# In-Situ Scale Inhibitor interaction with Surface Area of Porous Sandpack: A Numerical Approach

U. C. Anyanwu[1], G. F. Oluyemi[1]
1. Department of Engineering, Robert Gordon University, Aberdeen, SC, United Kingdom.

## Introduction:

Many experiments, mathematical and numerical simulations have been carried out to evaluate behaviour, performance and interaction of squeezed Scale Inhibitors within porous media relative to their efficiency in addressing the frequent scale formation and its associated consequences. However, several physical (loose sand particles) and chemical processes affect the adsorption and performance of squeezed scale inhibitors onto formations.

In this research, Transport of Diluted Species in Porous Media node of COMSOL Multiphysics 5.3 software was used to simulate the adsorption and desorption isotherms of Methylenephosphonic acid scale inhibitor. The result showed a good fit with that of Veloso et al., 2014.

**Aim:**

To use 3-D model and Transport of Diluted Species in Porous Media node of COMSOL Multiphysics software to study the interactions of Scale inhibitors with surface area of porous Sandpack.

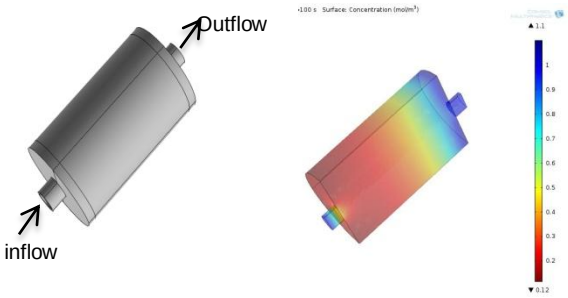


**Figure 1**. Showing inflow and outflow of 3-D Geometry and 2-D Axisymmetric surface concentration of the model

**Numerical Method:**

Transport of Diluted Species in Porous Media node of COMSOL was used to simulate the adsorption and desorption isotherms. The Langmuir equation solved is as shown below;

$$q_a = \frac{q_s b C_{eq}}{(1+bC_{eq})} \quad \text{Eqn. 1}$$

Where $q_a$ = the adsorption capacity (mol/kg), $q_s$ = saturation capacity (mol/kg), $C_{eq}$ = concentration at equilibrium in the liquid phase (mol/m$^3$), b = affinity coefficient between the adsorbate/adsorbent (m$^3$/mol).

COMSOL uses the following partial differential equation (PDE) Eqn. 2 to evaluate mass transfer to the adsorbent.

$$P_{1,i}\frac{\partial c_i}{\partial t} + P_{2,i} + \nabla.\Gamma_i + u.\nabla C_i = R_i + S_i \quad \text{Eqn. 2}$$

Where: $C_i$ is the concentration of the species (mol/m$^3$).
u is the velocity vector (m/s), $R_i$ is the reaction rate expression (production or consumption rate) for the species (mol/(m$^3$s)), $P_i$ and $P_2$ are the inlet and outlet pressures respectively (atmospheric).

**Results:**

Figures (2) and (3) show adsorption while Figures (4) and (5) show desorption isotherms of COMSOL simulations (purple) in comparison with gProms Linear Driving Force (red) and experimental (blue) obtained by Veloso et al., 2014 at concentrations of 3.34mol/m$^3$ and 33.4mol/m$^3$ respectively.

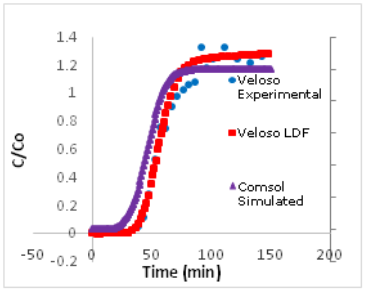


**Figure (2)**. Conc. at 3.34 mol/m$^3$

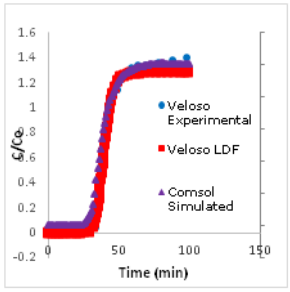


**Figure (3)**. Conc. at 33.4 mol/m$^3$

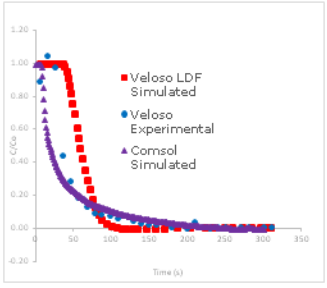


**Figure (4)**. Conc. at 3.34 mol/m$^3$

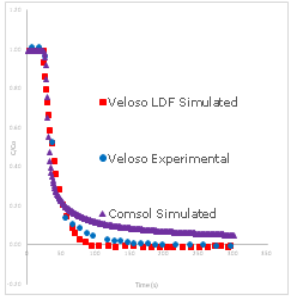


**Figure (5)**. Conc. at 33.4 mol/m$^3$

**Discussion:**

- The results of 3-D model using Transport of Diluted Species in Porous Media of COMSOL Multiphysics 5.3 were correlated with the results obtained from gProms Linear Driving Force model (Veloso et al., 2014).
- Minimum and maximum concentrations of 3.34mol/m$^3$ and 33.4mol/m$^3$ were used as feed concentrations to simulate the scale inhibitor break through adsorption.
- The results showed close fit between the Veloso Linear Dynamic Force simulated curve (red)/experimental (blue) and the COMSOL simulated curve (Purple).

**Conclusions:**

- Transport of Diluted Species in Porous Media node of COMSOL Multiphysics software is a veritable software for the work carried out in this study and for future simulation works to be carried out.
- Concentration affects the rate of adsorption of scale inhibitors on porous Sandpack.

**References:**

1. Veloso, C. B. et al., 2014. Scale Inhibitor Adsorption Studies in Rock Sandstone Type. Adsorption 20, Pages 977-985.
2. Wegner, J. and Ganzer, L., 2012. Numerical Simulation of Oil Recovery by Polymer injection using COMSOL Excerpt from the proceedings of the 2012 COMSOL conference in Milan.