Phase and Component Viscosity

In a component based simulator like STARS the *phase viscosity* is computed from *component viscosities*, which are the entities that much be input to the simulator.

However, especially with a background in black oil simulation, this kind of thinking is not very familiar, as the phase viscosity is what we encounter in practice.

This blog entry shows how to think "backwards" – with a known (or assumed) phase viscosity, how to compute the component viscosity that should be defined in the STARS data file?

We simplify the discussion somewhat by assuming only two components, water and a component that is diluted in the water – resulting in a *water phase*.

In general, STARS assumes *log-linear mixing*, i.e. the phase viscosity is calculated by:
(μ: viscosity; Superscript *f*: phase, superscript *c*: component, *C*: Concentration of diluted component)

$$\ln\left(\mu_w^f\right) = (1 - C_s)\ln(\mu_w^c) + (C_s)\ln(\mu_s^c)$$

A more general expression, allowing for non-linear mixing:

$$\ln\left(\mu_w^f\right) = (1 - C_s)\ln(\mu_w^c) + f_p(C_s)\ln(\mu_s^c)$$

where f_p is the non-linear mixing function.

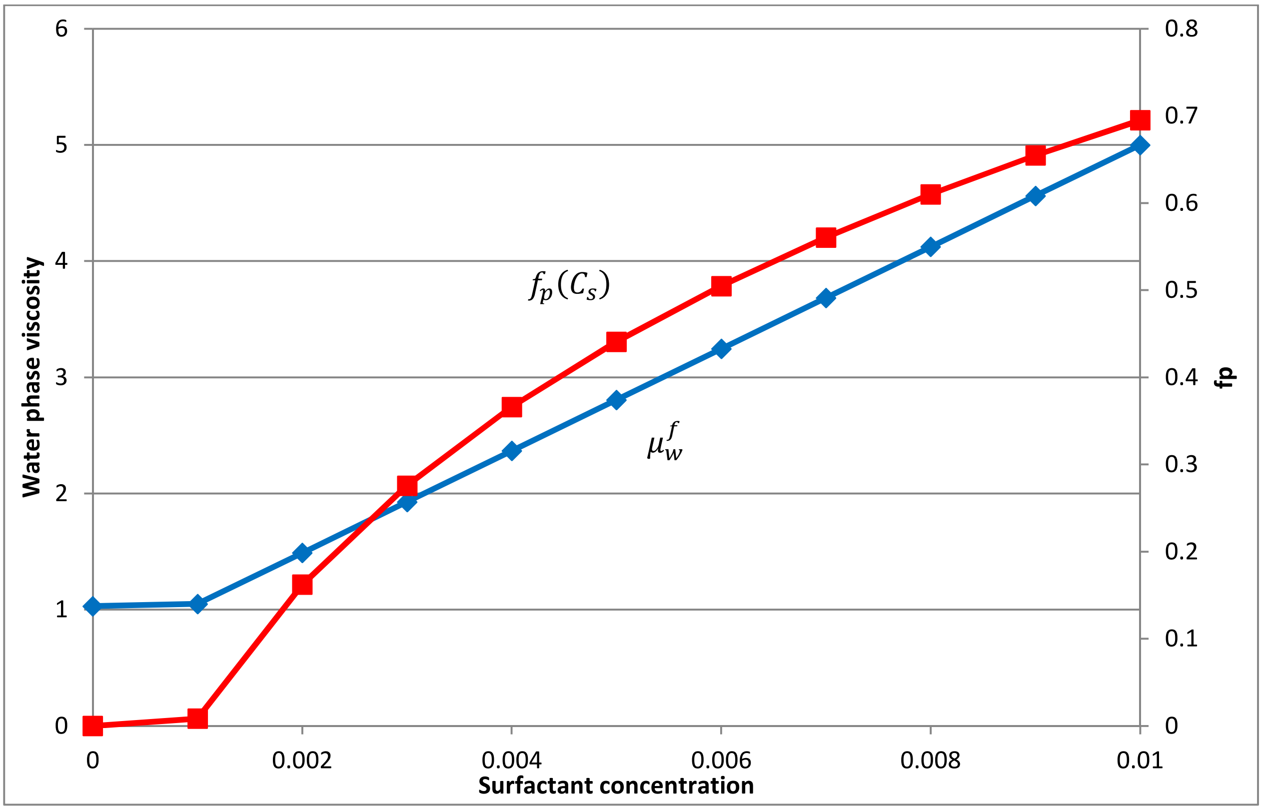
Assuming we know the effect of mixing a component in water, i.e. phase viscosity as function of concentration is known. In that case we can solve the equation to determine the mixing function:

$$f_p(C_s) = \frac{\ln\left(\mu_w^f\right) - \ln(\mu_w^c)}{\ln(\mu_s^c) - \ln(\mu_w^c)}$$

Example: When surfactant is diluted in water the water phase viscosity varies almost linearly:

Surf. conc.	μ_w^f
0.0	1.03
0.001	1.05
0.01	5.0

The component viscosity for surfactant is set to 10 cP, but this value is not important, as the mixing function is related to it, and the final phase viscosity is not dependent on the value. So computing the mixing function from the formula above gives us a relationship as in the figure below:



This function can be input to STARS by the keyword VSMIXFUNC, which works as follows:

The keyword VSMIXENDP defines lower and upper point on the mixing function.
In VSMIXFUNC a string of numbers is defined, such that the interval defined by VSMIXENDP is subdivided into corresponding equal sub-intervals:

Example:

```
VSMIXCOMP 'Surf'
VSMIXENDP 0 0.01
VSMIXFUNC 0 0.008461 0.162106 0.27576 0.365998 0.440841 0.504783 0.5606 0.610127
0.654637 0.695055
```

Note that it may be necessary to scale the mixing function to get the desired end phase viscosity.