CHAPTER 1

INTRODUCTION

Natural gas hydrates, a potential alternate energy resource, are known to occur worldwide including India in the sediments of the outer continental margins and in the Polar Regions in association with permafrost. Estimates of U. S. Geological Survey project that world methane hydrate, a major component of natural gas hydrate deposits contain approximately $2 \times 10^4$ trillion cubic meter of gas. Estimates of methane hydrate deposits off the coast of the United States is approximately $9 \times 10^3$ trillion cubic meter of methane with an additional 17 trillion cubic meter of methane in the permafrost on the north slope of Alaska [Collett and Kuuskraa, 1998; Makogon et al., 2007; Boswell and Collett, 2011].

Seafloor bathymetry (hydrostatic pressure), seafloor temperature, total organic carbon (TOC) content, sedimentary thickness, rate of sedimentation, and geothermal gradients indicate favorable prospects for gas hydrates in shallow marine sediments on both the western and eastern margins of India [Sain and Gupta, 2008; Ramana and Ramprasad, 2010; Sain et al., 2012, ]. The TOC content in the eastern offshore (the Bay of Bengal) is less than that in the western offshore (the Arabian Sea). However the sediment thickness in the eastern offshore is more than that in western offshore. A total volume of approximately 1900 trillion cubic meter of methane gas, locked in the form of hydrates, has been estimated [Collett et al., 2008]. This volume of gas is more than 1500 times India’s present natural gas reserve, can satisfy India’s energy requirement for about a century at the current rate of consumption even if only 10% of these reserves are recovered. The natural gas hydrates are stable under limited range of temperature and pressure conditions, which normally exist within few hundred meters of ocean sediments, in water depths greater than about 800 m especially in tropical region.

The industrial interest in gas hydrates began with the discovery that hydrate formation could plug natural gas pipelines. Oil and gas wells always produce undesired water along with hydrocarbons. As the flowing mixed phases cool, hydrates form and plug the transmission lines, causing costly production stoppages, sometimes for as long as months, in large
pipelines while the hydrates are dissociated. Industry is spending millions of dollars per day both to inhibit the formation of hydrate in pipelines and mitigate or remove it once unwanted hydrate is formed. The petroleum industry would like to maintain their processes outside the hydrate stability range. Unfortunately, however, low temperatures (such as the deep-sea floor temperature of 277 K) and the mandates of high pressure for economic energy densities place many pipelines within the hydrate-formation region. High pressures and low temperature require hydrate-inhibition methods.

Now hydrate is not only a potential energy resource or nuisance during production of oil and gas but it is considered as a new means of storage and transportation of natural gas. Since the physical characteristics of methane hydrates offer an interesting and potentially valuable alternative for storage and transportation of methane gas in hydrate state. Hydrates can store large quantities of natural gas e.g. 180 volume of gas per volume of hydrates \[\text{Makogon, 1997; Khokhar et al., 1998.}\]

It has been found that hydrate formation of natural gas in water suffers from slow formation rate and inadequate storage capacity of natural gas in hydrate has also been considered to be a critical problem hindering the industrial application of gas hydrates for storage and transportation of natural gas. In real practice, laboratory experimental works on natural gas systems have shown to achieve hardly 30% uptake of maximum theoretical uptake.

The modern studies of hydrates are aimed at certain goals. These are:

- Exploitation of natural gas reserves accumulated in the earth in hydrate state.
- Prevention of formation and removal of large hydrate accumulation in natural gas production, transportation and processing systems.
- Develop new technology by utilizing the properties of hydrates for storage and transportation of gas in hydrate state.

Thus Gas hydrate has been viewed as a potential energy resource, source of problem during production operations of oil and gas and a new means of storage and transportation of natural gas in hydrate state. These are the different aspects of gas hydrate that has motivated researchers to work on gas hydrate.
1.1 OBJECTIVE OF THE PRESENT RESEARCH WORK

The gas hydrates either in natural environment or encountered in production operations of oil and gas are always associated with clays, sand, silts, salts and other substances. Naturally its property gets changed during formation as well as in dissociation. To exploit natural gas hydrates economically or inhibit hydrate in order to avoid its formation in production operations or develop hydrate as a new means of storage and transportation, the understanding of gas hydrate formation and dissociation is crucial in presence of various additives. The efficiency of any exploitation strategy depends on the knowledge of kinetics of hydrate formation and dissociation. Therefore the main objective of this work is to develop fundamental understanding of gas hydrate formation and dissociation in presence of various additives.

The present research work is undertaken as follows:

- Methane a major constituent of natural gas hydrate is used as hydrate guest molecule, water as host to encapsulate methane in cage of water molecules and various extraneous materials in water like clay, sand, salts, glycols, and surfactants after detailed literature survey (Chapter 3) to observe the effects of these materials on methane hydrate formation and dissociation.

- Hydrate formation is greatly dependent on pressure and temperature. Therefore experiments were carried out with fixed temperature and pressure for a given sets of experiments to observe the effects of particular additive and their different concentration in water on hydrate formation and dissociation.

- The temperature and pressure conditions of hydrate formation and dissociation are measured experimentally in presence of various additives.

- Induction time of hydrate formation is a major kinetic parameter of hydrate formation which can be measured. Once we could know the temperature-pressure conditions of hydrate formation, how long it would be inhibited without hydrate formation is determined by the measurement of induction time.