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New approaches for determining solubility of volatile liquid chemicals

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Introduction

Water solubility is a fundamental parameter in environmental risk assessment of chemicals, and is theoretically a simple parameter to determine.

Main challenge for liquid hydrophobic chemicals:
- avoiding formation of dispersions or micro-droplets
- while establishing equilibrium within a reasonable time frame

Two new approaches were directed at solubility determinations:
1) Passive dosing from a saturated silicone polymer
2) Dosing from pure phase liquid through the headspace

Silicone loading kinetics

- Loading kinetics were determined for dodecylbenzene
- 30 rods were placed in dodecylbenzene and rolled at 20 rpm.
- At certain time steps, five rods were removed and wiped
- Swelling was determined by weight

Swelling times:
- 95% of max swelling = 11 hours
- 99% of max swelling = 18 hours

Figure 1: Swelling kinetics for 3 mm silicone rod immersed in dodecylbenzene. Fit: First order biphasic model

Experimental setup

Passive dosing from saturated silicone
- Cleaned silicone rod (diameter: 3mm) was cut into pieces of 0.4 g (See A, bottom panel)
- Rods were loaded by immersion in the liquid test chemical
- Loaded rods were wiped with damp lint free tissue and rinsed three times with water
- Water was added to the loaded rods and equilibrated on a roller at 20 rpm (B & C)

Equilibration through headspace
- Glass wool was placed in glass inserts in 20 mL vials
- Liquid test chemical was added to the inserts
- Water was added to the vials
- Vials were shaken at 200 rpm, 10mm orbit for 23 hours

Test chemicals: dodecylbenzene, isopropyl myristate, hecylcyclohexane, +αPinene (D)
Analysis was done using liquid/liquid extraction with iso-octane (1:5 mL iso-octane to 5-10 mL sample) and GC-MS (E).
Calibration by 13C labeled standard for Dodecylbenzene and external standards for all other compounds.

Generating saturated solutions

- Equilibrium kinetics for direct passive dosing and headspace dosing of isopropyl myristate. Mean and s.d.
- 100% Direct passive dosing • Headspace equilibration • EpiSuite estimated solubility • 90% Direct passive dosing • Headspace • EpiSuite experimental database

Figure 2: Equilibrium kinetics for direct passive dosing and headspace dosing of isopropyl myristate

Figure 3: Direct passive dosing of dodecylbenzene from silicone rods loaded at varying swelling percentages

Cross-validation

- Measured solubility
- 100% loading of silicone
- 90% loading of silicone
- 1:1

Figure 4: Solubility measured by direct passive dosing from 100 and 90% swelling of silicone as a function of solubility measured by headspace dosing. Mean and s.d.; n=3

Conclusion

- Saturation of 3 mm silicone rod by swelling can be obtained within one day
- Direct passive dosing at 90% swelling agreed with headspace equilibrated solubility measurements
- Direct passive dosing at 100 % swelling produced markedly higher concentrations than headspace equilibration and direct passive dosing at 90 % swelling – third phase challenges
- Headspace dosing is a promising method for solubility determinations for volatile liquid chemicals
- Direct passive dosing for solubility measurements of hydrophobic chemicals requires further work

References:
2Trac, L.N., Schmidt, S.N and Mayer, P. Submitted. Headspace passive dosing of volatile hydrophobic chemicals – aquatic toxicity testing exactly at the saturation level.
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