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FACULTY OF
BIOSCIENCE ENGINEERING

DEPARTMENT CROP PROTECTION
LABORATORY OF CROP PROTECTION CHEMISTRY

REDUCTION OF POST-APPLICATION PESTICIDE VOLATILISATION BY FORMULATION

Pesticide Behaviour in Soils, Water and Air

1/09/2017

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Potential of adjuvants to reduce pesticide volatilisation

Impact

- Volatilisation of active ingredients
  - Widely observed
  - Amount volatilised adds up from 30 to 50%

Vapour pressure (mPa)	Active ingredient	Vapour pressure (mPa)	Active ingredient	Vapour pressure (mPa)	Active ingredient	Vapour pressure (mPa)	Active ingredient
2980000	**1,3-Dichloropropene**	1.1	Pyrimethanil	0.153	Metrafenone	0.019	2,4-D
6600	Metaldehyde	1	Ethefon	0.15	Cymoxanil	0.0178	Bifenthrin
730	Propamocarb	0.953	Ammoniumthiocyanaat	0.15	Terbutylazin	0.016	Aclonifen
78	Ethoprofos	0.877	Tolclofos-Methyl	0.15	Prochloraz	0.015	Methiocarb
57.5	Metam-Natrium	0.83	Endosulfan	0.15	Carbendazim	0.014	Maneb
24	Chloorprofam	0.79	Prosulfocarb	0.121	Metribuzin	0.0133	Mancozeb
19.2	Clomazon	0.67	Oxadiazon	0.12	Fluazifop-P-Butyl	0.0133	Cyazofamide
17	Fenpropidin	0.65	Ethofumesaat	0.1	Mepiquatchloride	0.0133	Prohexadion
12	Tri-Allaat	0.56	Fosthiazaat	0.1	Triclopyr (HE)	0.0133	Methoxyfenozide
11.97	Diazinon	0.51	Cyprodinil	0.098	Zwavel	0.0133	Bifenazaat
7.5	Fluazinam	0.48	Dodemorf	0.093	Metazachloor	0.0133	Pyriproxyfen
5.7	Spiroxamine	0.43	Pirimicarb	0.09	Flufenacet	0.0131	Glyphosate
5.7	Thiodicarb	0.4	Mcpa	0.0762	Chloorthalonil	0.013	Zoxamide
5.1	Linuron	0.4	Metobromuron	0.072	Carfentrazon-Ethyl	0.013	Amidosulfuron
4.3	Metoxuron	0.37	Dimethenamide	0.06	Indoxacarb	0.013	Imazamox
3.9	Fenpropimorf	0.366	Penconazool	0.056	Dichloorprop-P	0.013	Flazasulfuron
3.7	S-Metolachlor	0.34	Pethoxamide	0.056	Propiconazool	0.013	Milbemectine
3.7	Thiabendazool	0.3	Benthiavalicarb	0.055	Haloxyfop-R	0.0127	Daminozide
3.35	Chloorpyrifos	0.25	Dicofol	0.051	Oxamyl	0.012	Quinoxyfen
3.3	Metalaxyl-M	0.247	Dimethoaat	0.0416	Carbaryl	0.011	Beflubutamide
3.2	Flumioxazine	0.23	Mecoprop-P	0.0386	Flusilazool	0.01	Chloormequat
3	Chloorpyrifos-Methyl	0.2	Tolylfluanide	0.0354	Cyflufenamide	0.01	Diquat
2.3	Thiram	0.198	Myclobutanil	0.033	Amitrol	0.01	Maleinehydrazide
2.16	Trinexapac-Ethyl	0.192	Asulam	0.027	Tepraloxydim	0.01	Epoxyconazool
1.94	Pendimethalin	0.191	Triflumizool	0.0267	Propyzamide	0.01	Metiram
1.73	Benfluralin	0.18	Tetraconazool	0.026	Cyproconazool	0.01	Paraquat
1.67	Dicamba	0.17	Bentazon	0.026	Laminarine	0.01	Florasulam
1.6	Mecoprop	0.17	Bromoxynil	0.0232	Mepanipyrim	0.01	Gibberellinezuur
1.36	Clopyralid	0.162	Bifenox	0.022	Napropamide	0.01	Fenpyroximaat
1.1	Dazomet	0.158	Imazalil	0.02	Piperonylbutoxide	0.00944	Diethofencarb

Potential of adjuvants to reduce pesticide volatilisation

Mitigation

- Several strategies to reduce volatilisation
  - Slow or controlled release formulations
  - Incorporation in soil, fast uptake into plant

- Large variability
  - Between different models
  - Between different field observation

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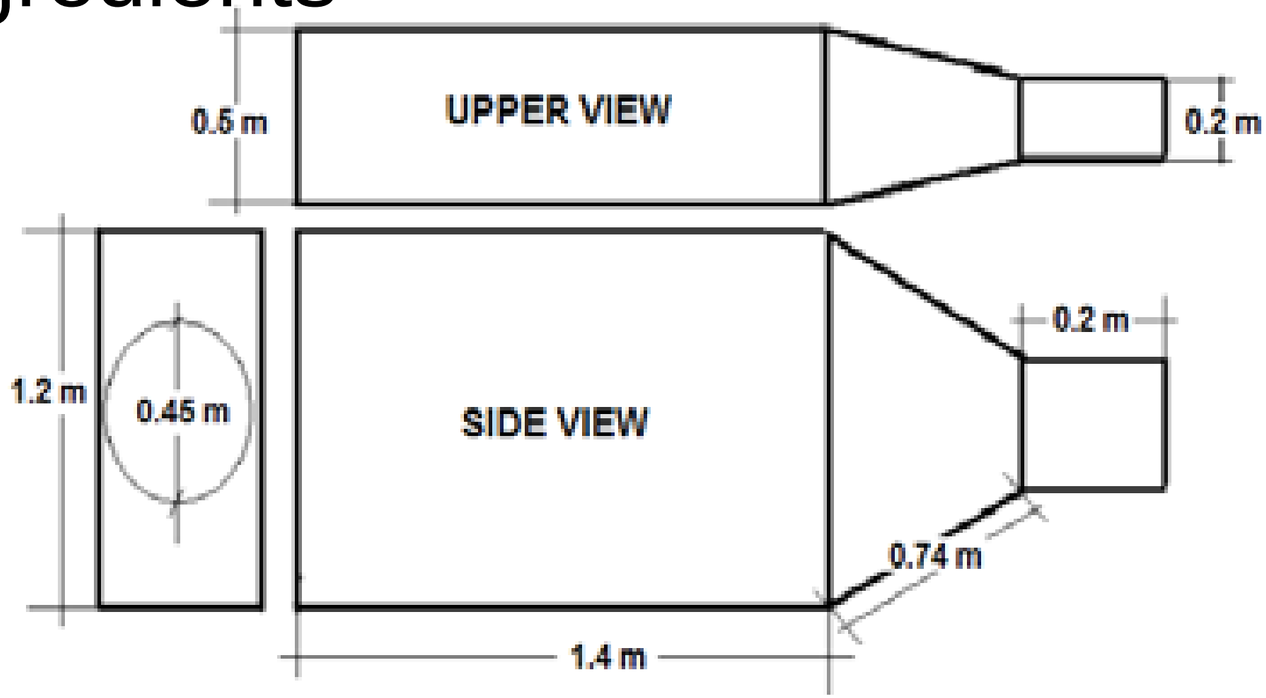
Evaporation of active ingredients in wind tunnel

Potential

- Evaluate several active ingredients
  - Technical product
  - Commercial formulation
  - Laboratories formulations
- Evaluated adjuvants
  - Oil’s
  - Surfactants



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Evaporation of active ingredients in wind tunnel

Modelling volatilisation

- First order dissipation
- Degradation neglectable
  - On glass surfaces
  - Temperature kept at 21 °C
  - Volatilisation in the dark

$$\ln\left(\frac{M}{M_0}\right) = \frac{k_1}{k_2}\left(e^{-k_2 t} - 1\right)$$

(Da Silva et al., 2001)

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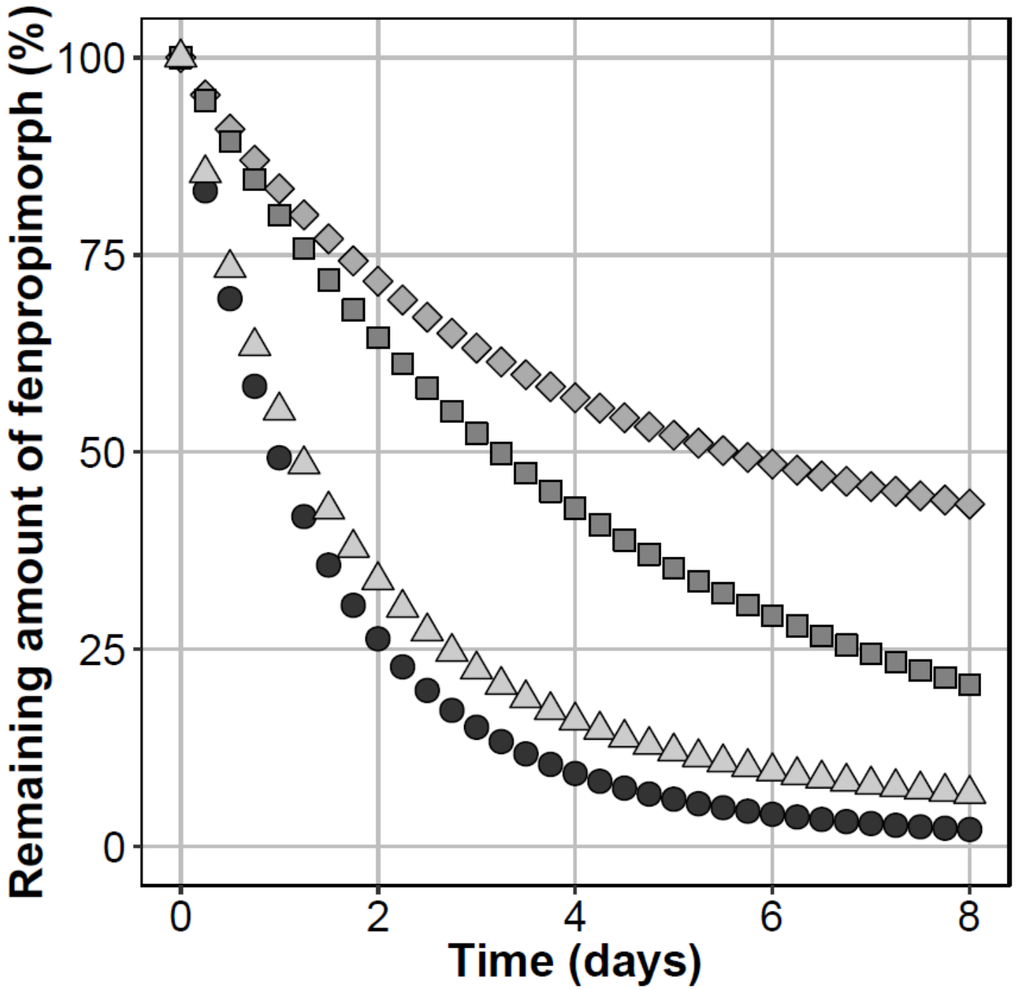
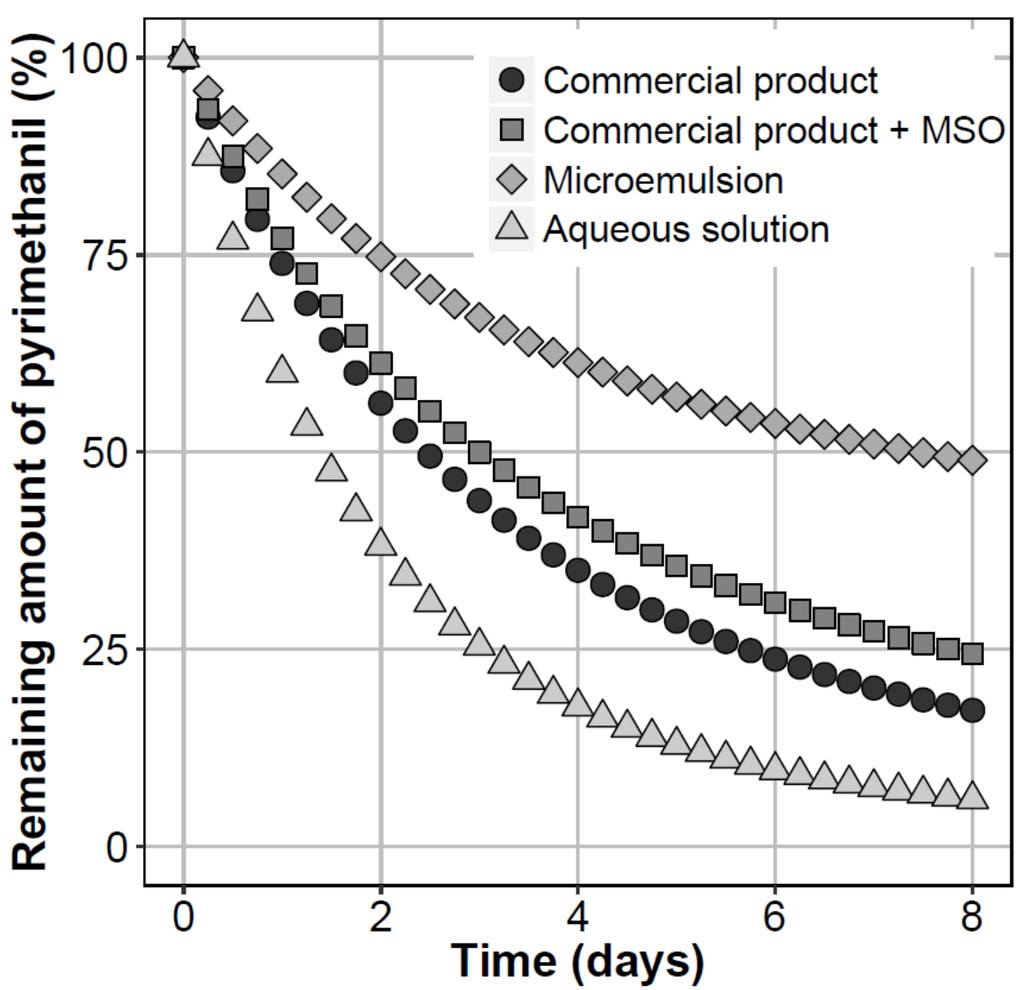
Evaporation of active ingredients in wind tunnel





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Evaporation of active ingredients in wind tunnel

Residue after 48 hours

	Fenpropimorph	Pyrimethanil
Technical product	33.7%	40.1%
Commercial product	26.3% (EC)	56.2 % (SC)
Technical product + MSO	60.9%	72.1%
Commercial product + MSO	64.5% (EC + MSO)	61.1% (SC + MSO)

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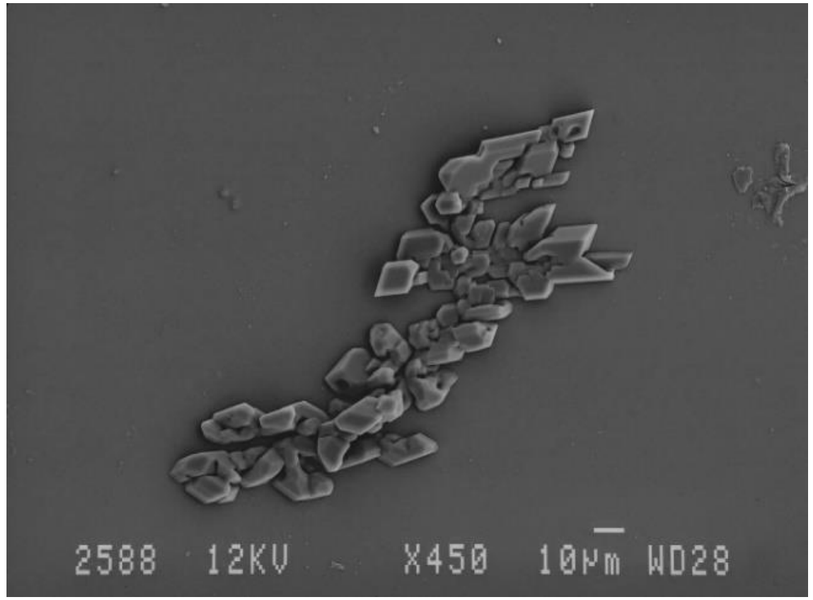
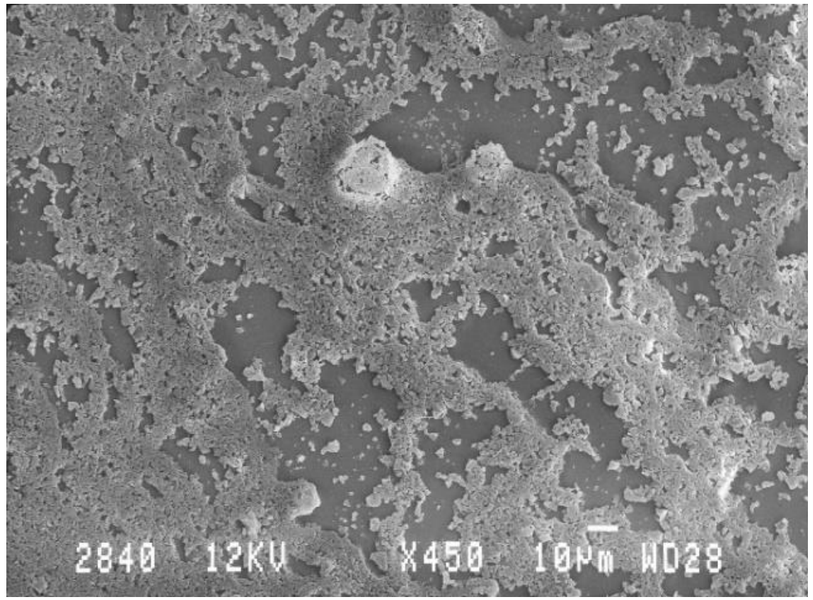
Evaporation of active ingredients in wind tunnel

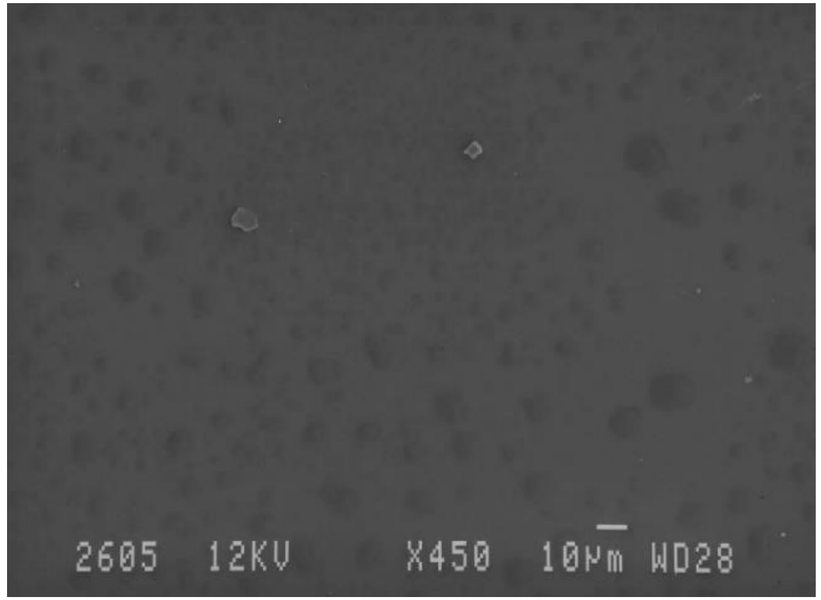
Scanning electron micrographs



Aqueous solution of pyrimethanil



Suspension concentrate of pyrimethanil



Emulsifiable concentrate of pyrimethanil

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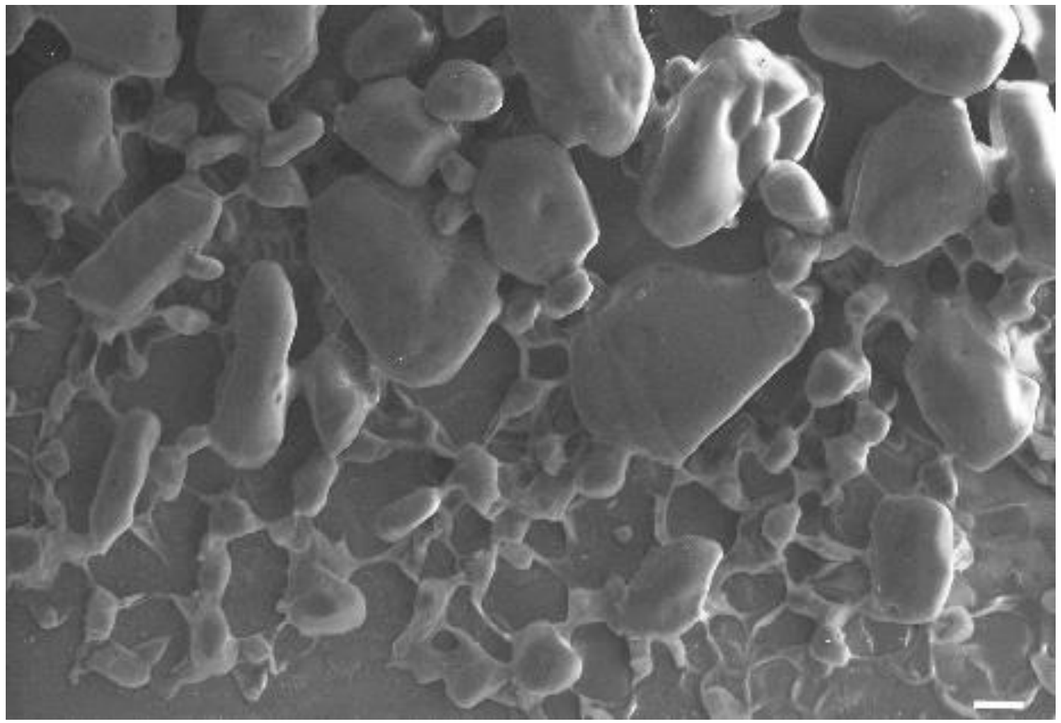
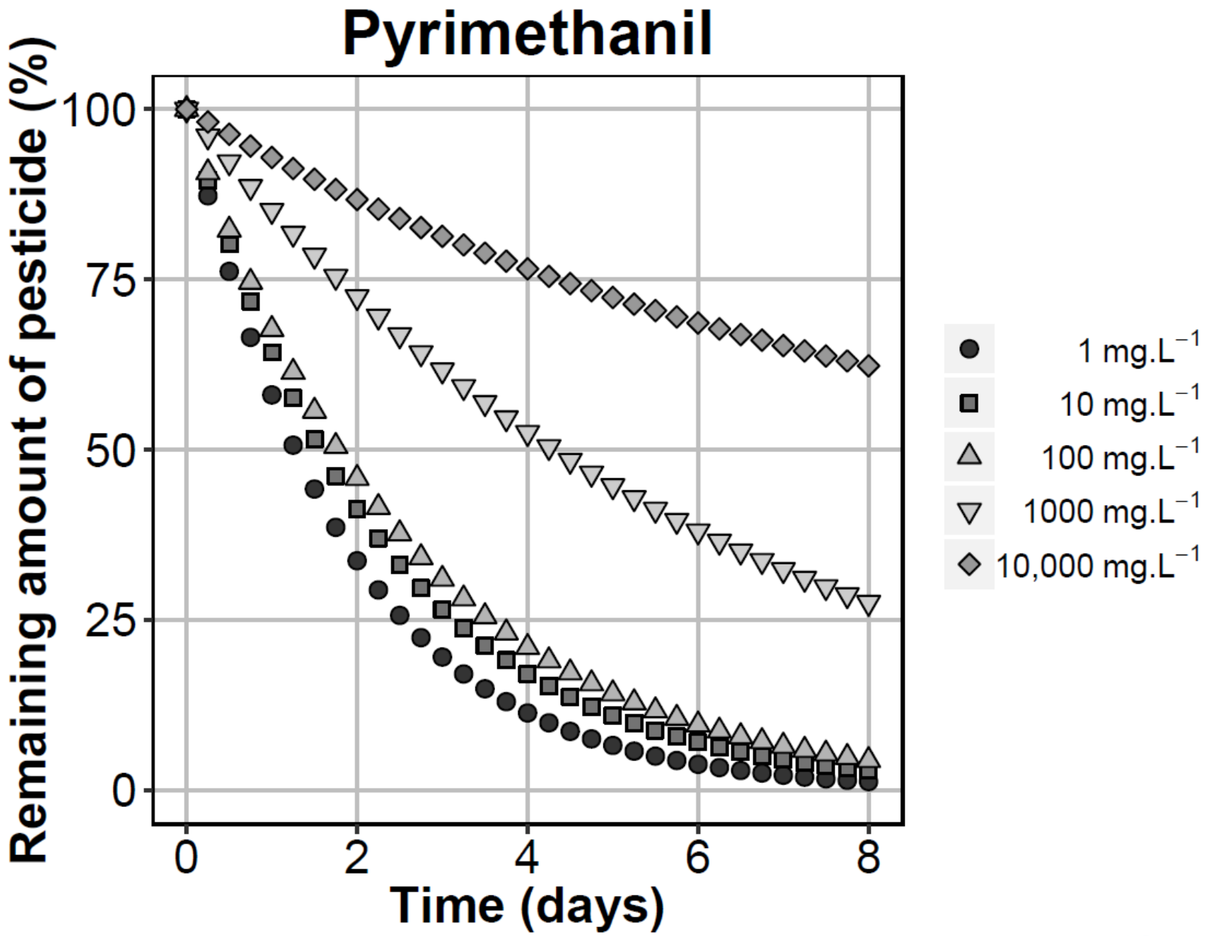
Evaporation of active ingredients in wind tunnel

Effect of surfactant concentration





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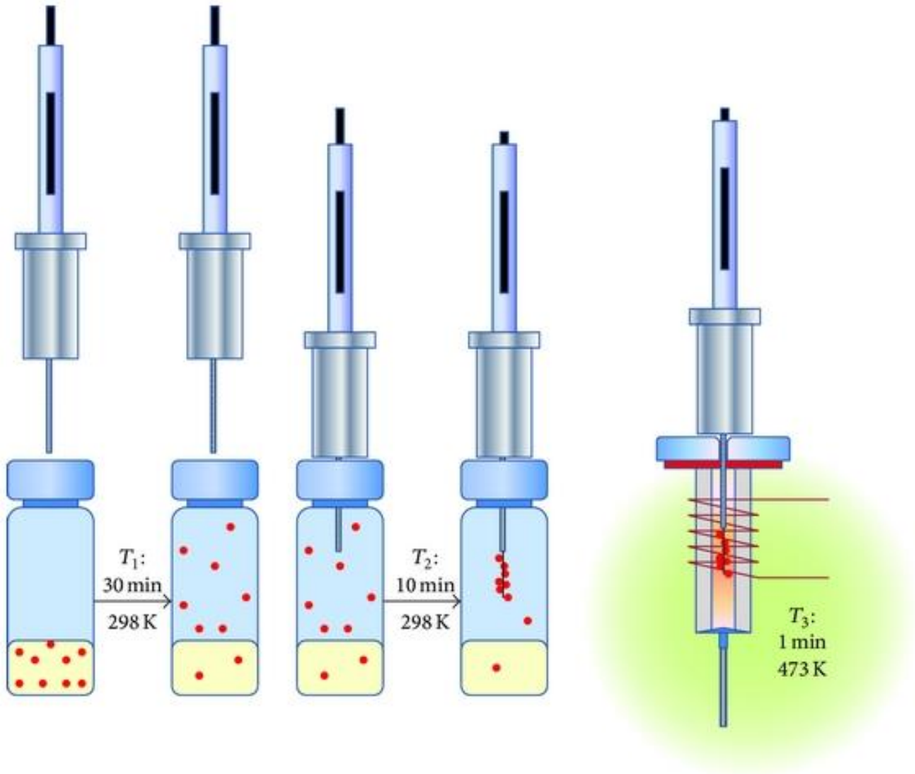
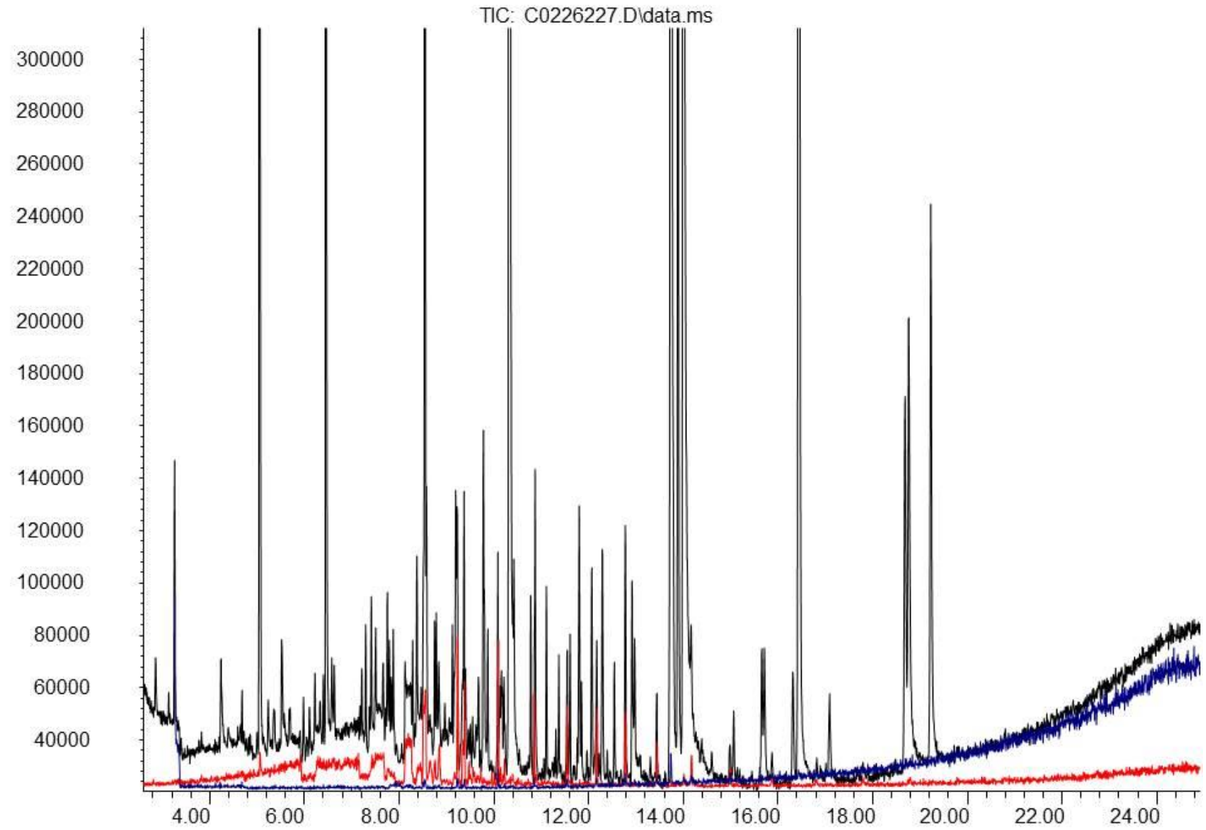
Volatilisation of pesticide and effective vapour pressure

Headspace solid-phase microextraction





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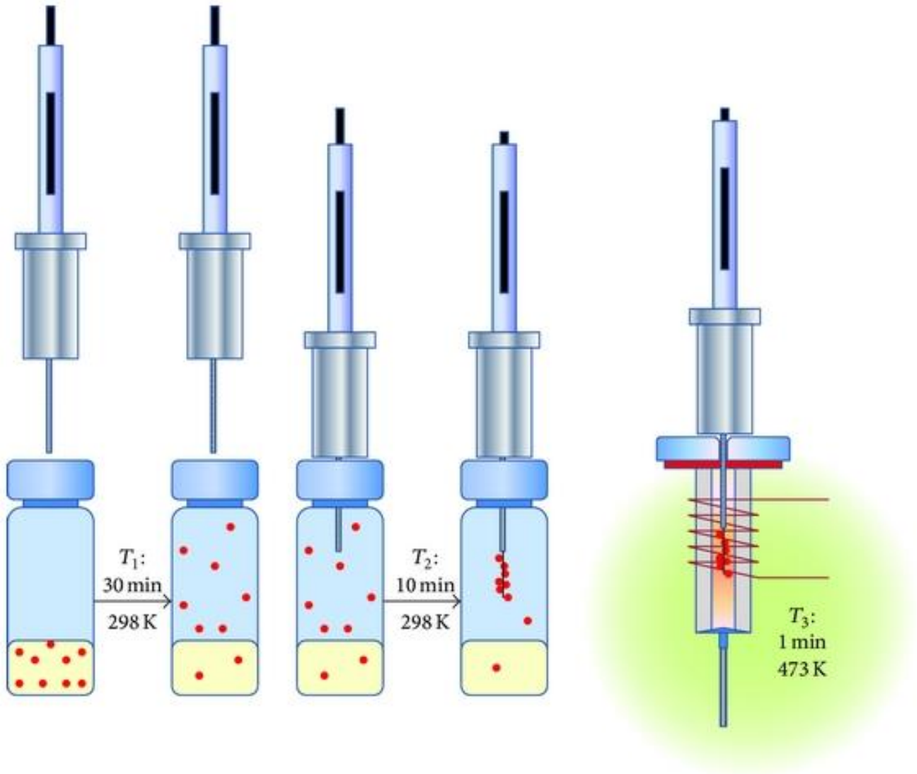
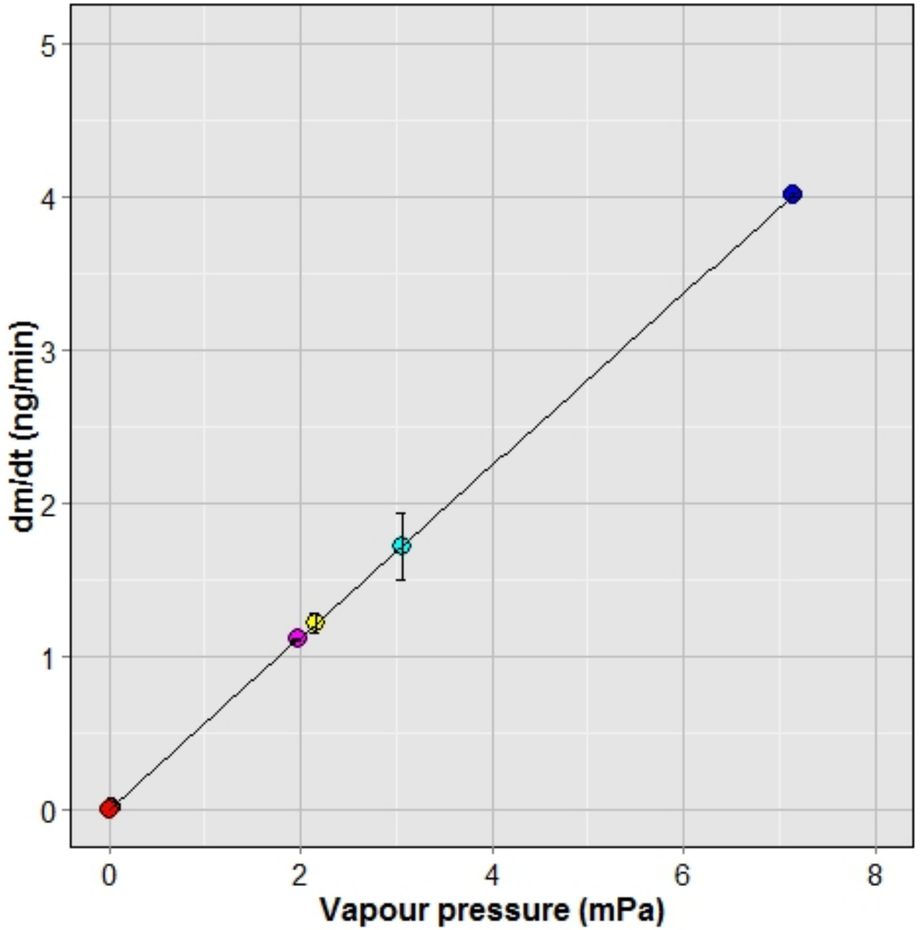
Volatilisation of pesticide and effective vapour pressure

Headspace solid-phase microextraction





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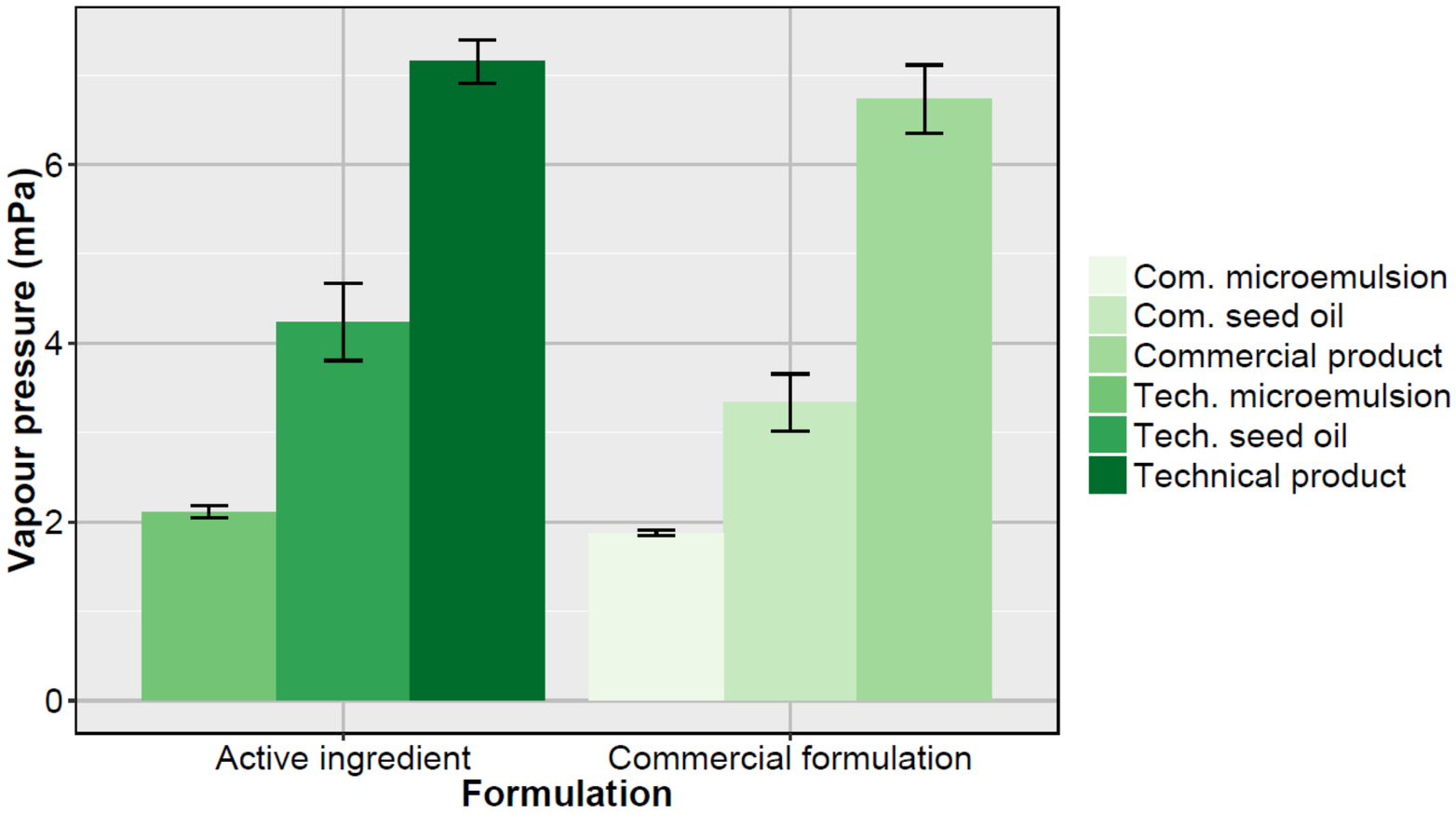
Volatilisation of pesticide and effective vapour pressure

Effective vapour pressure vs wind tunnel

	Fenpropimorph
	Amount volatilised
Active ingredient	66.3%
Commercial product	73.7%
Active ingredient + microemulsion surfactant	22.4%
Commercial product + microemulsion surfactant	28.4%
Active ingredient + oil	39.1%
Commercial product + oil	35.5%



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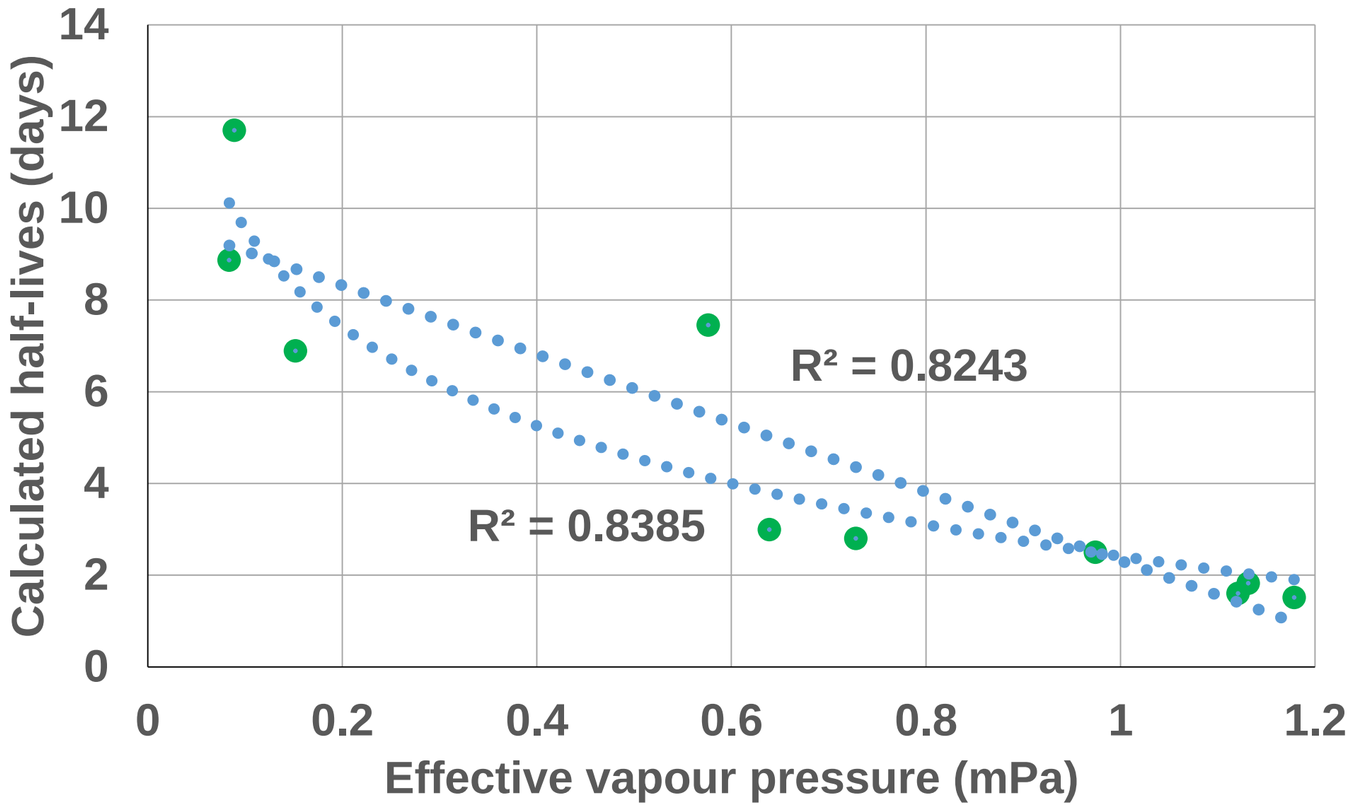
Volatilisation of pesticide and effective vapour pressure

Effective vapour pressure vs half life

Pyrimethanil	Vapour pressure (mPa)	Half-life (days)
Aqueous solution	1.18	1.51
Emulsifiable concentrate	1.13	1.82
Low surfactant conc.	1.12	1.6
Average surfactant conc.	0.97	2.5
Suspension concentrate	0.73	2.8
Suspension concentrate + MSO	0.64	2.99
Microemulsion	0.58	7.45
Encapsulation	0.15	6.89
High surfactant conc.	0.09	11.7
Cocrystal	0.08	8.87



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Volatilisation of pesticide and effective vapour pressure

Conclusion

- Adjuvants and formulation effect volatility of pesticides
  - Adjuvants can act as fixatives (especially low volatile solvents)
  - Surfactants show limited effect at conventional concentration
- Reduction in volatility can be measured by effective vapour pressure
  - Establishment of volatility reducing factor for formulations
  - Use of effective vapour pressure in pesticide emission models

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