Chapter 9
Clathrate Hydrates: A Hope for the Fuel Industry and Great Ecological Hazard

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ABSTRACT

Water is a mysterious substance; being hydrophilic (by definition), it can capture hydrophobic or hydrophobic-hydrophilic species forming different kinds of hydrate inclusion compounds. Hydrate inclusion compounds can be formed by a variety of molecules and molecular associates, which are commonly referred to as guests. Common to all these compounds is the presence of a more or less complex framework built of hydrogen-bonded water molecules. This framework is commonly referred to as the host framework. The chapter deals with two major issues associated with clathration of natural methane by water: (1) possible uses and state of the art in methane hydrate exploitation and (2) disaster risks associated with possible eruptions of methane from submarine deposits being the major component of natural methane stored on Earth.

INTRODUCTION

Water is a mysterious substance; being hydrophilic (by definition) it can capture hydrophobic or hydrophobic-hydrphilic species forming different kinds of hydrate inclusion compounds. Hydrate inclusion compounds can be formed by a variety of molecules and molecular associates, which are commonly referred to as guests. Common to all these compounds is the presence of a more or less complex framework built of hydrogen-bonded water molecules. This framework is commonly referred to as the host framework. An example of one of the hydrate inclusion compounds with a relatively simple water framework is shown in Figure 1. One of the most studied and practically important classes of hydrate

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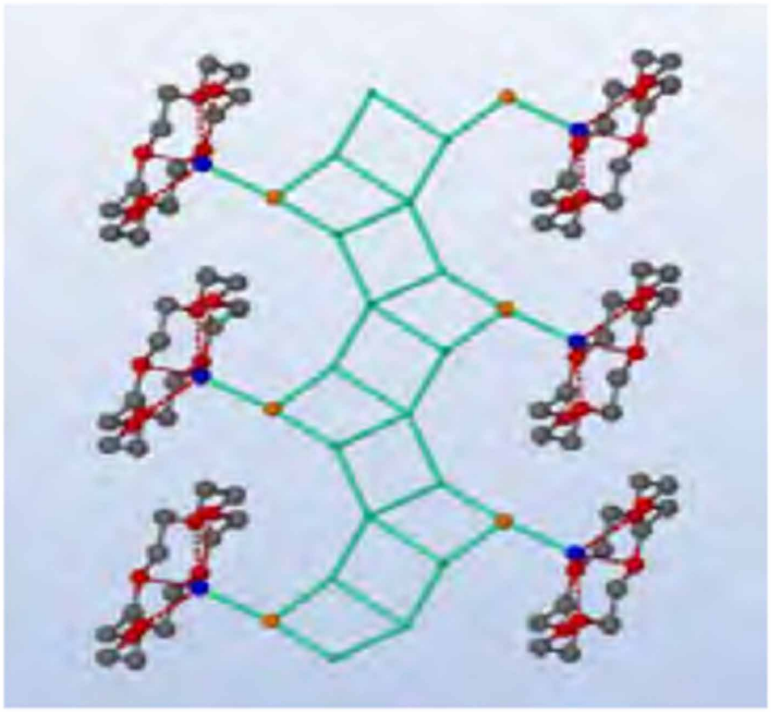
inclusion compounds are clathrate hydrates, in which the interaction of the guest components and the host's water framework is predominantly of a van der Waals nature. This class of compounds will be discussed below.

Figure 1. An example of water structure containing hydrophobic-hydrphilic compound (complex of 18-crown-6 with ammonium fluoride). Water molecules, shown as small light-green balls, form hydrogen-bonded aggregates containing in their outer space hydrophobic parts. Hydrogen bonds are shown as light-green sticks. Nitrogen atoms marked in blue, orange – fluoride, red – macrocycle oxygen and gray – carbon atoms. Blue lines display hydrogen bonds between water oxygen atoms (light green), fluoride and nitrogen.



STRUCTURES, PHASE DIAGRAMS AND PROPERTIES

Structures of gas hydrates represent itself open crystal frameworks built by the hydrogen-bonded water molecules. These frameworks have molecular-size cavities in which molecules of hydrate former are located (Figure 2). The structures of hydrates are usually depicted in the form of polyhedra stuck together along the edges, the vertices of which correspond to the oxygen atoms of water molecules and the edges represent hydrogen bonds. Hydrates of three structural types are found in nature, usually designated sI, sII and sH (Sloan & Koh, 2008; Carroll, 2014). The vast majority of natural hydrates have sI or sII.

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