

RICE
Unconventional Wisdom

Annual Newsletter for the Rice University Consortium For Processes in Porous Media

MESSAGE FROM THE DIRECTOR

The goal of this consortium is to engaged in collaborative research to advance the fundamental understanding of porous media processes. Our core research areas include the study of surfactant and foam Enhanced Oil Recovery (EOR) processes, wettability alteration with smart water, asphaltene deposition, and NMR & molecular simulation studies of unconventional formations. As the Director of this research consortium, I thank you for your support of our research and welcome you to potential opportunities for collaboration and participation.



- George Hirasaki

Save the Date:

Annual Consortium

Meeting will take place

April 23, 2018 in the BRC at Rice University

Research Highlight:

NMR in Organic Shale

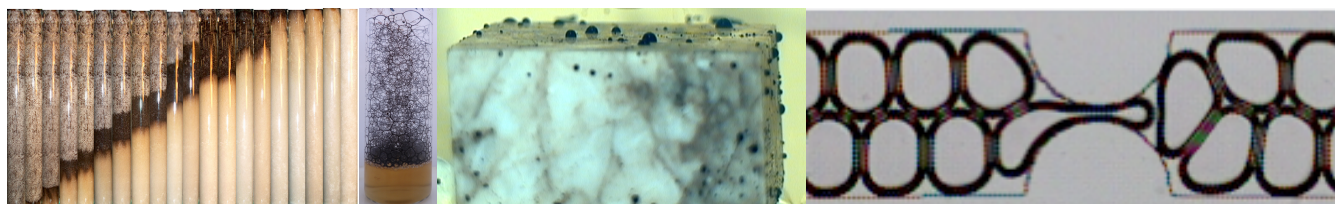
-Dr. Philip Singer

NMR (nuclear magnetic resonance) is proving to be an evermore powerful technique for characterizing unconventional reservoirs such as gas-shale and tight-oil shale. Important petrophysical quantities derived from NMR in organic shale include total porosity, movable-fluid porosity, hydrocarbon saturation, and pore-size distribution. However unlike conventional hydrocarbon reservoirs, a significant portion of the light hydrocarbons produced from organic-shale reservoirs originate from connected organic nano-pores. Nano-pore confinement has a significant effect on the NMR response of fluids, which complicates the use of NMR for predicting hydrocarbon reserve estimates and transport properties in organic-shale reservoirs.

The Hirasaki research group is developing techniques to help

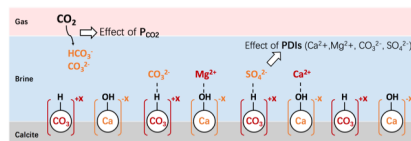
oil companies overcome such challenges. Our laboratory NMR studies involve re-saturating the as-received organic-shale core with the light hydrocarbons (e.g. methane, ethane, etc.) that were lost when the core came to surface. We then make in-situ NMR measurements of the light hydrocarbons in the core, and compare with down-hole NMR log-data. Such NMR core-log integration studies provide valuable petrophysical information for characterizing the organic-shale reservoir. Further laboratory studies involve isolating the kerogen and bitumen from the organic-shale core, and investigating the fundamental mechanism behind the complex NMR response of hydrocarbons in organic nano-pores. These NMR measurements are also compared with polymer-alkane mixes, where the highly-viscous polymer acts as a model system for kerogen and bitumen.

In collaboration with the Chapman research group, we also integrate our NMR measurements with MD (molecular dynamics) simulations and molecular DFT (density functional theory), thereby gaining further fundamental insights into the effects of nano-pore confinement on hydrocarbons in organic-shale.



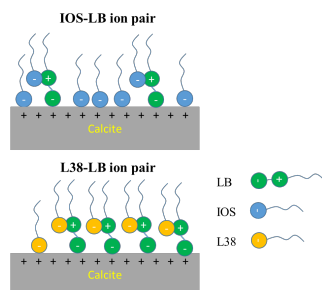
2017 Research Publications

Wettability Alteration



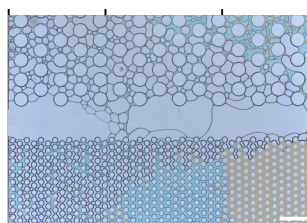
- ♦ Song, J., Zeng, Y., Wang, L., Duan, X., Puerto, M., Chapman, W.G., Biswal, S.L. and Hirasaki, G.J. **Surface Complexation Modeling of Calcite Zeta Potential Measurements in Brines with Mixed Potential Determining Ions (Ca^{2+} , CO_3^{2-} , Mg^{2+} , SO_4^{2-}) for Characterizing Carbonate Wettability.** Journal of Colloid and Interface Science 506 (2017), pp. 169-179.

Surfactant Adsorption



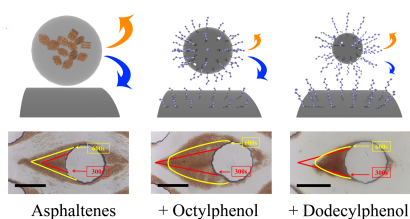
- ♦ Jian, G., Puerto, M., Wehowsky, A., Miller, C., Hirasaki, G.J. and Biswal, S.L., **Characterizing Adsorption of Associating Surfactants on Carbonates Surfaces.** Journal of Colloid and Interface Science, 513 (2018), pp.684-692.

Visualization of Foam in Porous Media with Microfluidics

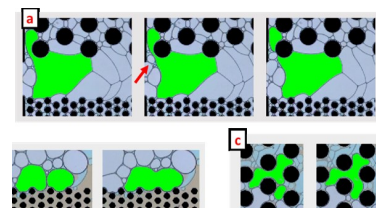


- ♦ Xiao, S., Zeng, Y., Vavra, E.D.; He, P., Puerto, M., Hirasaki, G.J., Biswal, S.L, **Destabilization, Propagation, and Generation of Surfactant-Stabilized Foam during Crude Oil Displacement in Heterogeneous Model Porous Media.** Langmuir 34 (2017), pp 739-749.

Asphaltene Deposition

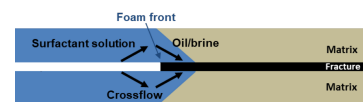


- ♦ Lin, Y.; He, P., Tavakkoli, M., Mathew, N., Fatt, Y.Y., Chai, J.C., Goharzadeh, A.; Vargas, F.M., and Biswal, S.L., **Characterizing Asphaltene Deposition in the Presence of Chemical Dispersants in Porous Media Micromodels.** Energy & Fuels, 31(2017), pp. 11660-11668.



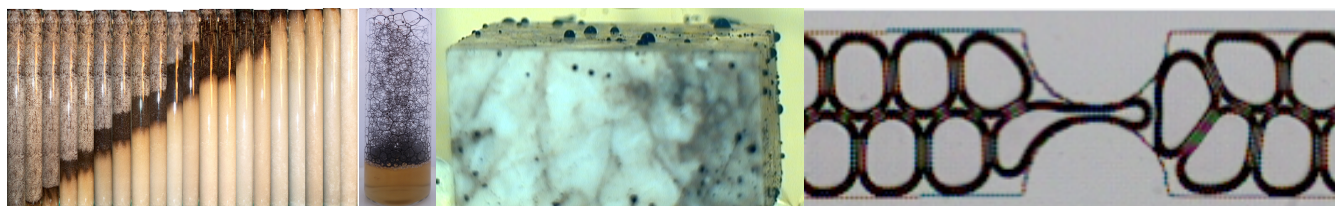
- ♦ Vavra, E., Zeng, Y., Xiao, S., Hirasaki, G.J., Biswal, S.L., **Microfluidic Devices for Characterizing Pore-Scale Events Processes in Porous Media for Oil Recovery Applications.** Journal of Visual Experiments, 131

Low Tension Foam for Heterogeneous Reservoirs

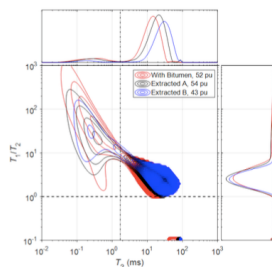
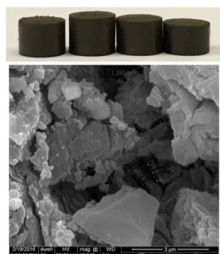


- ♦ Dong, P., Puerto, M., Ma, K., Mateen, K., Ren, G., Bourdarot, G., Morel, D., Bourrel, M., Biswal, S.L., and Hirasaki, G., **Low-Interfacial-Tension Foaming System for Enhanced Oil Recovery in Highly Heterogeneous/Fractured Carbonate Reservoirs.** SPE International Conference on Oilfield Chemistry, SPE-184569-MS (2017).

PDF copies of all research articles are available for members at: www.owl.net.rice.edu/~gjh/Consortium/

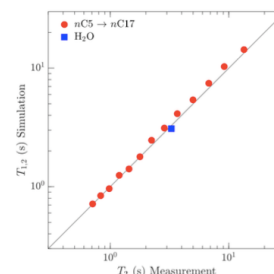
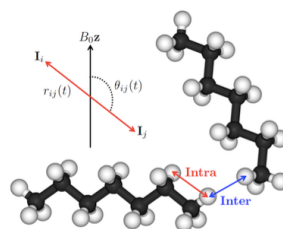


NMR Measurements of Saturated Kerogen Isolates



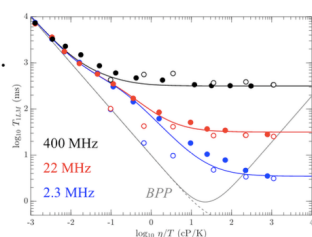
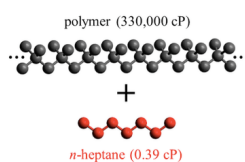
- ♦ Chen, Z., Singer, P.M., Kuang, J., Vargas, F.M., Hirasaki, G.J., **Effects of Bitumen Extraction on the 2D NMR Response of Saturated Kerogen Isolates**, *Petrophysics* 58(5) (2017), pp 470-484.

NMR Measurements and MD Simulations



- ♦ Singer, P.M., Asthagiri, D., Chapman, W.G., Hirasaki, G.J., **Molecular Dynamics Simulations of NMR Relaxation and Diffusion of Bulk Hydrocarbons and Water**, *Journal of Magnetic Resonance* 277 (2017), pp 15-24.

NMR Measurements of Polymer-Heptane Mixes



- ♦ Singer, P.M., Chen, Z., Alemany, L.B., Hirasaki, G.J., Zhu, K., Xie, Z.H., Vo, T.D., **Interpretation of NMR Relaxation in Bitumen and Organic Shale Using Polymer-Heptane Mixes**, *Energy & Fuels* (2018), DOI: 10.1021/acs.energyfuels.7b03603

Contact Us:
Porous Media Consortium
6100 Main St. MS 362
Houston, TX 77005

Ph: 713-348-5416
gjh@rice.edu