University of Glasgow

The Use of Hollow-Fiber Liquid-Phase Microextraction in Bioanalyses

Dr. Rafael Venson

Advances in Forensics & Toxicology eSeminar

Toxicological Analyses

Sampling

Sample preparation

Sample pre-treatment

- Centrifugation
- Filtration
- Thawing
- Protein precipitation

Extraction

- LLE
- SPE
- SPME
- LPME

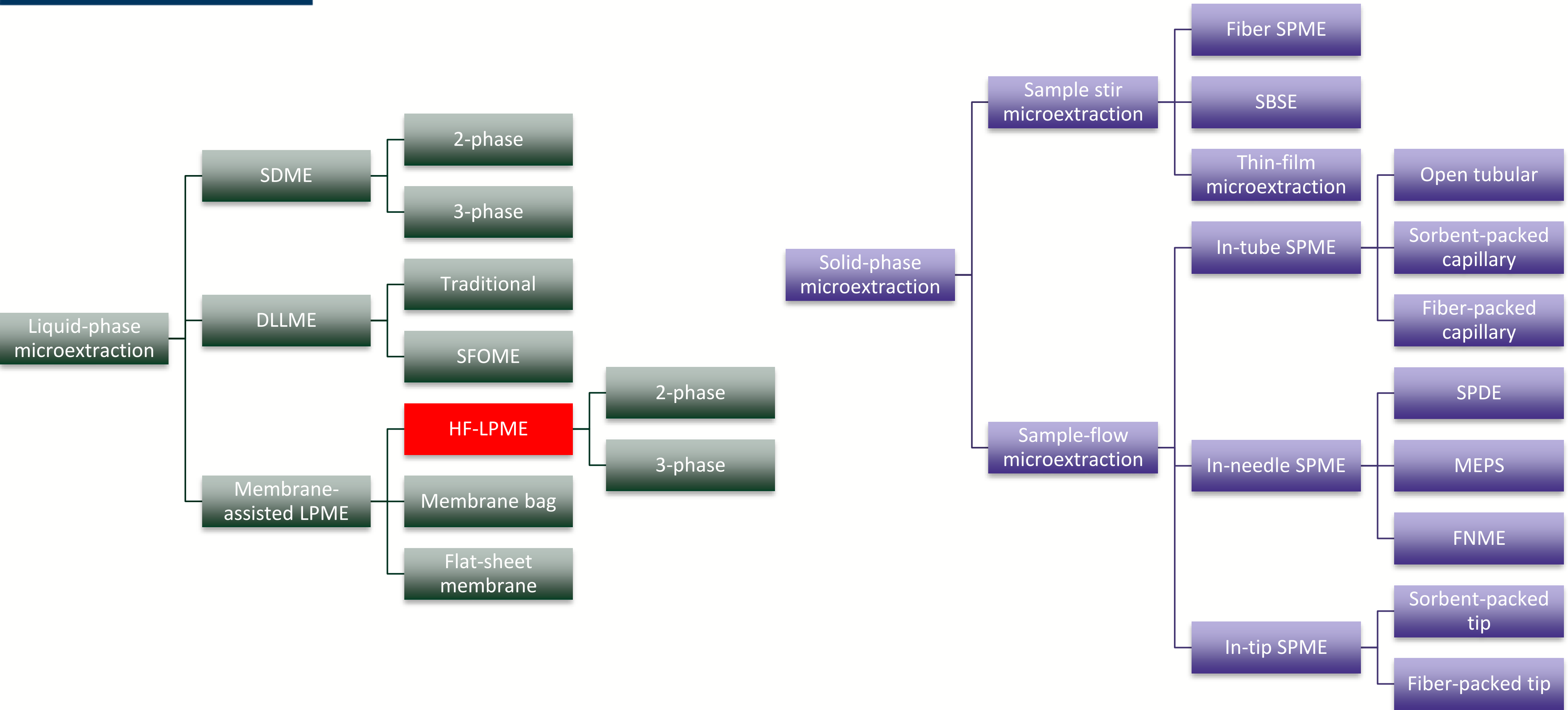
Detection/quantification

- GC-MS
- HPLC-UV
- HPLC-MS
- CE-UV

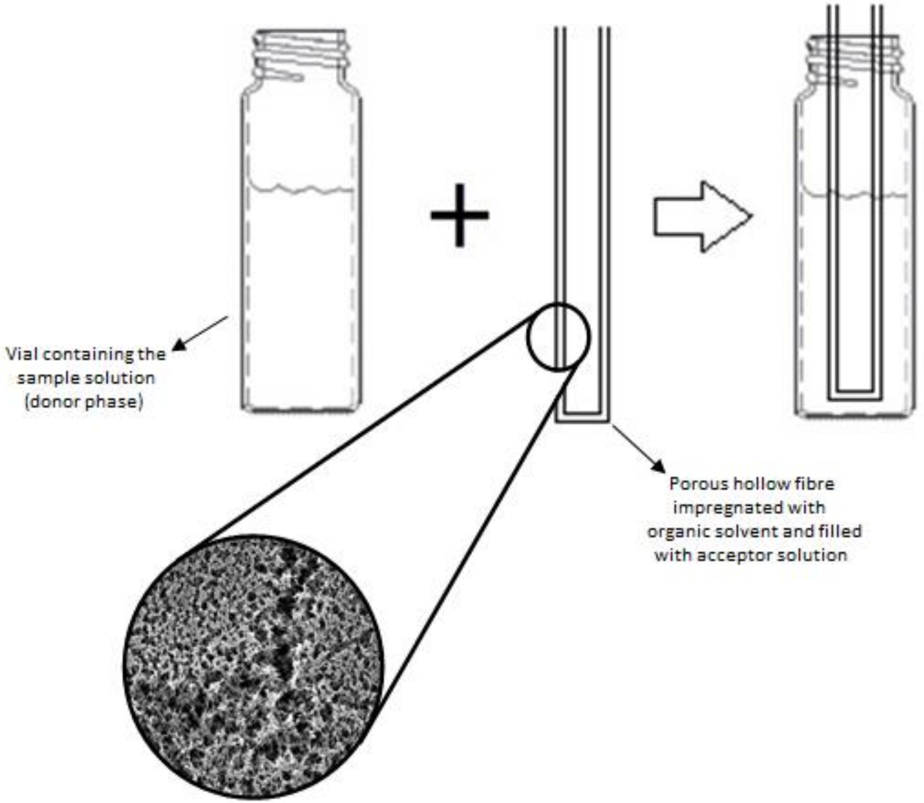
Statistical evaluation

Decision making/writing report

Microextraction methods



What is HF-LPME?



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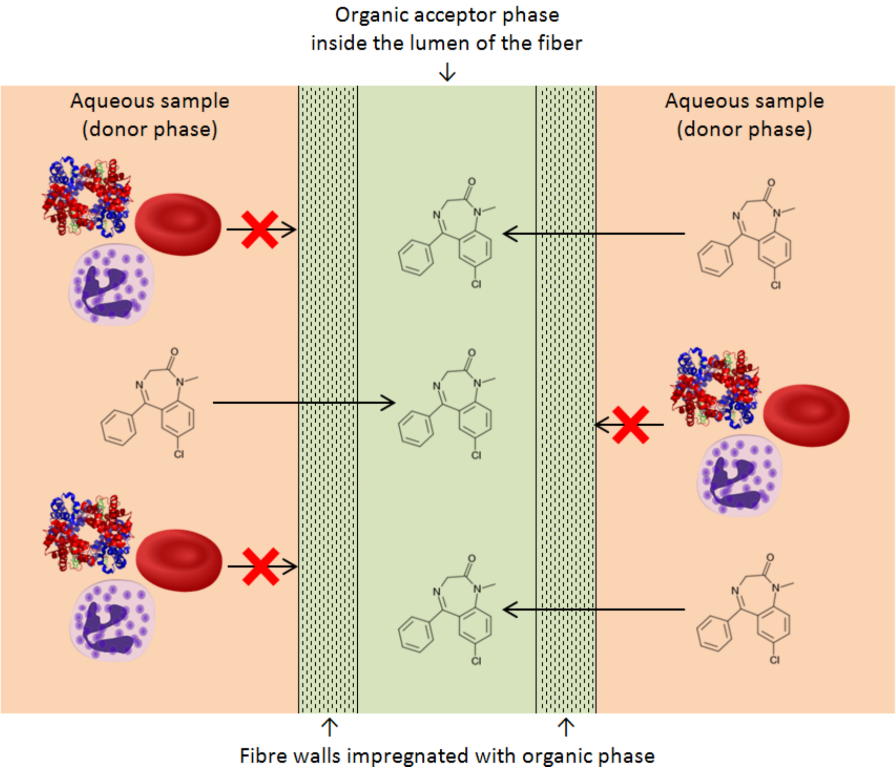
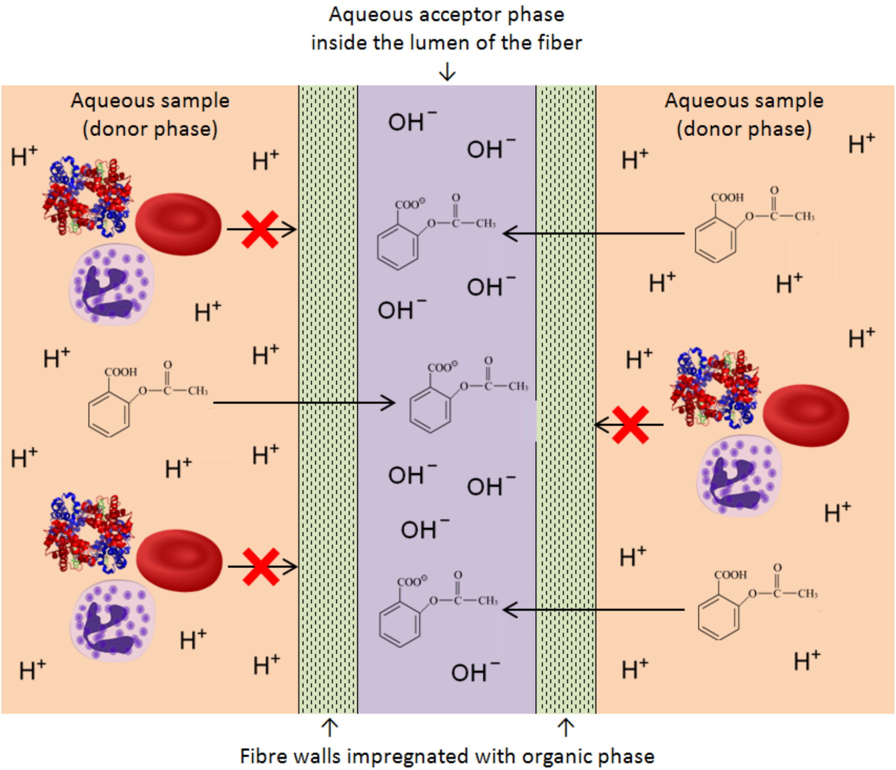
2- and 3-phases HF-LPME



DP ⇆ S/AP



DP ⇆ S ⇆ AP

The Equilibria Process

Optimising the Process

Factors that influence HF-LPME: Type of solvent

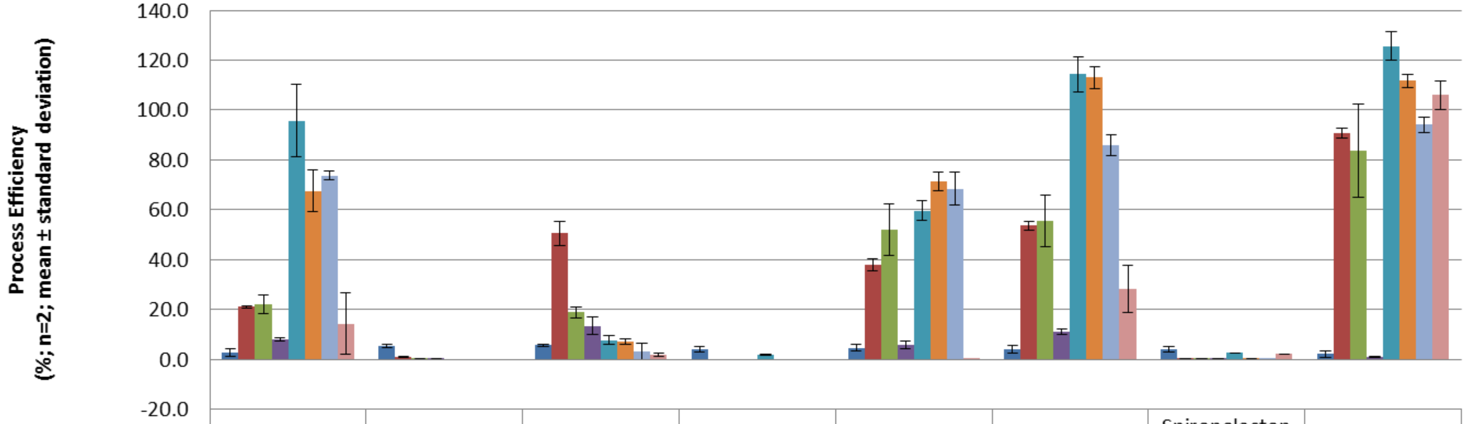
- Good selectivity/like-dissolves-like
- High partition coefficient
- Ideal viscosity
- Low water solubility
- Low vapour pressure

Properties of the tested organic solvents

Solvent	Viscosity (cP at 20°C)	Surface tension ($g.cm/s^2$)	Vapour pressure (kPa at 25°C)	Water solubility (μL/mL at 20°C)	log K_{ow}
Undecane	1.1	19.2	0.075	5.4×10^{-6}	6.6
Toluene	0.6	29.7	3.79	0.29	2.73
1-octanol	6.5[a]	29.0	0.0106	0.59	3.0
1-undecanol	-	30.1	0.00551	0.026	4.72
Dodecyl acetate	2.8[b]	29.6	0.00013	0.0031	6.1
Dihexyl-ether	1.7	25.6	0.0197	0.018	5.23
2-NPOE	12.8	37.9	0.00001125	0.81	5.45

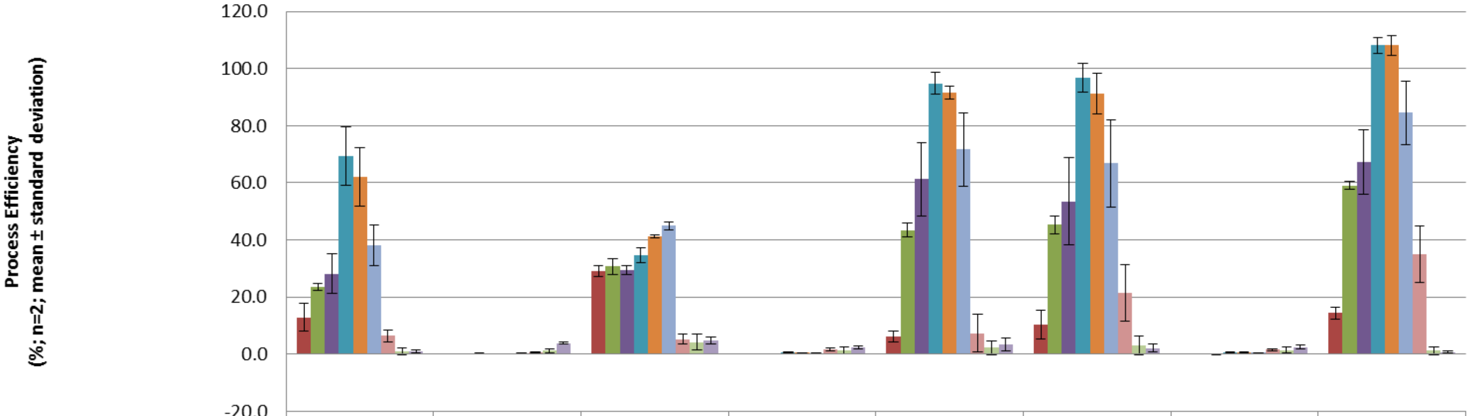
[a]at 30°C; [b]at 35°C; K_{ow}=Octanol/water partition coefficient

Factors that influence HF-LPME: Type of solvent



	Amlodipine	Atenolol	Bisoprolol	Canrenone	Doxazosin	Norverapamil	Spironolactone	Verapamil
1-butanol	2.8	5.3	5.6	4.1	4.5	4.1	3.9	2.1
1-octanol	21.0	1.0	50.6	0.0	38.0	53.6	0.1	90.8
1-undecanol	22.1	0.2	18.8	0.0	52.0	55.5	0.2	83.9
2-hexyl-1-decanol	7.9	0.0	13.4	0.0	5.6	11.1	0.1	0.8
Di-hexyl ether	95.8	0.0	7.7	1.8	59.7	114.4	2.5	125.7
Dodecyl acetate	67.6	0.0	7.0	0.0	71.4	113.1	0.4	111.8
NPOE	73.7	0.0	3.1	0.0	68.5	85.9	0.1	94.1
Undecane	14.2	0.0	1.8	0.0	0.4	28.0	2.1	106.1

Factors that influence HF-LPME: Type of solvent

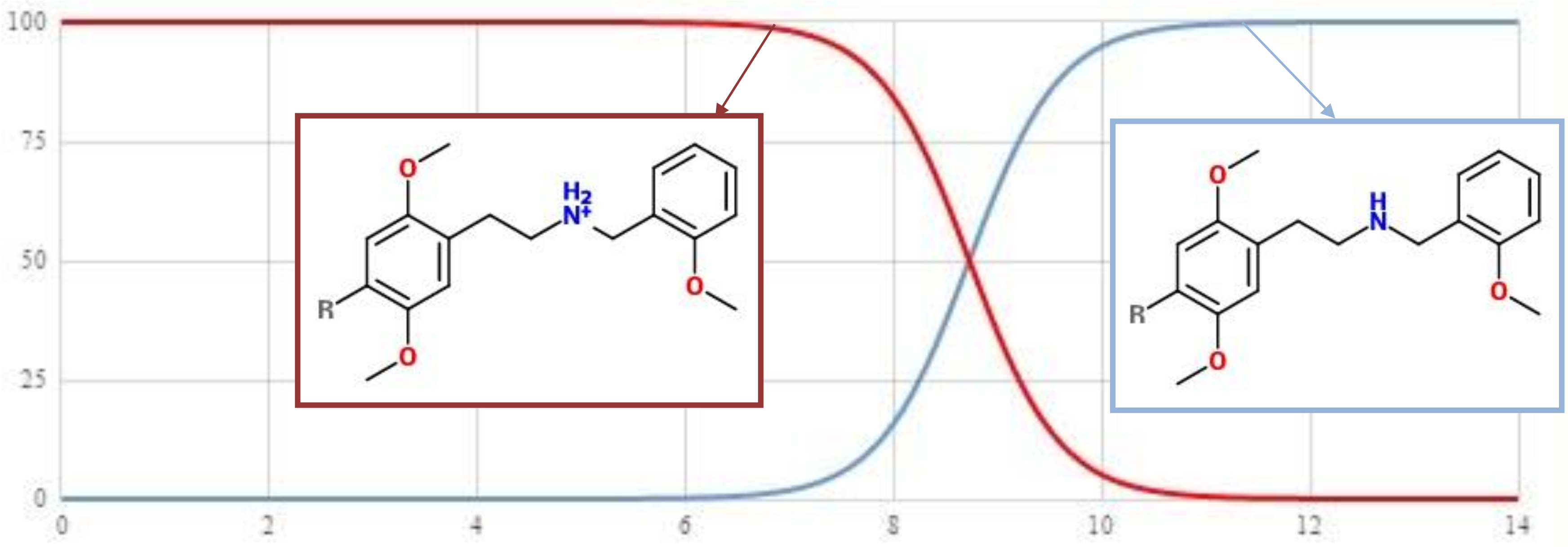


	Amlodipine	Atenolol	Bisoprolol	Canrenone	Doxazosin	Norverapamil	Spironolactone	Verapamil
1-octanol:NPOE 1:1	12.9	0.3	29.2	0.0	6.2	10.3	0.0	14.4
1-octanol:dodecyl acetate 1:1	23.4	0.2	30.7	0.0	43.4	45.2	0.0	59.0
1-octanol:dihexyl ether 1:1	28.2	0.2	29.5	0.0	61.3	53.5	0.0	67.3
1-octanol:dihexyl ether 1:3	69.3	0.1	34.7	0.6	94.8	96.9	0.7	108.1
1-octanol:dihexyl ether 1:2	62.0	0.2	41.3	0.4	91.6	91.2	0.6	108.1
1-octanol:dihexyl ether 1:1	38.1	0.4	44.9	0.3	71.6	66.9	0.5	84.5
1-butanol:dihexyl ether 1:3	6.3	0.7	5.2	1.6	7.3	21.5	1.5	35.0
1-butanol:dihexyl ether 1:2	1.0	1.2	4.2	1.4	2.2	2.9	1.4	1.2
1-butanol:dihexyl ether 1:1	0.9	3.8	4.8	2.3	3.3	2.1	2.4	0.7

Factors that influence HF-LPME: pH of donor/acceptor phases

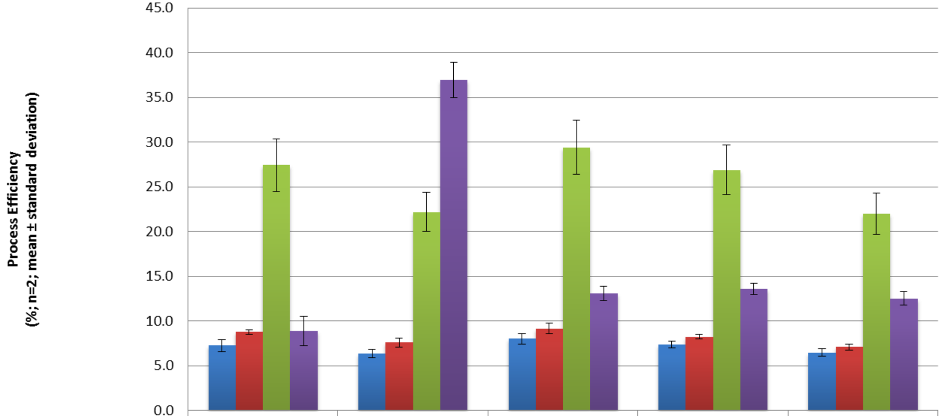
	2-phase HF-LPME		3-phase HF-LPME	
	Acidic analyte	Basic analyte	Acidic analyte	Basic analyte
Donor phase	Acidic	Basic	Acidic	Basic
Acceptor phase	n.a.	n.a.	Basic	Acidic

Factors that influence HF-LPME: pH of donor/acceptor phases



x=pH and y=% non-charged species

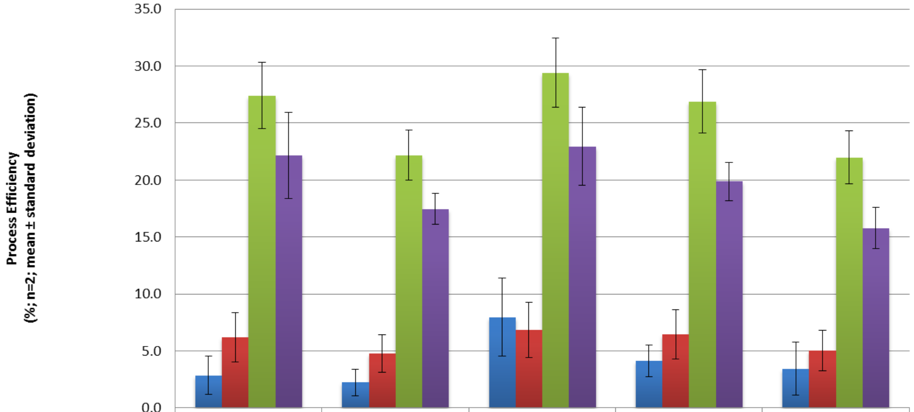
Factors that influence HF-LPME: pH of donor/acceptor phases



	25D-NBOMe	25E-NBOMe	25C-NBOMe	25B-NBOMe	25I-NBOMe
1 mole/L (pH ca. 14)	7.2	6.3	8.0	7.3	6.5
0.1 mole/L (pH ca. 13)	8.8	7.6	9.2	8.2	7.1
0.01 mole/L (pH ca. 12)	27.4	22.2	29.4	26.9	22.0
0.001 mole/L (pH ca. 11)	8.9	37.0	13.1	13.6	12.5

Quantifier Ion MRM Transitions

Effect of the pH of the donor phase using different molarities of NaOH

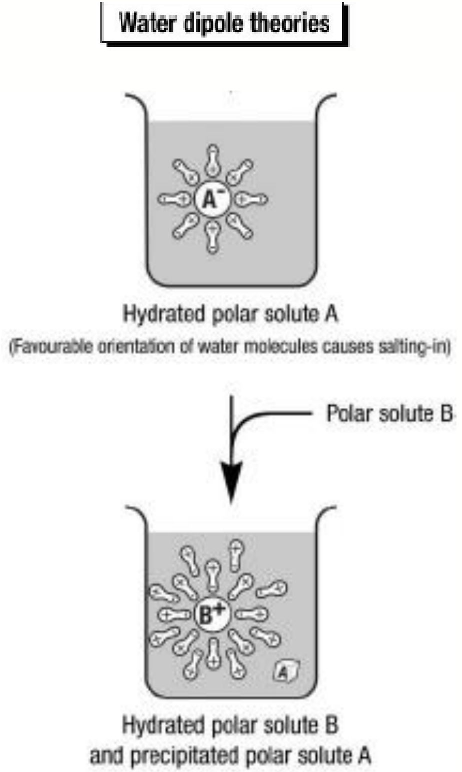


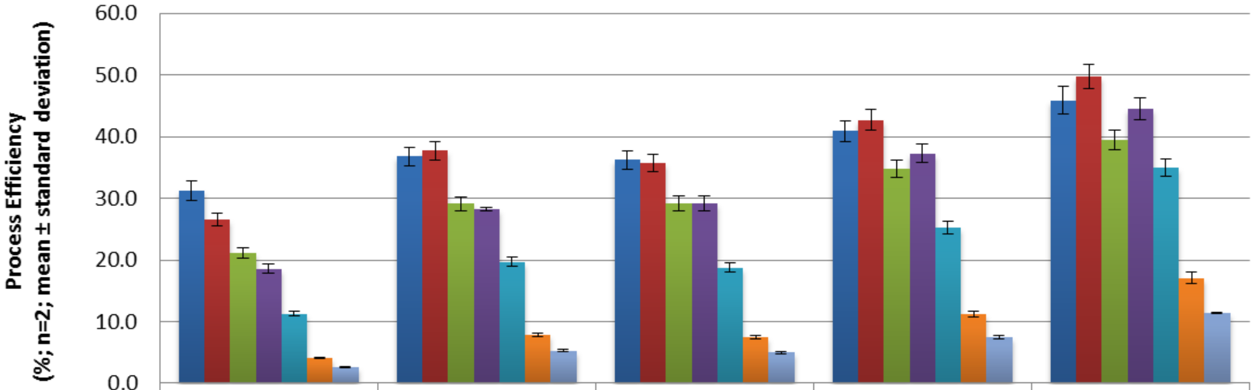
	25D-NBOMe	25E-NBOMe	25C-NBOMe	25B-NBOMe	25I-NBOMe
1 mole/L (pH ca. 0)	2.9	2.2	7.9	4.1	3.4
0.1 mole/L (pH ca. 1)	6.2	4.8	6.8	6.4	5.0
0.01 mole/L (pH ca. 2)	27.4	22.2	29.4	26.9	22.0
0.001 mole/L (pH ca. 3)	22.2	17.5	23.0	19.9	15.8

Quantifier Ion MRM Transitions

Effect of the pH of the acceptor phase using different molarities of HCl

Factors that influence HF-LPME: Ionic strength of donor phase



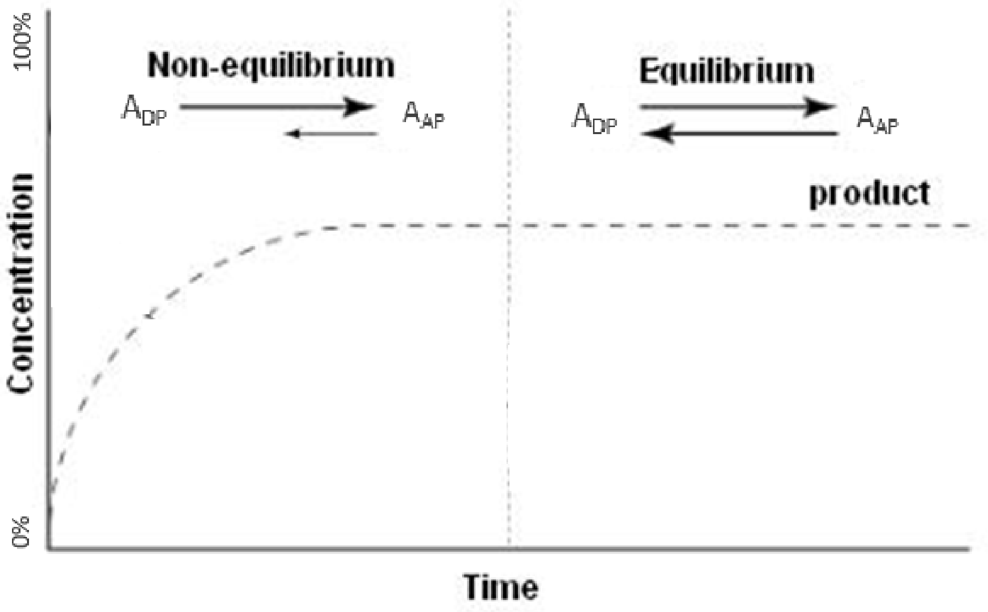


	25D-NBOMe	25E-NBOMe	25C-NBOMe	25B-NBOMe	25I-NBOMe
0.0% (w/v)	31.2	36.8	36.2	40.9	45.9
0.1% (w/v)	26.5	37.7	35.7	42.7	49.8
0.5% (w/v)	21.1	29.1	29.2	34.7	39.4
1.0% (w/v)	18.6	28.3	29.2	37.3	44.5
5.0% (w/v)	11.3	19.7	18.8	25.3	35.0
10.0% (w/v)	4.1	7.8	7.5	11.2	17.1
20.0% (w/v)	2.6	5.3	5.0	7.4	11.4

Quantifier Ion MRM Transition

Factors that influence HF-LPME: Extraction time

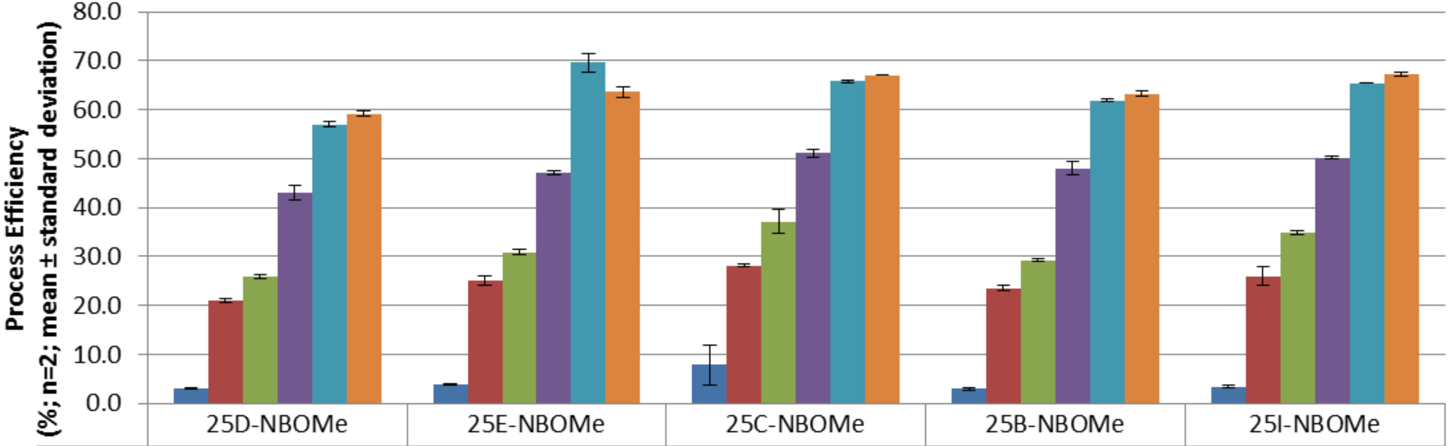
- Too long: loss of solvent
- Too short: not enough extraction



Factors that influence HF-LPME: Forced convection

- Stirring, vortex-shaking, sonicating
- Increases the mass transfer
- Decrease time to reach equilibrium
- Bubbles formation
- Leakage and evaporation of solvent
- Damaging the fiber

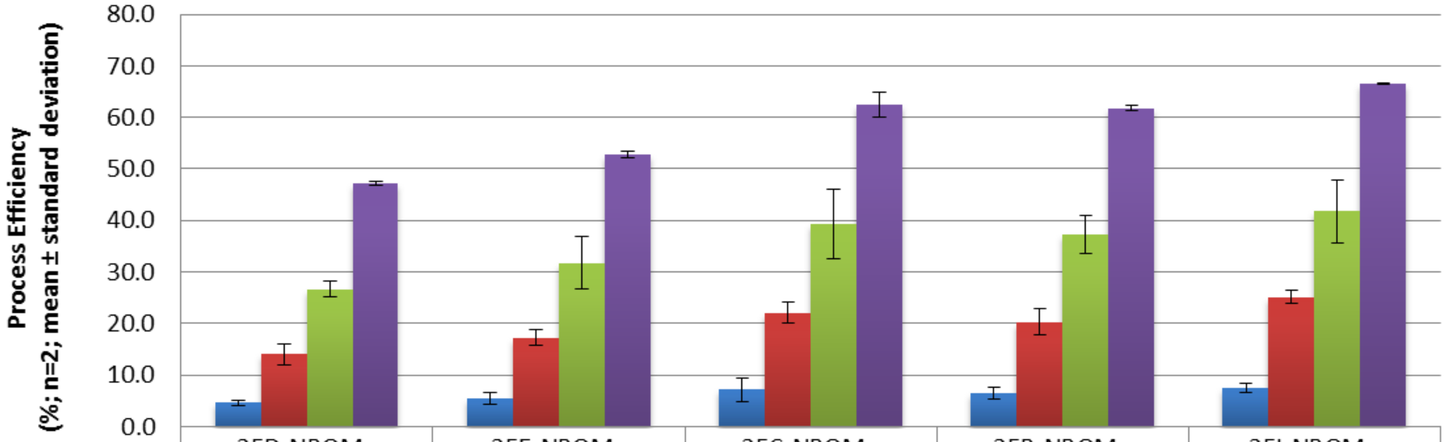
Factors that influence HF-LPME: Time and forced convection



	25D-NBOMe	25E-NBOMe	25C-NBOMe	25B-NBOMe	25I-NBOMe
5min	3.0	3.9	7.8	2.9	3.4
10min	21.0	25.0	28.1	23.5	26.0
20min	26.0	30.9	37.2	29.2	34.9
30min	43.0	47.2	51.1	48.0	50.1
40min	57.0	69.6	65.8	61.9	65.4
50min	59.2	63.6	67.1	63.3	67.2

Quantifier Ion MRM Transition

Factors that influence HF-LPME: Time and forced convection



	25D-NBOMe	25E-NBOMe	25C-NBOMe	25B-NBOMe	25I-NBOMe
1 min	4.6	5.4	7.1	6.6	7.6
2 min	14.0	17.2	22.1	20.3	25.2
4 min	26.7	31.7	39.3	37.2	41.8
6 min	47.2	52.8	62.6	61.8	66.6

Quantifier Ion MRM Transition

Acknowledgements

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References

- [1] Pawliszyn, J. and H.L. Lord, Handbook of Sample Preparation. 2012: Wiley.
- [2] Kokosa, J.M., A. Przyjazny, and M.A. Jeannot, Solvent Microextraction: Theory and Practice. 1st ed. 2009, United States of America: John Wiley & Sons, Inc.
- [3] Mitra, S., Sample Preparation Techniques in Analytical Chemistry. 2004: Wiley.
- [4] Xu, L., C. Basheer, and H.K. Lee, Chemical reactions in liquid-phase microextraction. J Chromatogr A, 2009. 1216(4): p. 701-7, DOI: 10.1016/j.chroma.2008.10.005.
- [5] Kislik, V.S., Solvent extraction classical and novel approaches. 2012, Elsevier: Oxford. p. 1 online resource (xv, 555 p.),
- [6] Psillakis, E. and N. Kalogerakis, Developments in liquid-phase microextraction. Trend Anal Chem, 2003. 22(10): p. 565-574, DOI: 10.1016/S0165-9936(03)01007-0.
- [7] Sarafraz-Yazdi, A. and A. Amiri, Liquid-phase microextraction. Trend Anal Chem, 2010. 29(1): p. 1-14, DOI: 10.1016/j.trac.2009.10.003.
- [8] Armenta, S., S. Garrigues, and M. de la Guardia, Green Analytical Chemistry. Trend Anal Chem, 2008. 27(6): p. 497-511, DOI: 10.1016/j.trac.2008.05.003.
- [9] Kabir, A., et al., Recent advances in micro-sample preparation with forensic applications. Trend Anal Chem, 2013. 45: p. 264-279, DOI: 10.1016/j.trac.2012.11.013.
- [10] Chimuka, L., et al., Advances in sample preparation using membrane-based liquid-phase microextraction techniques. Trend Anal Chem, 2011. 30(11): p. 1781-1792, DOI: 10.1016/j.trac.2011.05.008.
- [11] Kokosa, J.M., Advances in solvent-microextraction techniques. Trac -Trend Anal Chem, 2013. 43: p. 2-13, DOI: 10.1016/j.trac.2012.09.020.
- [12] He, Y., Recent advances in application of liquid-based micro-extraction: A review. Chemical Papers, 2014. 68(8): p. 995-1007, DOI: 10.2478/s11696-014-0562-6.
- [13] Lambropoulou, D.A. and T.A. Albanis, Liquid-phase micro-extraction techniques in pesticide residue analysis. J Biochem Biophys Methods, 2007. 70(2): p. 195-228, DOI: 10.1016/j.jbbm.2006.10.004.
- [14] Ghambarian, M., Y. Yamini, and A. Esrafili, Developments in hollow fiber based liquid-phase microextraction: principles and applications. Microchimica Acta, 2012. 177(3-4): p. 271-294, DOI: 10.1007/s00604-012-0773-x.

University of Glasgow

Questions?

Dr Rafael Venson
rafaelvenson@yahoo.com.br