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Ionic Liquids as Multi-purpose Inhibitors to avoid Natural Gas Hydrates during Gas Processing

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The issue of hydrate formation during gas processing is a challenging problem for the oil and gas industries. Billions of dollars spent annually to get rid of the blockage of pipelines due to hydrate clogging by applying various methodologies [1]. Among them injecting chemical inhibitors is the most widely accepted solution; however, choosing a chemical is a difficult task which depends a lot on the gravity of the situation. Generally methanol, glycols and salts also known as thermodynamic inhibitors (THIs) are used which needs to be added in large quantities (50 wt% or above) making them expensive and non-environmental friendly. Also, because methanol is flammable there is always risk and cost associated to its storage. Currently, a new class of inhibitors (generally polymers and surfactants) known as low dosage hydrate inhibitors (LDHIs) are getting much attention which can be used in much less amount (1–3 wt% or less) making them economically and environmentally feasible [2]. Industries are always looking for chemicals which are economic, environmental friendly and have peculiar set of properties. Currently, ionic liquids (ILs) have attracted the attention due to their potential for fulfilling the industrial demands [3]. In this work, we have shown that how a slight variation in the structure of ammonium ILs result in peculiar behavior towards methane gas hydrates.

Five ionic liquids (ILs) belonging to the same ammonium family but structurally and functionally different were tested for their hydrate inhibition ability using a meso-scale rocking-rig apparatus. The first IL studied was tetramethylammonium acetate (TMAA) which is very similar to a tetra-alkylammonium salt; well known hydrate inhibitors/promoters. The other four ILs belong to choline, also known as, substituted alkyl-ammonium family where one of the alkyl substitutions of TMA is replaced by hydroxy-ethyl functionality. The four choline ILs were attached to anions which are different in nature viz., butyrate and iso-butyrate are isomeric counterparts; whereas hexanoate and octanoate has a difference in the chain length. It has been shown in this work that any slight structural variation in the compound used for hydrate inhibition resulted in a unique behavior. The working concentration and pressure

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range are also some important factors. It has been shown that at 1 wt% and at higher pressures the Ch-Oct, Ch-But and TMAA act as hydrate promoters. Whereas, at 5 wt% in the whole experimental pressure range (40–120 bar) all the studied ILs act similarly as hydrate inhibitors with TMAA showing the best performance almost comparable to methanol at high pressure. Hydrate suppression temperatures were determined and the performance of individual IL has been discussed quantitatively. Molar hydrate dissociation enthalpies were calculated and their values were interpreted in the light of the thermodynamic inhibition results which indicate that the ILs do not participate in the hydrate cages. Induction time analysis shows that Ch-Oct due to its micelles forming ability acts as a strong kinetic inhibitor which delays the hydrate formation time by more than an hour. Thus, it must be emphasized that a slight structural variations in the structure of ILs reveals their doubly dual nature for methane hydrates system viz., thermodynamic inhibition, hydrate promoter, kinetic inhibition and surfactant character. Since, the used ILs are also biocompatible, non-toxic and biodegradable it make them an excellent alternative class of inhibitors compared to their conventional counterparts.