THE HIGH SOLUBILITY OF WATER IN LIQUID NITROGEN AND OTHER CRYOGENIC LIQUIDS

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INTRODUCTION

The solubility of water in cryogenic liquids, such as liquid nitrogen (LIN), liquid oxygen (LOX) and liquid methane, would be expected to be extremely low and undetectable according to normal theories of solution[1,2]. Following indications by unstable surface evaporation phenomena, recent work at Southampton University using gravimetric methods suggested that the solubility of water in liquid nitrogen may be as high as 10 ppm or 10^{-5} mole fraction[3]. This figure is many orders of magnitude greater than that expected which is 10^{-16} to 10^{-18} mole fraction[3,4]. In this paper, experiments using Fourier transform, infra-red absorption sepctroscopy are described which confirm the extraordinary solubility of water in liquid nitrogen, oxygen and methane, and eliminate the possibility of experimental artifacts by making parallel observations on solutions of heavy water D_2O in liquid nitrogen. This discovery has a bearing on many handling and storage situations in the cryogenic engineering industry and in low temperature laboratories.

THE IR ABSORPTION CELL

The vacuum insulated absorption cell, used for the infra-red spectroscopic measurements, is illustrated schematically in Fig.1.

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It is constructed almost entirely of one material, namely brass, to reduce the effects of differential thermal contraction. The sample cell (A), together with the enclosing thermal shield chamber (C), is suspended from the top plate by low thermal conductivity stainless-steel tubes (B,D,E), which allow free movement when the cell contracts on cooling.

The thermal shield chamber can be filled or topped off independently of the sample cell so as to maintain solution samples at constant temperature in the sample cell without boiling for long periods of time.

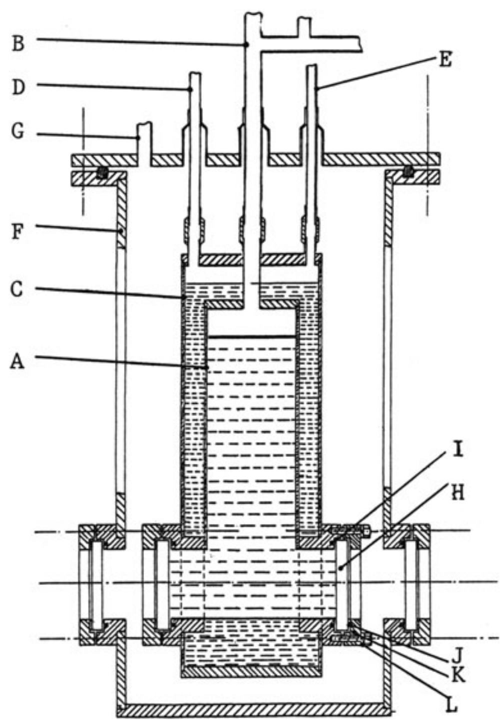

Fig. 1. Low temperature infra red absorption cell: sample chamber (A), filling assembly (B), thermal shield chamber (C), inlet (D), and boil-off (E) tubes, vacuum jacket (F) with pump out tube (G).