Measurement of Thin Film Characteristics In Porous Media

Emily Thornley
Department of Chemical, Biological and Environmental Engineering
Oregon State University
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Introduction

- At low saturations water moves in thin films around objects rather than by capillary action.

- Liquid film formation in unsaturated porous media is not commonly included in subsurface flow and transport models.

- Thin films provide greater areas of air/water interfaces at which a large variety of microbes flourish.
The Project

- Construct a virtually 2-D flow cell using Yucca Mountain tuff grains cut to 0.5 millimeter thickness

- The flow cell must incorporate a relative humidity and temperature sensor while remaining a closed system
The Project

• The flow cell is wetted and dried while being digitally imaged.

• Saturation levels from images are combined with relative humidity and temperature data to create a model for conditions at which film flow occurs.
Set Up

- First, I found a digital sensor small and accurate enough to work in such a small space.
Set Up

• The RH sensor was calibrated using an analog RH sensor
Set Up

- Readings from the two sensors were repeatable and closely correlated

![Graph showing Calibration 1 with the equation y = 0.8359x + 13.39 and R^2 = 0.9917]
Set Up

Calibration 2

\[ y = 0.9592x + 2.686 \]
\[ R^2 = 0.995 \]

Calibration 3

\[ y = 0.9597x + 3.322 \]
\[ R^2 = 0.9968 \]
Set Up

- Next, I constructed flow cells using glass slides and epoxy. These incorporated a housing for the RH sensor.

- Glass inside of the cells were treated to be made hydrophobic.
Experiments

• A few versions of the flow cell have been created due to leakage and other issues
Experiments

- Tests were done using different flow cells and a digital microscope while monitoring relative humidity and temperature.
Results

• Images capturing thin film flow have been obtained

Dry Grain Surface  Wetted Grain Surface
Results

• Progress has been made in image optimization
Results

• Further experimentation is being done to optimize flow cells

• Possibilities for use of a polymer called Polydimethyl Siloxane (PDMS) in flow cell construction instead of glass are being explored

• Once these problems have been corrected, the data can be used to model thin film flow
Conclusions

• Further experimentation is needed to optimize imaging and flow cell construction techniques

• Once a thin film flow model is achieved, the aspect of this project may be applied to include microbial growth and transport models
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