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Development of Green Inhibitors to Prevent Hydrates Formation, Protect Environment and Reduce Energy Cost in Oil and Gas Industry

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Gas hydrates are identified as ice-liked solid, crystalline compounds having polyhedral water cavities, where gas molecules get trapped during operation under high pressure and low temperature condition. These hydrates have a tendency to completely block the pipelines and can cause major operations shutdown, leading to large economic losses and causing high safety risk in transmission pipelines. Thus, annually the oil and gas sector spends over 100 million US \$ on purchase of chemical inhibitors that can help to prevent hydrates formation in subsea lines.

These inhibitors are classified into two separate categories, the thermodynamic and kinetic inhibitors. The thermodynamic inhibitors act by shifting the hydrates formation temperature and the kinetic inhibitors act by shifting the hydrates formation time. Currently, the thermodynamic inhibitors like Methanol and Methylene ethylene glycol (MEG) are mainly used in industry. These inhibitors are highly flammable and cannot be disposed of easily into the environment. They are required in bulk quantities (>30 wt%) and separate facility is needed for their storage and treatment process. This increases the overall energy cost and leads to major environmental disposal issue. Therefore, there is a high demand for inhibitors that are environmentally friendly and cost effective in oil and gas sector.

Ionic liquids (ILs) are salt like compounds that have received attention due to their environmentally friendly, recyclable and non-flammable nature. These ILs have potential to prevent hydrate formation and they can act as both thermodynamic and kinetic inhibitors simultaneously. In this work, the Pyrrolidinium based ILs have been tested as gas hydrate inhibitors and synergistic compounds (Syn) are added with these ILs to improve their overall effectiveness. For the first time, the thermodynamic and kinetic study on ILs has been conducted using high dosage mixture of ILs + Syn on methane rich gas mixture to check their effectiveness in preventing gas hydrates formation.

All the experiments are performed using a high pressure rocking cell assembly supplied by PSL Systemtechnik GmbH, at different pressures ranging from (40 to 120) bars. According to the tests results, we have evaluated that the

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mixtures were able to prevent hydrates formation by providing a temperature shift of up to 2.2°C at low pressures and by delaying hydrates formation time by (6 to 14) hours.

These results confirm the dual inhibition behaviour of these mixtures, as they were able to shift hydrates formation temperature and delay hydrates formation time simultaneously. The results were also compared with widely known industrial inhibitor methanol and only a difference of 0.5°C was observed. Thus, this research provides an innovative approach towards development of environmentally friendly inhibitors and to reduce energy cost in the oil and gas industry.