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Contribution ID: **66** Type: **Oral Presentation**

A level set approach to Ostwald ripening of real gases in porous media

Thursday, 3 June 2021 10:00 (15 minutes)

Ostwald ripening phenomenon is particularly important for foam EOR and geological CO_2 storage projects where coarsening can lead to increased mobility of isolated gas bubbles. It is a thermodynamic process by which bubbles in bulk foam coarsen with bigger bubbles growing at the expense of smaller bubbles. Previous studies in literature have shown that in porous media this gas phase interaction is more complicated and bubble growth depends on the bubble interfacial radius (or pressure) rather than size. However, research on Ostwald ripening in porous media is generally carried out with a notable assumption that the pressure of fluid in contact with gas phase is constant. In porous media, fluid phase pressure varies during flow through pores and pore throats which in turn should affect the pressure and interfacial radius of gas bubbles. This makes it imperative to study the phenomena considering isolated fluid ganglia in contact with gas bubbles.
In this work, we have used a multiphase local volume conserved level-set method based on SAMRAI framework (Jettestuen et al., 2021) to model Ostwald ripening process in porous media. The approach is based on the ghost bubble method proposed by Lemlich(1978) to characterize fluid phase interactions in wet foam. We suggest chemical potential difference instead of pressure difference as the driving force behind mass transfer. This approach directly links the mass transfer to Gibbs energy potential of the bubbles. The method is validated for two-phase systems interacting within pore space with results from deChalendar et al. (2018). Our pore scale model is compatible with parallel programming and can be used to carry out studies on large computational grids. The model can also incorporate different wettability states of the porous media using different phase contact angles.
Comparative study was carried out between Soave-Redlich-Kwong (SRK), Van der Waals'(VdW) and Ideal gas equation of state to study the effect of using ideal gas assumption. The equations of state were used to calculate fugacity of gas in isolated bubbles at different pressures and reservoir temperature. The gas bubble fugacity was used to determine their chemical potential. The model was also used to study mobilization of an isolated bubble in a microchannel due to Ostwald ripening from smaller bubbles in adjoining pore space. We have also studied the effect of local capillary pressure on gas bubble stability. Finally, we show how Ostwald ripening impacts residual two-phase fluid configurations in a 3D sandstone pore geometry after waterflooding. We quantified the evolution of pressure, volume and area relationship, for residual bubbles.
One significant result of our work is that presence of an isolated fluid phase between two gas bubbles can limit coarsening and stabilize small gas bubbles in porous media. Another important result is that it shows that use of ideal gas equation underpredicts the rate of coarsening.

Time Block Preference

Time Block B (14:00-17:00 CET)

References

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Jettestuen, E., Friis, H.A., & Helland, J.O. (2021). A locally conservative multiphase level set method for capillary-controlled displacements in porous media. J. Comput. Phys., 428, 109965. DOI: https://doi.org/10.1016/j.jcp.2020.109965

Lemlich, R. (1978). Prediction of Changes in Bubble Size Distribution Due to Interbubble Gas Diffusion in Foam. Ind. Eng. Chem. Fundam., 17, 89-93. DOI: https://doi.org/10.1021/i160066a003

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