Multiple Recovery and Re-use of Commercial Kinetic Hydrate Inhibitors from Produced Water and Rich Glycol

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Multiple Recovery And Re-use Of Commercial Kinetic Hydrate Inhibitors From Produced Water and Glycol

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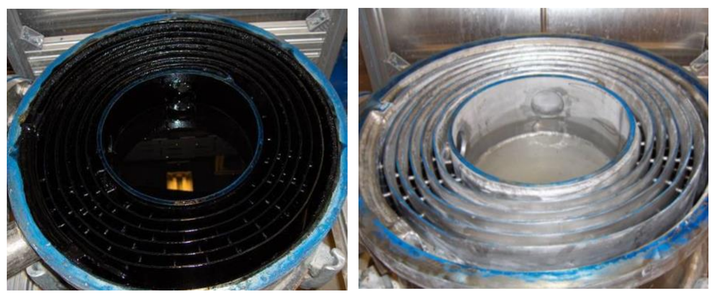
Introduction

Kinetic Hydrate Inhibitors (KHIs) are currently once through chemicals, but offer a low dosage option (0.5-2.5wt% relative to water) for the prevention of gas hydrates. KHIs can also be used in conjunction with MEG to reduce the MEG requirement. However, there are several challenges emerging in the handling/treatment and disposal of produced waters or MEG containing KHIs.

Active elements of KHIs are generally polymers that are susceptible to precipitation as solid/semi-solid deposits in the presence of some brines and at higher temperatures. This can lead to fouling problems in process equipment, separation, and storage facilities. Also, the environmental impact of KHIs released to environment can be a concern, preventing widespread use of KHIs.



Left picture: Spiral heat exchanger fouled with KHI.

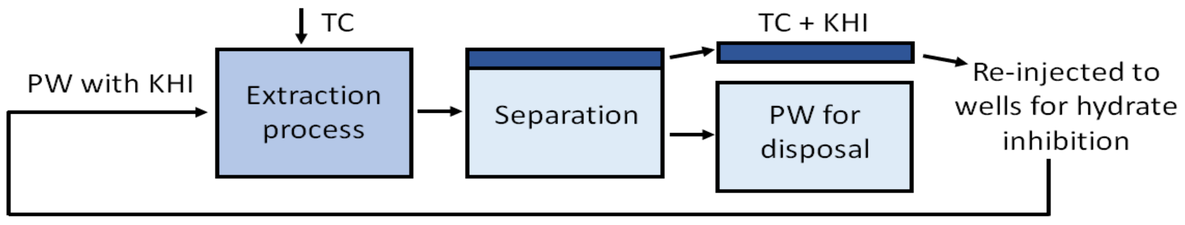
Right picture: Same heat exchanger after cleaning.

Efficient KHI removal from produced water or KHI could enable use of more efficient KHIs with higher sub-cooling and make it easier to combine with MEG for debottlenecking and more flexibility in field development, new tie-ins etc.

If the KHI can also be reused there is a potential for significant reduction chemical usage and OPEX

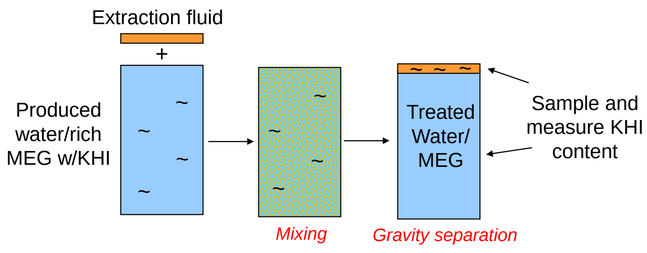
Removal & Reuse Concept

An extraction fluid is appropriately mixed with the produced water (or rich MEG) to allow the KHI to partition to the extraction fluid. Subsequently the extraction fluid is separated from the produced water (or rich MEG). The extraction fluid + KHI formulation can be re-injected to the wells as is for hydrate inhibition

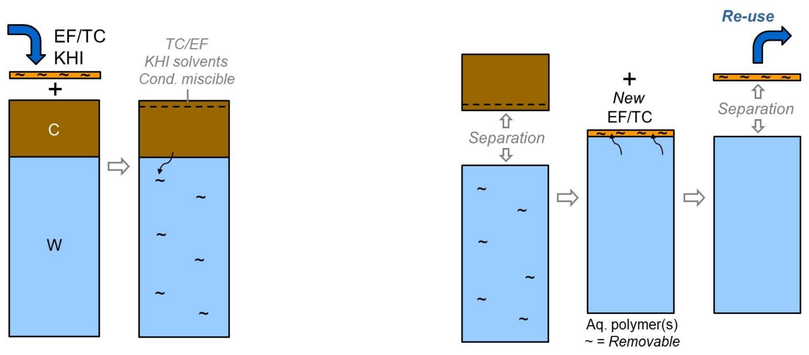


Experimental

For the initial screening tests the extraction fluid is added to artificial produced water which contains salts, corrosion inhibitor and different commercial KHI formulations. The solution is first stirred, then left to separate by gravity. The water phase and separated extraction fluid are sampled and analysed for KHI content.



Two field qualified KHIs were chosen for multiple recovery and reuse trials. The separated extraction fluid containing KHI were injected to a mix of artificial produced water (30vol%) and condensate (70vol%, C7) and then mixed. The extraction fluid partitions into the condensate and the majority of the KHI partitions to the water phase. After gravity settling and separation of the condensate from the water phase, the partitioning of KHI to the water phase was analysed. After that the removal step described above was repeated, whereby extraction fluid was injected, mixed and then separated. This cycle was repeated 4 times and for each step the partitioning of KHI to the water phase (reuse step) and to the extraction fluid (recovery step) was measured.

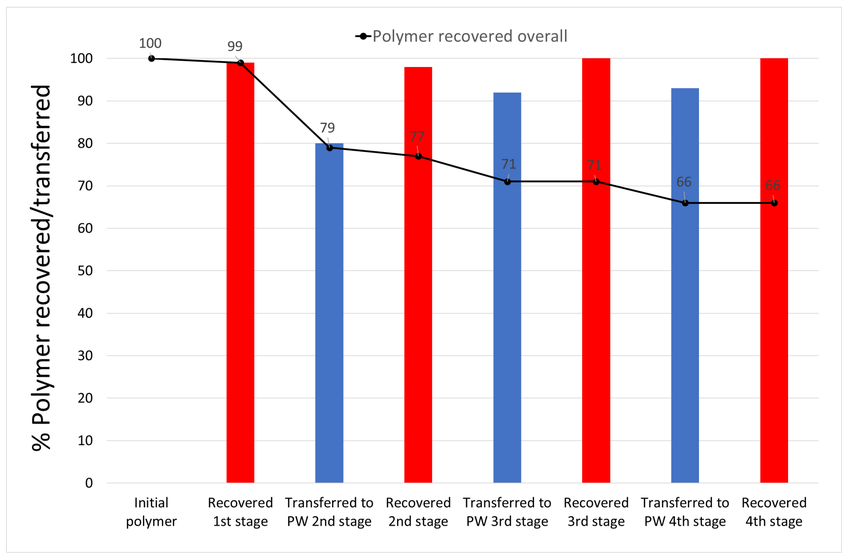


Results

The below figure summarizes the percentage of KHI B polymer recovered (red bars), and percentage transferred to produced water phase (blue bars) at each stage for 4 times recovery and re-use. The overall calculated recovered KHI polymer relative to the initially injected KHI (from 1st stage) is shown as the black line.

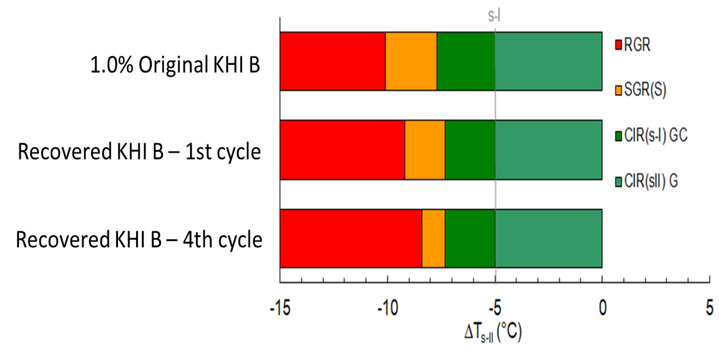
The removal step is very efficient resulting in almost 100 % polymer recovery at all stages. The main losses seem to be due to KHI lost to condensate phase when the formulation is re-injected. However, the overall recoverability improves for each stage, suggesting that the most recoverable KHI polymer strands are enriched over time while the less recoverable polymer strands are lost.

Conclusively, around 66 wt% of the originally KHI B polymer added was still remaining after 4 cycles of recovery and re-use. On average this means that only ~8.5% of the polymer is lost per cycle and thus the need for top-up of fresh KHI chemical can potentially be reduced by more than 90% compared to a once through system.



Hydrate Inhibition with Recovered KHI

The hydrate inhibition performance for 1.0% original KHI (w/ 10% active) was compared to the performance of recovered KHI after 1 cycle and 4 cycles. A non-time/nucleation dependent in-house 'crystal growth inhibition' (CGI) evaluation approach developed by Hydrafact was used. The complete inhibition region (CIR, green area) is the most important parameter and shows nearly identical performance after 4 cycles. The main difference can be seen in the less important slow growth region (SGR(S)), which only offers a modest safety margin This may be e.g. due to 'refining' of polymer average molecular weight, during repeat dissolution / extraction cycles.



Conclusions and Further Work

Multiple recovery and reuse of a commercial and field qualified KHI has been demonstrated on lab scale. The same concept has also been found to work in presence of MEG. Challenges remains on achieving efficient separation of the extraction fluid from the water phase, which is currently addressed.

Preliminary results from pilot tests at NOVs test facilities at Flotta (Orkney Islands) has shown that the process is up-scalable to field conditions.

Acknowledgements

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