Notice of the Final Oral Examination
for the Degree of Master of Science

of

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BSc (University of Tripoli, 2009)

"Optical Techniques for Crude Oil and Asphaltene Characterization"

Department of Electrical and Computer Engineering

Friday, December 8, 2017
11:00 A.M.
Engineering Office Wing
Room 430

Supervisory Committee:
Dr. Reuven Gordon, Department of Electrical and Computer Engineering, University of Victoria (Supervisor)
Dr. Thomas Tiedje, Department of Electrical and Computer Engineering, UVic (Member)

External Examiner:
Dr. Mohsen Akbari, Department of Mechanical Engineering, UVic

Chair of Oral Examination:
Dr. Henry Reiswig, Department of Biology, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

In this work, different optical techniques have been explored to study and characterize crude oil and its asphaltene. Crude oil is extremely complex fluid used to produce fuel for a wide range of applications. The characterization of this fluid is key for optimum operations in the oil and gas industry.

First, we demonstrate the application of gold nanorods in characterizing a different set of crude oils. We utilize the high sensitivity of the Localized Surface Plasmon Resonance (LSPR) of the nanorods to the surrounding environment to measure the crude oil refractive index. We immobilized the nanorods on a glass substrate and took the measurement in a reflection configuration. The setup and the nanorods were calibrated using different fluids with known refractive index, and a sensitivity of 247 nm/RIU and a resolution of 0.013 RIU have been achieved. In addition to the simplicity of this approach, it has eliminated the absorption issue and made it possible to measure high optical density crude oils with typical Visible-NIR wavelengths. Surface-Enhanced Raman Spectra (SERS) can also be measured. SERS can provide additional useful information, especially to some applications such as downhole fluid analysis, where confirmation of the hydrocarbons presence is necessary.

In the second part of this work, we used Terahertz Time-Domain Spectroscopy (THz-TDS) to study the asphaltene in three different crude oils. THz-TDS has a feature of measuring the amplitude and time delay and consequently the refractive index and absorption coefficient spectra simultaneously. Our approach is based on measuring the THz signal from neat crude oil samples and comparing it with the THz signal after removing the asphaltene from the samples (maltene). The results show that the difference in the time delay and the peak amplitude between the neat oil and the maltene have a linear relation with the asphaltene content. The refractive index spectra of different asphaltenes show variation in the low THz frequencies and comparable spectra in the higher frequencies. The absorption of asphaltene was mild and no distinctive absorption feature was observed except for some narrow absorption peaks that we attributed to water molecules adsorbed on the asphaltene.