exposed to water
- Any form of water!

Applications

Labels for greases in the EU

SS 155470

Vessel General Permit (VGP)

The general requirements of labelled products

- Substance specific information required
- Exclusion of specific substances
- Biodegradability
- Bioaccumulation
- Aquatic toxicity
- Renewability
- Technical performance

EU flower – Grease related categories

	Category 2 requirements Greases	Category 3 requirements Total loss lubricants
Toxicity		
Non toxic %	Not limited	Not limited
Harmful %	max 25	max 5
Toxic %	max 1	max 0,5
Very toxic %	max 0,1	max 0,1
Biodegradation and bioaccululation		
Ultimatelly biodegradable %	> 75	> 90
Inherenty biodegradable %	max 25 together	max 5
Non-biodegradable and non-bioacculative %		max 5
Non-biodegradable and bioaccumulate %	max 0,1	max 0,1
Fraction not assessed by toxicity %	<0,5	<0,5
Fraction not assessed by biodegradation/bioaccumulation %	<0,5	<0,5
Renewable content %	min 45	min 70

LuSC-list

Soaps

Metal containing compounds are forbidden except sodium, potassium, magnesium and calcium

In thickeners Li and Al are accepted

Environmental properties are different with different fatty acids and not all of them listed

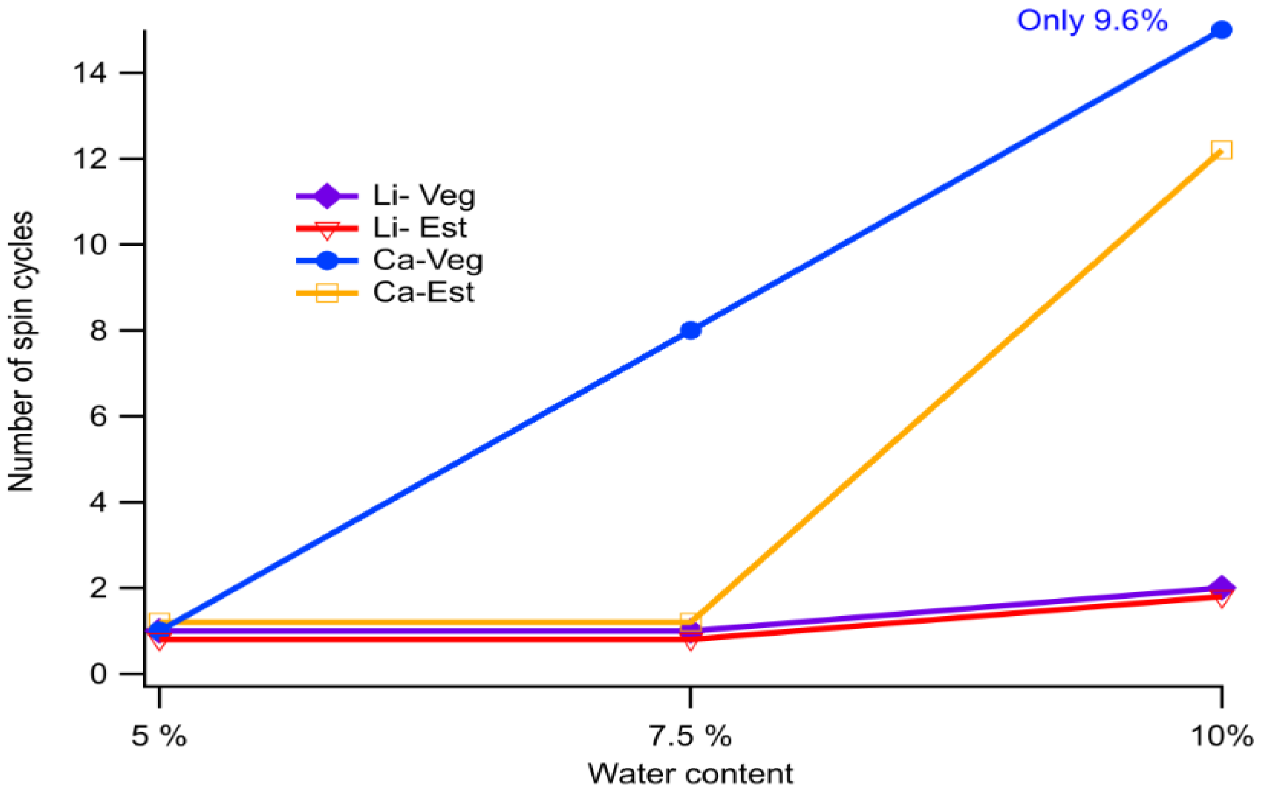
Soaps for EEL

Soap	Grease	Classification
Sodium stearate	Na	Biodegradable, non toxic
Calcium distearate	Ca	Biodegradable, non toxic
Calcium di-12-hydroxystearate	Anhy-Ca	Biodegradable, non toxic
Calcium acetate	CaX	Not biodegradable, non toxic
Lithium 12-hydroxystearate	Li	Inherently aerobically, harmful
Dilithium sebacate	LiX	Not biodegradable, harmful
Dilithium azelate	LiX	Not biodegradable, harmful
Silica gel	Si	Not biodegradable, non toxic

Grease selection

Identifier	Thickener	Thickener concentration [%]	Base oil	BOV at 40°C [mm^2/s]
Ca-Veg	Anhy-Calcium	11	Rapeseed oil	36
Ca-Est	Anhy-Calcium	11	TMP ester	44
Li-Veg	Lithium	13	Rapeseed oil	36
Li-Est	Lithium	11	TMP ester	44

Water in grease

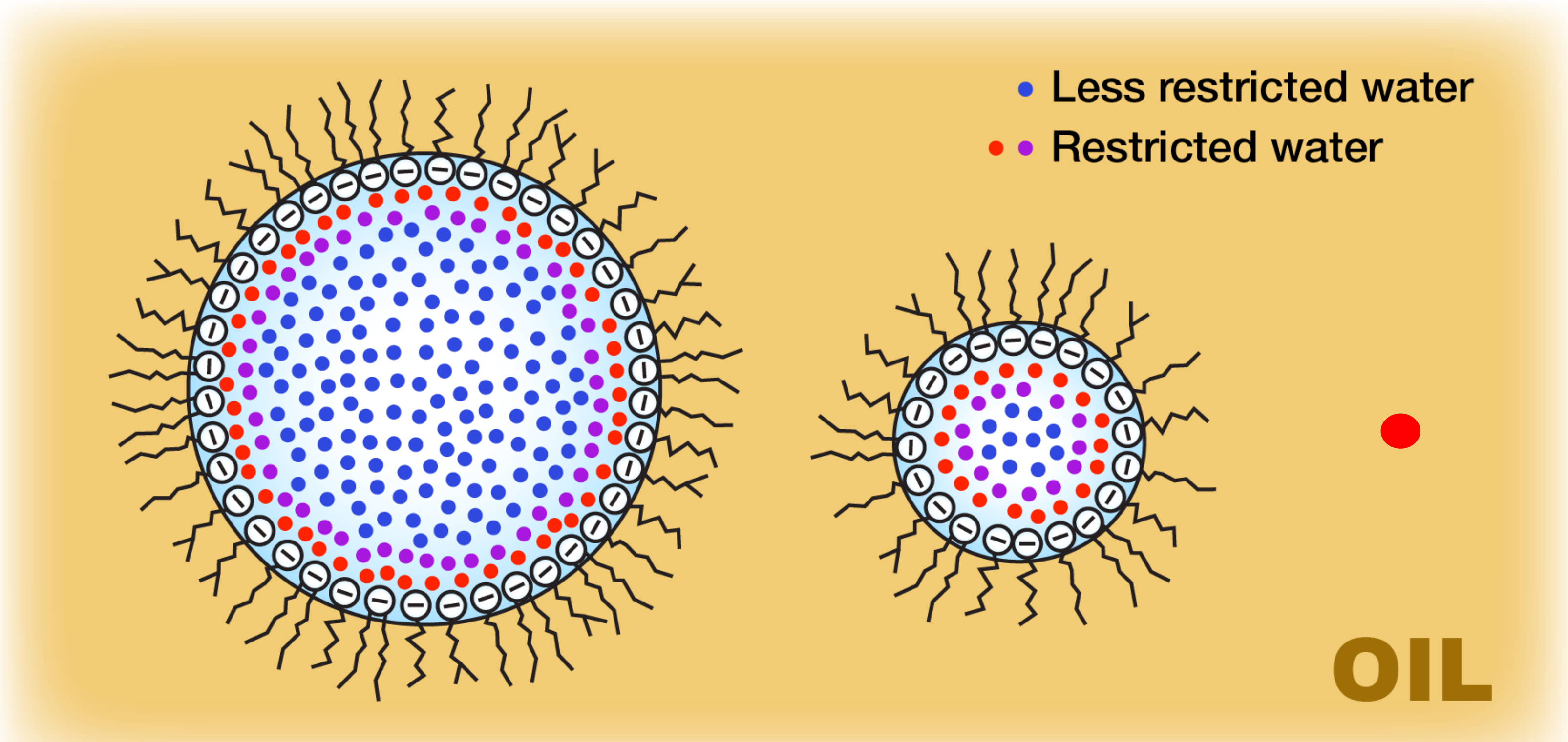


1 cycle is 1800 rpm, 5 min

Diffusion NMR

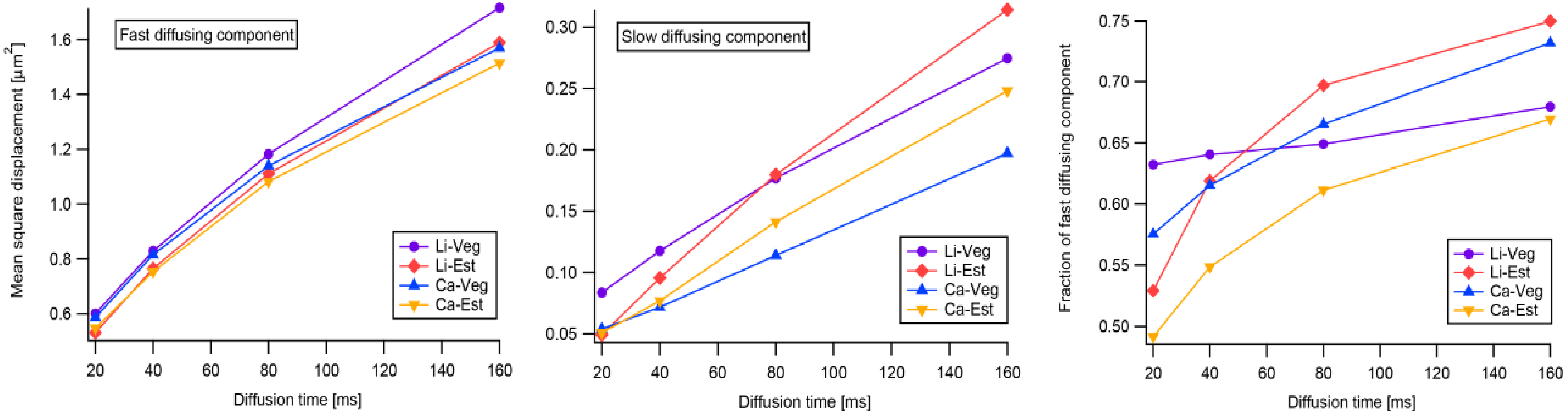
How is water organized in the grease? Emulsified water

Bound water

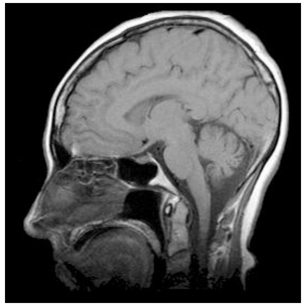


Water in oil emulsion

Diffusion NMR



Magnetic resonance imaging (MRI)



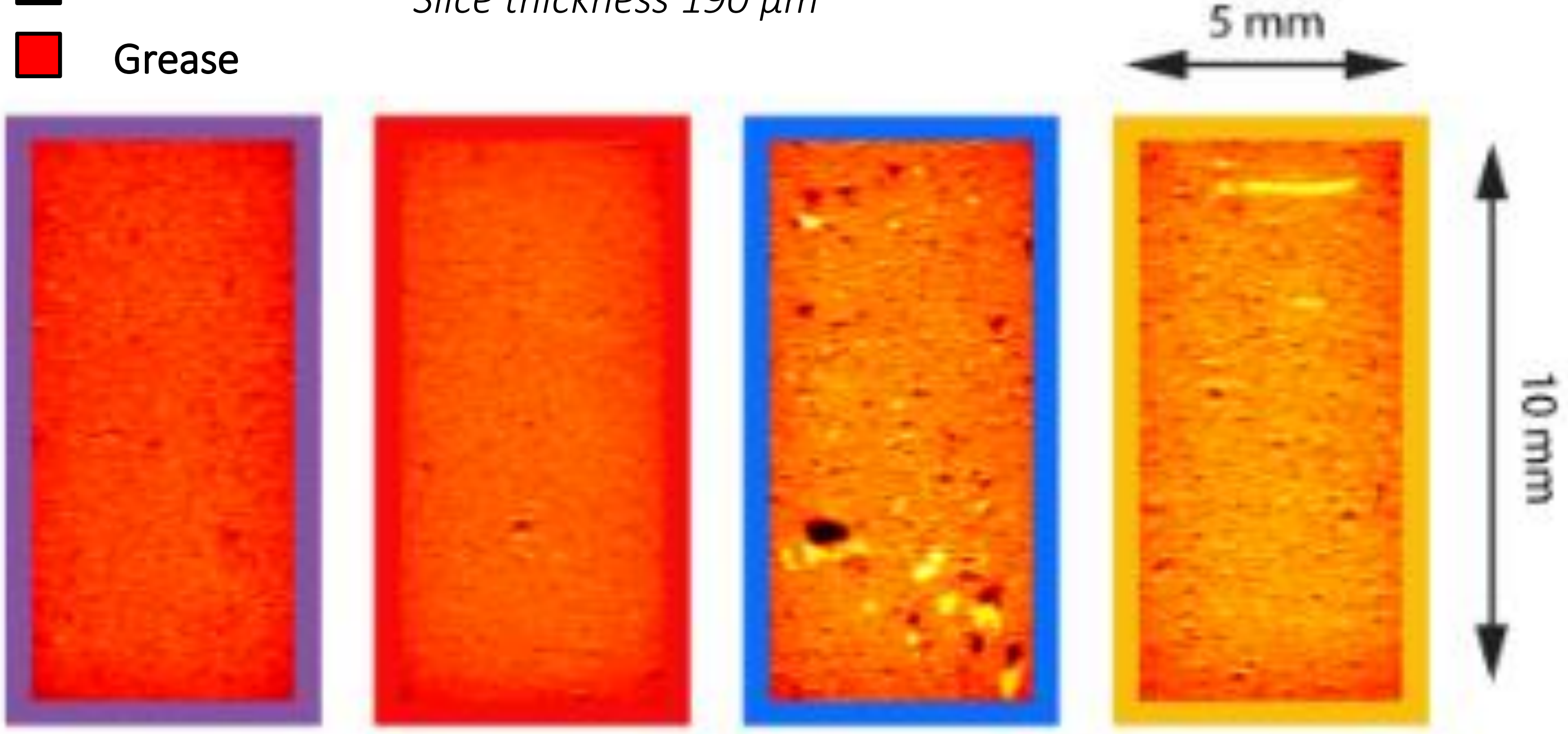
Water

Air

Grease

Resolution 20 µm
Slice thickness 190 µm

Li-Veg Li-Est Ca-Veg Ca-Est



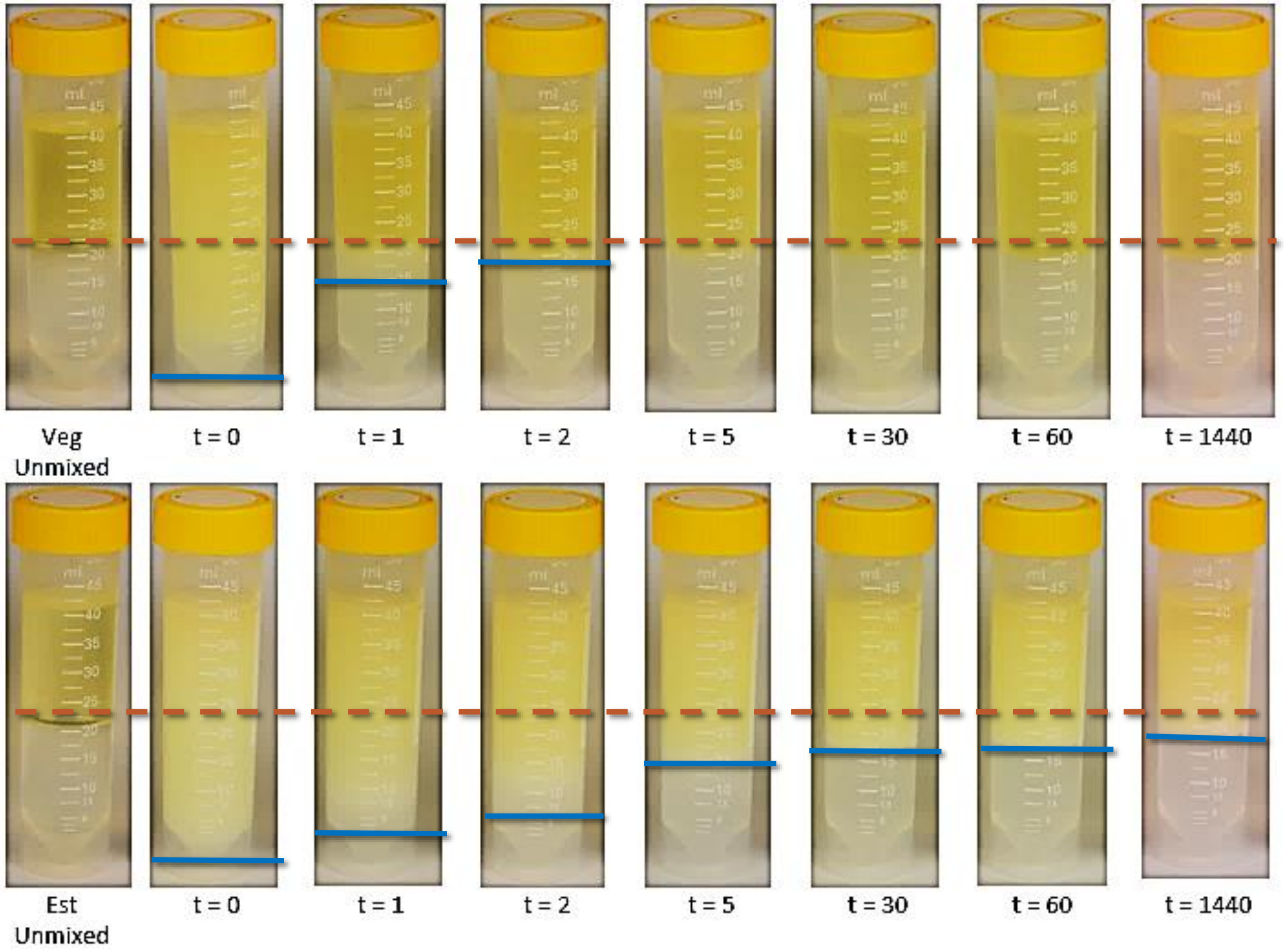
Base oils separate from water (min)

Rapeseed oil

water

TMP ester

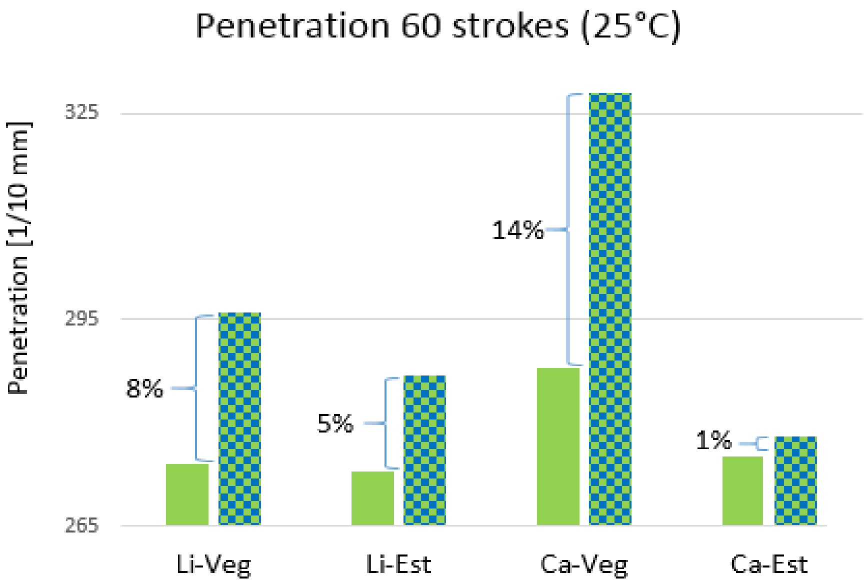
water

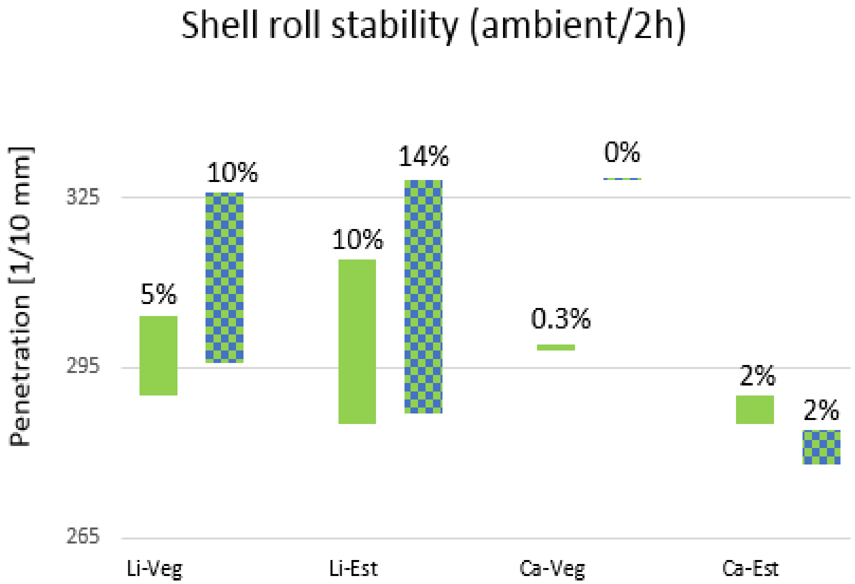


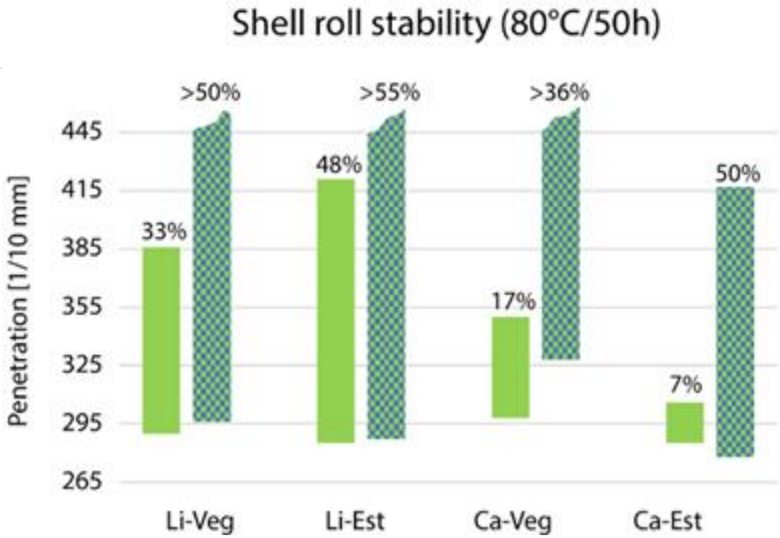
50%

50%

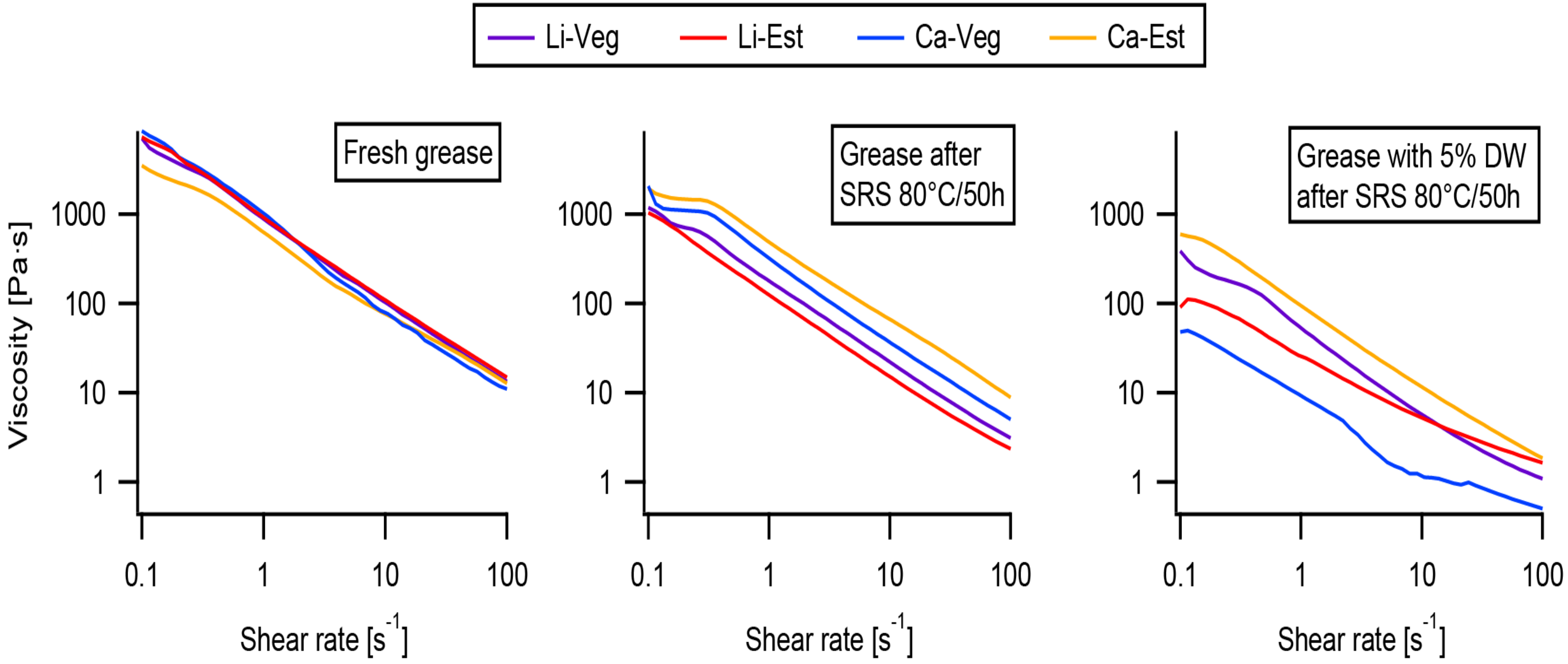
Mechanical stability

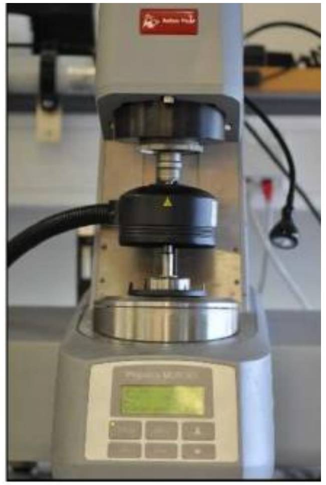




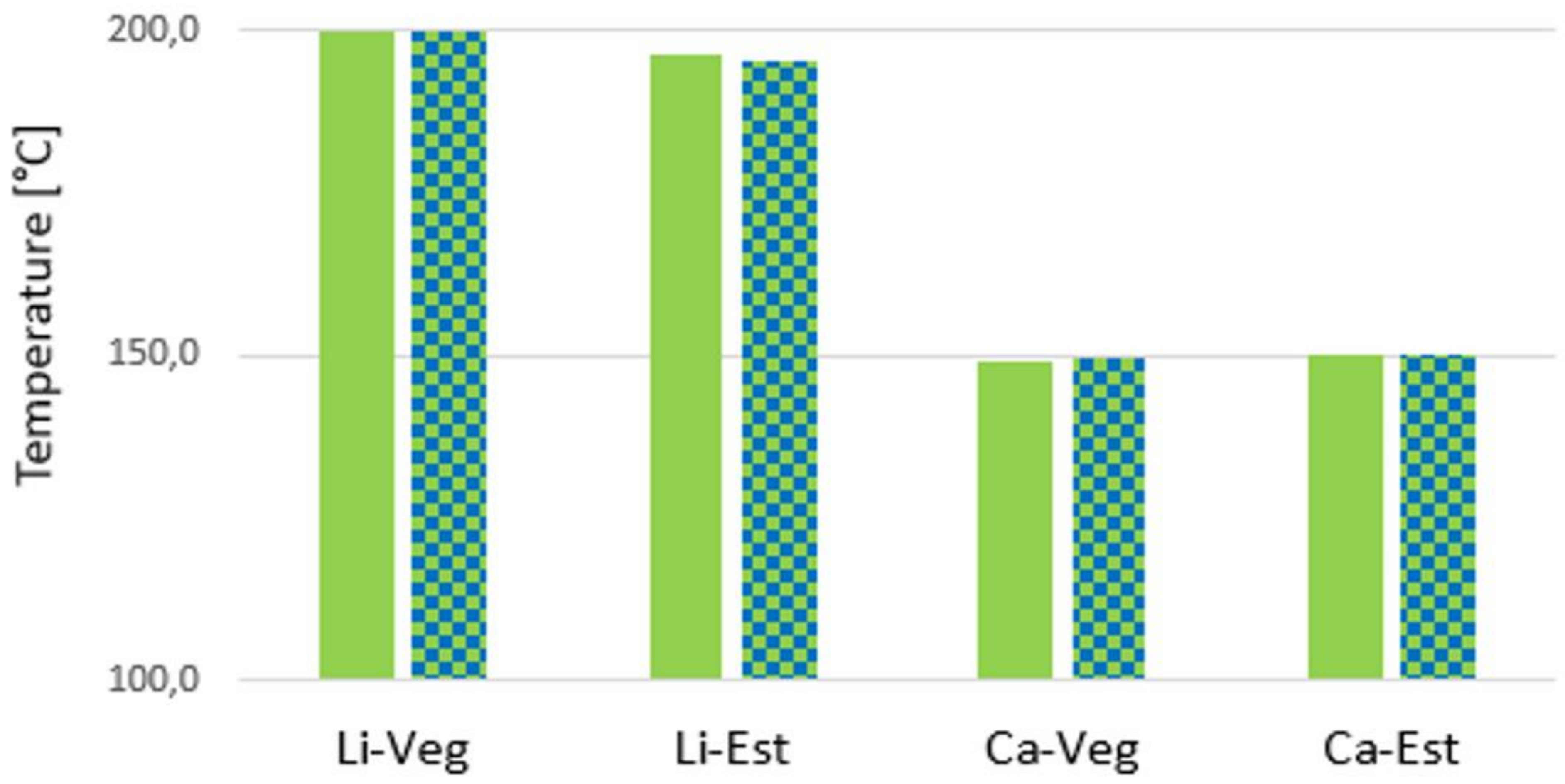


Remaining viscosity





Dropping point

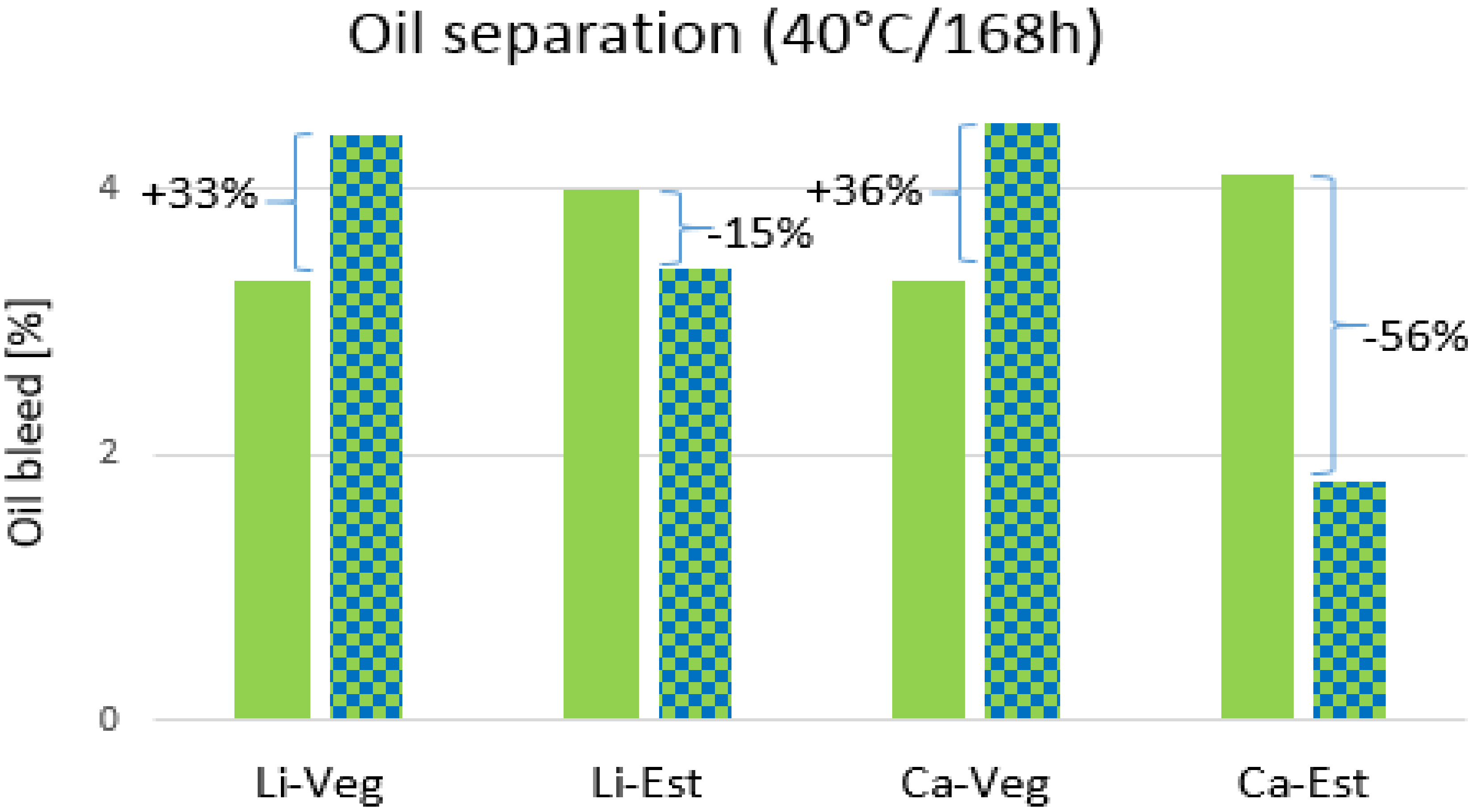


Water repellency

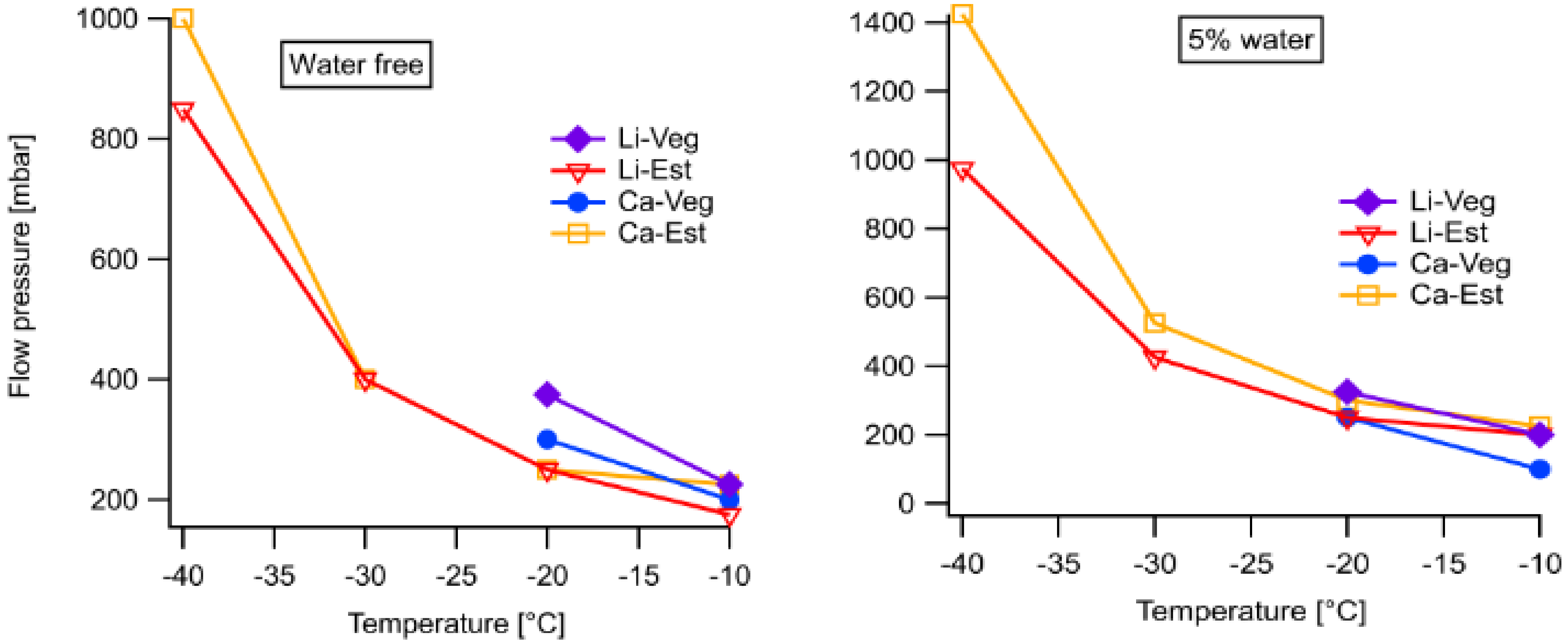
Identifier	Water resistance (90°C/3h)		Water spray off [%] (38°C/5min)		Water spray off [%] (38°C/1min)[1]	
	No water	Water	No water	Water	No water	Water
Li-Veg	0	0	100	100	97	97
Li-Est	0	0	100	100	94	86
Ca-Veg	0	0	100	100	97	97
Ca-Est	0	0	100	100	67	60

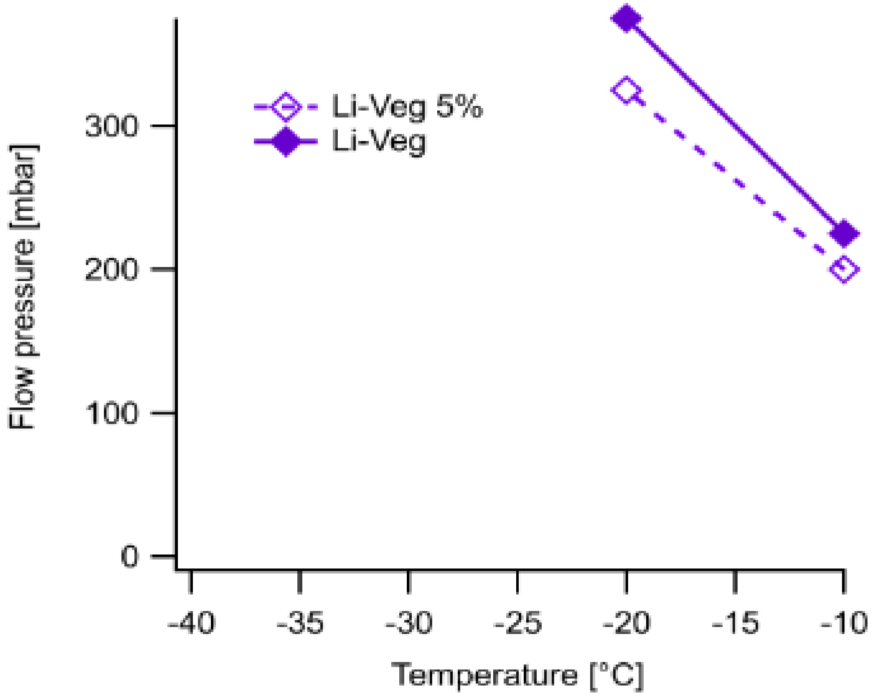
1: shortened time

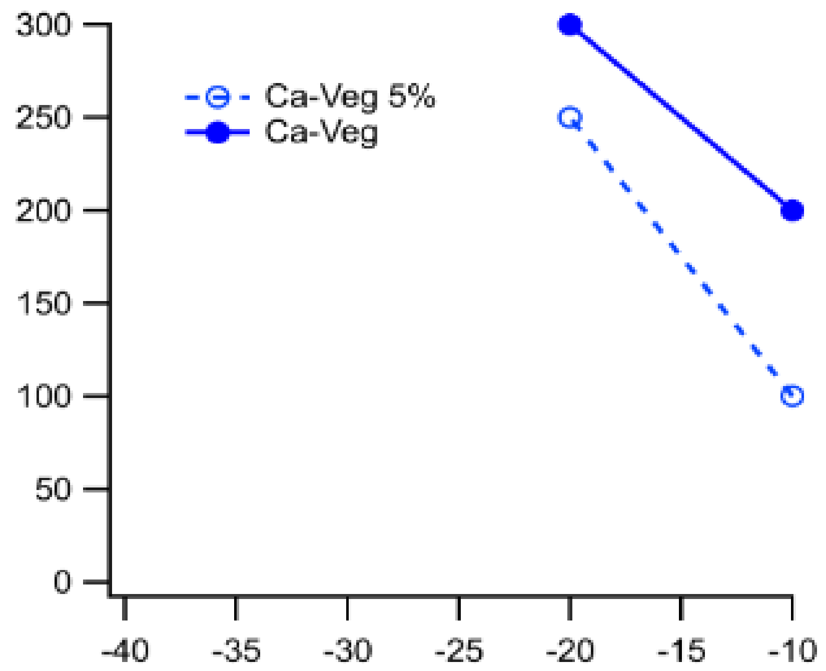
Storage stability

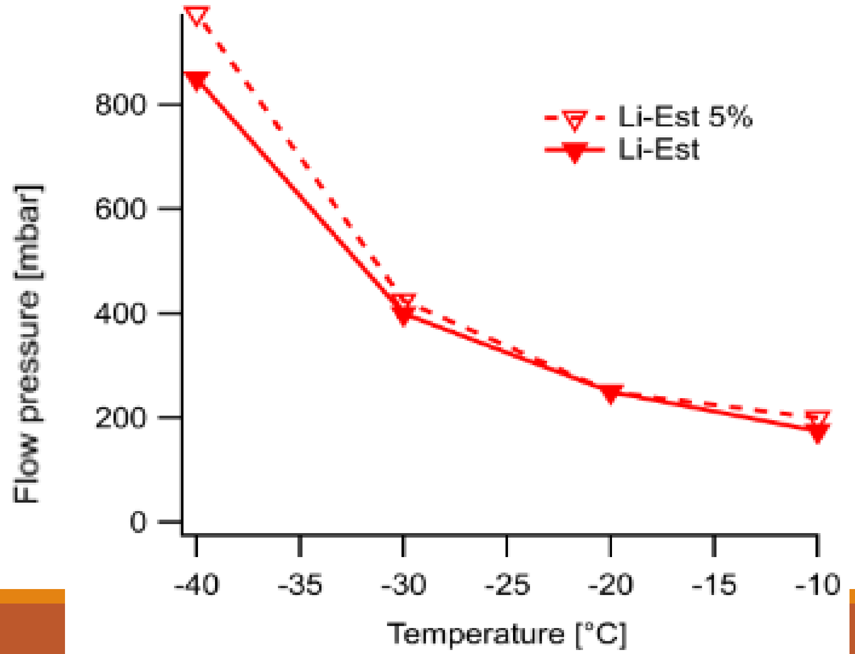


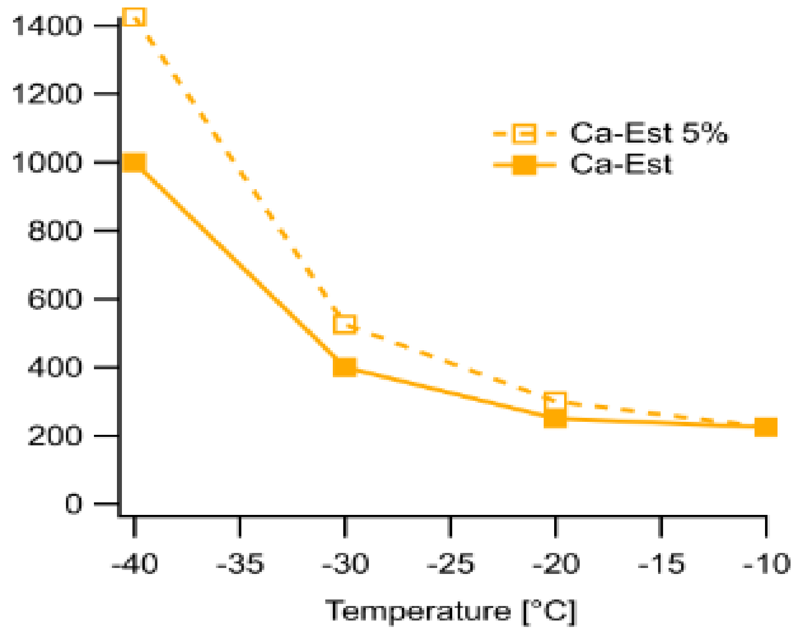
Low temperature performance




Li-Veg 5%
Li-Veg
Flow pressure [mbar]
Temperature [°C]

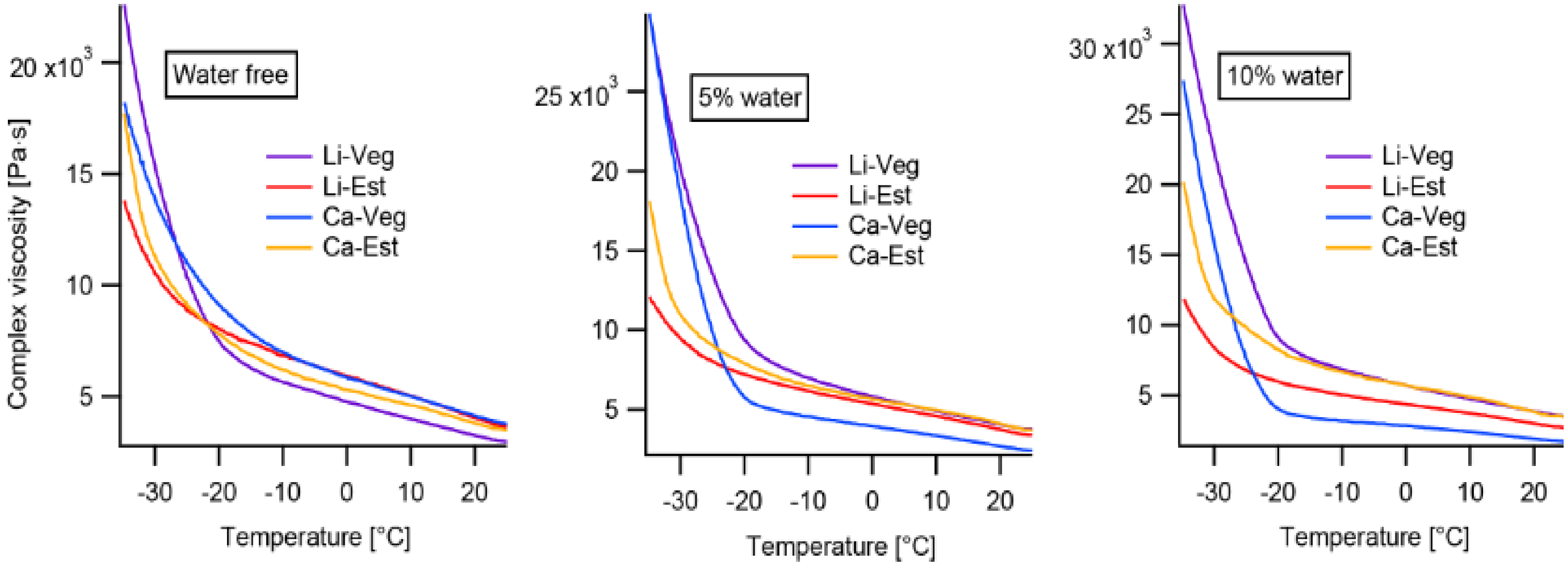

Ca-Veg 5%
Ca-Veg

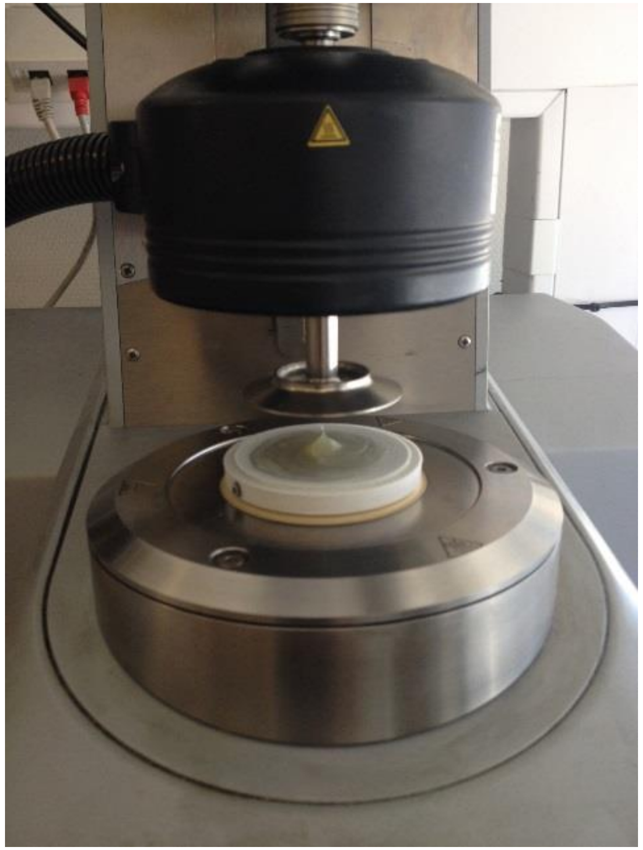

Li-Est 5%
Li-Est
Flow pressure [mbar]
Temperature [°C]

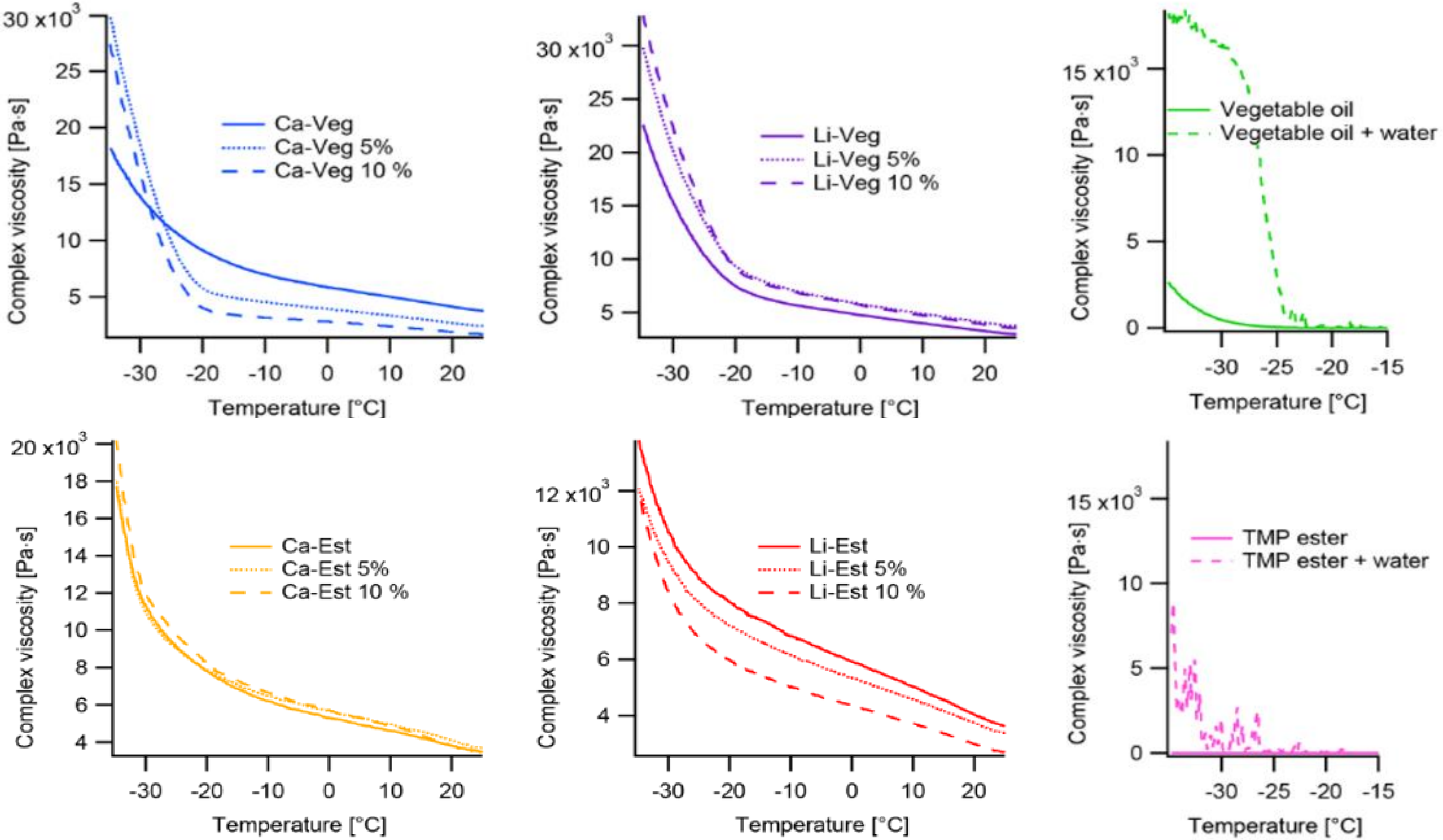

Ca-Est 5%
Ca-Est
Temperature [°C]

Low temperature structural change

- Oscillatory movement, 0,1% at 10 rad/s
- Temperature ramp from 25°C to -35°C
- Cooling speed 3°C/min






30 x10^3
25
20
15
10
5
Complex viscosity [Pa·s]
Ca-Veg
Ca-Veg 5%
Ca-Veg 10 %
-30 -20 -10 0 10 20
Temperature [°C]
30 x10^3
25
20
15
10
5
Complex viscosity [Pa·s]
Li-Veg
Li-Veg 5%
Li-Veg 10 %
-30 -20 -10 0 10 20
Temperature [°C]
15 x10^3
10
5
0
Complex viscosity [Pa·s]
Vegetable oil
Vegetable oil + water
-30 -25 -20 -15
Temperature [°C]
20 x10^3
18
16
14
12
10
8
6
4
Complex viscosity [Pa·s]
Ca-Est
Ca-Est 5%
Ca-Est 10 %
-30 -20 -10 0 10 20
Temperature [°C]
12 x10^3
10
8
6
4
Complex viscosity [Pa·s]
Li-Est
Li-Est 5%
Li-Est 10 %
-30 -20 -10 0 10 20
Temperature [°C]
15 x10^3
10
5
0
Complex viscosity [Pa·s]
TMP ester
TMP ester + water
-30 -25 -20 -15
Temperature [°C]

Summary

	Biodegradability	Aquatic toxicity	Renewability	Water repellancy	General performance	Low temp. performance
Li-Veg	+	0	++	−−	− ↙↙	−− ↙
Li-Est	+	0	+	−−	−− ↙	++ ↗
Ca-Veg	++	++	++	++	+ ↙↙	− ↙↙
Ca-Est	++	++	+	+	++ ←	+ ←

Performance

Change with water

Conclusions

- If the lubrication point is exposed by water or/and low temperature, ester based anhy-Ca is a very good solution

- The study need to be continued with different EAL oils and additives to investigate water resistance in EALs

Thank you for your attention!