Methane Hydrates: Fuel of the Future?

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ABSTRACT

Gas hydrates are crystalline solids that form from mixtures of water and light natural gas such as methane, carbon dioxide, ethane, propane and butane. They are of considerable interest for their potential as an energy resource and for their role in global warming. From an energy resource point of view, the enormous amounts of methane hydrate under the ocean and beneath arctic permafrost represent an estimate 53% of all fossil fuel (coal, oil, natural gas) reserves on earth, about 10,000 gigatons. The difficulty with recovering this source of energy is that the fuel is in solid form and is not amenable to conventional gas and oil recovery techniques.

INTRODUCTION

Gas hydrates are crystalline molecular complexes formed by the physical combination of water and low molecular weight gases. They have the general formula $M_n(H_2O)_p$, where one or more hydrate forming molecules M called "guest" associated with p "host" water molecules. The guest gas molecules are physically encaged in interstices or cavities in the lattice structure formed by the water molecules that are held by hydrogen bonds (Holder et al, 1988). There are three different kinds of gas hydrates according to its structure; Structure I, structure II and structure H. A typical illustration of structure I gas hydrate is shown in figure 1 (Sloan, 1997).

Estimations of world hydrate reserves are very high but somewhat uncertain. Kvenvolden estimated it as 10^{16} m^3 (1994). Figure 2 gives sites with evidence of either on-shore or off shore hydrate deposits and figure 3 gives the relative magnitude of gas hydrates as a reservoir of organic carbon on earth. Methane hydrates, which form structure I gas hydrate, store immense amount of methane and occur in abundance in marine and Arctic sediments (Kvenvolden, 1994). One unit volume of methane hydrates can contain over 160 volumes of gas and less than one unit of water at standard conditions. According to estimations by Collett, as much as 200,000 trillion cubic feet of methane may exist in hydrates in the U.S. permafrost regions and surrounding waters (DOE, 1998). Because of its huge quantities, methane hydrates represent a potentially enormous natural gas resource.

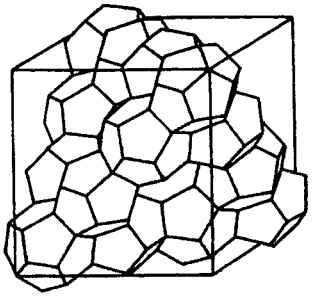

Figure 1. Unit cell of a gas hydrate of structure II
Reference: Mak, T.C.W., McMullan, R. K., *J. chem. Phys.*, 42, 2732 (1965).

Another important factor is that methane is less carbon-intensive fuel than coal or oil. Methane from hydrates (or other sources) produces only half as much carbon dioxide as coal per