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Method Article

Dynamic interfacial tension measurement method using axisymmetric drop shape analysis

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A B S T R A C T

The current method describes a simple modification to the dynamic and equilibrium interfacial tension (IFT) measurement in a multiphase system (gas-liquid/liquid-liquid) by the Axisymmetric Drop Shape Analysis (ADSA) pendant drop technique. The primary difficulty associated with dynamic IFT measurement by ADSA is providing the appropriate phase densities, especially in a system consisting of gas (CO_2, methane, and propane) and liquids (water and hydrocarbon). The density of the phases is calculated using a, considering the solubility og gases in liquids, as a function of time. The calculated densities of the phases are then used as inputs in the experiment to measure the IFT at high pressure and temperature PVT-cell.

The method offers benefit such as:

- Straightforward and cost effective as it does not require additional experimental setup (like density meter) or a complicated equation of state.
- The composition of the binary mixtures (mole and mass) and the density changes of the binary mixture due to mass transfer may be obtained as a function of time at fixed pressure and temperature.
- IFT as a function of time is measured by taking into consideration of correct phase density.

A R T I C L E I N F O

Method name: Dynamic IFT measurement

Keywords: Dynamic IFT, Pendant drop method, Multiphase, Dynamic density

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Specifications Table

Subject area	*Select one of the following subject areas:* • *Chemical Engineering* • *Engineering* • *Mathematics*
More specific subject area	*Mass transfer and interfacial science*
Method name	*Dynamic IFT measurement*
Name and reference of original method	Bagalkot, Nikhil, and Aly A. Hamouda. "Experimental and numerical method for estimating diffusion coefficient of the carbon dioxide into light components." *Industrial & Engineering Chemistry Research* 56.9 (2017): 2359–2374. Zolghadr, Ali, Mehdi Escrochi, and Shahab Ayatollahi. "Temperature and composition effect on CO2 miscibility by interfacial tension measurement." *Journal of Chemical & Engineering Data* 58.5 (2013): 1168–1175.
Resource availability	Equipment theory: https://www.kruss-scientific.com/services/education-theory/glossary/pendant-drop/ Equipment: https://www.kruss-scientific.com/products/contact-angle/dsa100/drop-shape-analyzer-dsa100/ Software: https://www.kruss-scientific.com/products/advance-software/overview/

Method background and description

Interfacial tension plays a significant role in numerous engineering applications involving multiphase flow. Measuring the IFT is a crucial part of multiphase systems, there are several methods available like ring method, drop volume method, spinning drop method, bubble pressure method and pendant drop method. In recent years, the pendant drop method has been widely used as an effective method with high accuracy (± 0.05 mN/m^2) [1,2], especially at elevated pressure and temperature. There are several types of equipment available that rely on pendant drop method to estimate the IFT, few of them are IFT-700 (Vinci Technologies), IFT-10-P (Core laboratories), DSA-00 (KRÜSS), and Model-190 (ramé-hart instrument). Most of these use image processing combined with Young-Laplace equation to estimate the IFT.

The primary difficulty associated with IFT measurement by pendant drop mechanism is providing the appropriate densities of the two phases, especially in a system consisting of gas (like CO_2, methane, and propane) and liquids (water and hydrocarbon). Multiphase systems like CO_2-hydrocarbon, CO_2-water/brine, and carbonated water-hydrocarbon are of increasing interest due to their application in petroleum (CO_2 EOR), environmental (CO_2 sequestration) and renewable energy (geothermal). When CO_2 contact liquid (hydrocarbon) it diffuses and dissolves into the liquids, forming a binary mixture. The diffusion of gases into liquids alters the composition of the resulting binary mixture, hence alter the properties like density.

Obtaining the density of the binary mixture is complex, especially at elevated pressures and temperatures and as a function of time. Most of the studies have neglected the density changes due to the solubility effects of dissolved gases in bulk liquids and have used the density of pure fluids instead of the binary mixture [3,4]. While some studies have used separate high pressure and temperature density measuring equipment at equilibrium condition (not dynamic), which complicates the system [5,6], as it requires two different setups. Some studies have even used a complex equation of state model (GERG equation of state (EOS)) [7].

In the present study, a simple and effective method is used to measure the dynamic and equilibrium IFT of the fluid-fluid system with a mass transfer across the interface. Instead of a complicated EOS model or expensive additional instrument, in the present method, the density of changes in the hydrocarbon due to CO_2 mass trasfer is measured from a combination of experimental and analytical approach, and the obtained density is then used to estimate the IFT by pendant drop technique.

Principle of IFT measurement

The pendant drop method is an effective and popular means to measure the interfacial tension of liquid-liquid or liquid-gas system. In the pendant drop method, the drop is created from a needle