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Removal of Water From Wellhead Natural Gas: Implications for Gas Separation and Compound Hydrate Formation and Dissociation

Michael D. Max, John P. Osegovic, Shelli R. Tatro, Leslie A. Brazel, and Kathryn M. Sheps, MDS Research

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Abstract

A hydrate containing only one hydrate-forming material in addition to water may be formed and dissociated by selecting conditions with reference to a single pressure-temperature-concentration boundary. In contrast, compound hydrate, which is composed of more than one hydrate former, has a phase boundary that is sensitive to the kinetics of dissociation and the history of the material. The growth and dissociation phase boundaries for compound hydrates may be quite different depending on the composition of the surrounding gas during each process. The relative proportion of hydrate formers taken up during formation will affect the conditions required for dissociation depending on various kinetic factors. In order to dissociate a compound hydrate, it may be necessary to induce pressure – temperature conditions different from the formation phase boundary.

Introduction

Single hydrate-forming gases form a pure species of hydrate but two or more hydrate forming gases form compound (also called complex) hydrate. Because natural gas is usually a mixture of hydrocarbon and other gases, a wide range of compositions of hydrate may form as preferred hydrate formers are selectively removed from the gas mixture (in the presence of abundant water). Depending on the available hydrate formers, the phase boundary for the compound hydrate growth may be significantly different than the phase boundary conditions of dissociation pressure and temperature. This is because the compound hydrate takes up preferred hydrate formers into the growing hydrate in a much greater proportion than their relative abundance in the gas mixture. The most preferred hydrate former will tend to be removed first, followed by the next most preferred hydrate former present.

A simple table of hydrate forming preference (Table 1) is related to two factors: the relative abundance of the various hydrate formers, and the relative stability of the simple hydrate of each former (Fig. 1). In some cases, a preferred former can be completely extracted from a mixed gas and incorporated within compound hydrate (Uchida 2004). Of the common pollutants associated with natural gas, hydrogen sulfide and sulfur dioxide are the most preferred hyrate formers. Carbon dioxide is the next most common pollutant (Table 1).

Because the phase boundary of a given compound hydrate is sensitive to both the hydrate composition and the composition of the surrounding gas, it is necessary to know the concentration of each hydrate former within the hydrate in order to predict the position of its dissociation phase boundary.

Preference	Gases	Effect of Removal
Most	Hydrogen Sulfide	Sweetening
Preferred	Sulfur Dioxide	Sweetening
	Propane	Concentrated
	Ethane	BTU value
	Carbon Dioxide	Sweetening
	Methane	Separation
	Nitrogen	Sweetening
Least	Oxygen	Sweetening
Preferred	Argon	Sweetening

Table 1. Preference of Common Natural Gas Components

We wish to bring the unique characteristics, challenges, and advantages of compound hydrates to the attention of the gas hydrate community, which commonly has dealt with oceanic hydrate as essentially pure methane hydrate. We suggest that the type of hydrate observed in regions of low permeability or slow groundwater movement may at least reflect a paragenesis that has allowed nature to separate methane hydrate according to a natural process. We also suggest that these natural processes may well have industrial analogues that can be used to purify or remove water from natural gas and to promote flow assurance in gas and possibly oil pipelines. To industrialize the processes of gas dehydration and separation using gas hydrate, new apparatus