Extended Abstract | Electrical & Electronic Systems | 2021 | Vol.10 No.5

A Comprehensive Literature Review on Natural Gas Hydrate Inhibition

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Abstract

Gas hydrates are crystalline compounds made up of water and gas at high pressure and low temperature. Subsea and permafrost region pipelines favor such pressure and temperature conditions for hydrate formation. Ionic liquids (ILs) are popular designer green chemicals with great potential for use in diverse energy-related APPLICATIONS. Apart from the well-known low vapor pressure, the physical properties of ILs, such as hydrogen-bond-forming capacity, physical state, shape, and size, can be fine-tuned for specific applications. Natural gas hydrates are easily formed in gas pipelines and pose potential problems to the oil and natural gas industry, particularly during deep sea exploration and production. This review summarizes the recent advances in IL research as dual-function gas hydrate inhibitors. Almost all the available thermodynamic and kinetic inhibition data in the presence of ILs have been systematically reviewed to evaluate the efficiency of ILs in gas hydrate inhibition compared to other conventional thermodynamic and kinetic gas hydrate inhibitors.

The principles of natural gas hydrate formation, types of gas hydrates and their inhibitors, apparatuses and methods used, reported experimental data, and theoretical methods are thoroughly and critically discussed. The studies in this field will facilitate the design of advanced ILs for energy saving through the development of efficient low-dosage gas hydrate inhibitors. Gas hydrate solids occurrence is considered as one of the serious challenges in flow assurance as it affects the hydrocarbon production significantly, especially in deep water gas fields. The most cost-effective method to inhibit the formation of hydrate in pipelines is by injecting a hydrate inhibitor agent. Continuous studies have led to a comprehensive understanding on the use of low dosage hydrate inhibitors such as ionic liquid and quaternary ammonium salts which are also known as dual function gas hydrate inhibitors. This paper covers the latest types of quaternary ammonium salts (2020–2016) and a summary of findings which are essential for future studies. Reviews on the effects of length of ionic liquids alkyl chain, average suppression temperatures, hydrate dissociation enthalpies, and electrical conductivity to the effectiveness of the quaternary ammonium salts as gas hydrate inhibitors are included. Unless complete dehydration is performed or inhibitors are used, gas hydrates are to be expected in subsea flow lines. Since complete dehydration is not possible, the most functional & practical solution is the use of hydrate inhibitors .

The objective of this paper is to review the entire literature about gas hydrate inhibition to comprehend the existing techniques & latest development in hydrate inhibition technology, which would work as a guide to further develop this potentially interesting and important area of research. Traditionally, prevention of hydrate formation has been achieved with addition of thermodynamic inhibitors, commonly methanol or glycols. These inhibitors have the ability to shift hydrate equilibrium curves toward higher pressures and lower temperatures by lowering the activity of water molecules. However, in last two decades, economic and environmental factors have motivated research and development to identify new inhibitors like low dosage hydrate inhibitors (LDHI) for cost effectiveness & for environment friendliness. LDHI are divided into 2 class kinetic hydrate inhibitors (KHI) & Anti Agglomerates (AA).There are three ways to prevent hydrate plug formation: (i) prevent hydrate crystal nucleation, (ii) prevent hydrate growth (iii) prevent agglomeration of hydrate crystals. KHIs act as anti-nucleators & also delay hydrate growth. AAs prevent Hydrate crystals from agglomerating. A KHI polymer has a hydrophobic & a hydrophilic part.

Hydrophobic part is the backbone carbon structure (alkyl) while hydrophilic part is the incorporated functional group which is amide in most polymers. High molecular weight Polymer prevents hydrate crystal growth. But very high percentage of high molecular weight groups makes the polymer water-insoluble. Low molecular weight polymer performs better for gas hydrate nucleation inhibition. Controlling both nucleation stage and crystal growth stage gives the best results. This work will leads to search for new & better combinations of Polymers, Ionic Liquids and synergents that can prevent the pugging of natural gas pipelines by preventing or delaying hydrate formation. Simulation models have been used widely to help design, operate, control and optimize the processes of exploration and exploitation of natural gas hydrates and been responsible for many of the most important technology breakthroughs. Currently, a rich body of literature exists and is still evolving. This paper presents a critical review of the most influential works that are recognised as representative and important simulation models and links to the techniques commonly used in natural gas hydrate exploration and exploitation. Model background, ideal assumptions and main results are presented. Models are broadly classified into two categories: physically and empirically based models. Models are reviewed with comprehensive, although not exhaustive,

publications. The strengths and limitations of the models are discussed. The paper is concluded by outlining open questions and new directions for future work. The review is useful for understanding the innovation process and the current and future status of simulation models on exploration and exploitation of natural gas hydrate and highlights the key aspects of model improvement.