Using nanotechnology to treat wastewater from offshore oil and gas industry – a feasibility study

Zaki-Ul-Zaman Asam[1], Hongzhou Zhang[2], Weiwei Lei[3], Ying Chen[3], Abdul-Sattar Nizami[4], Liwen Xiao[1]

[1] Department of Civil, Structural and Environmental Engineering, Trinity College Dublin, Dublin, Ireland
[2] Centre for Research on Adaptive Nanostructures and Nanodevices (CRANN), Naughton Institute, Trinity College Dublin, Dublin, Ireland
[3] Institute for Frontier Materials, Deakin University, Warun Ponds, Victoria 3216, Australia
[4] Centre of Excellence in Environmental Studies (CEES), King Abdulaziz University, Jeddah, KSA

Background and Objectives

Wastewater produced during oil and gas extraction operations, referred as produced water (PW), constitutes the industry's most important waste streatm on the basis of volume. PW may has complex composition including organic or inorganic ingredients such as salts, metals, oils, phenols, organic acids, dissolved hydrocarbons and some compounds which may be added to it during oil separation process. The EU Water Framework Directive (WFD) is committed to 'zero discharge' in response to the need for a more protective system to tackle aquatic pollution (Directive 2000/60/EC, 2000). Most oil and gas companies around the world are now working towards the implementation of 'zero-discharge' of contaminants in PW (Pollestad, 2005). Until recently less attention was given to dissolved organics and heavy metals in PW, however, with expanding information about the environmental effects of discharging them into water bodies, current researches are paying more attention towards efficient and cost effective ways to remove these hydrocarbons and heavy metals from produced water. Nanomaterials, with relatively large surface areas and extremely high surface reactivity, could be an inexpensive and effective solution to remove dissolved hydrocarbons and heavy metals from produced water and can facilitate the achievement of ''a zero environmental harmful discharge'' goal in oil & gas industry.

The overall objective of this research project is to study the feasibility of using nano-particles to remove dissolved hydrocarbons and heavy metals from PW. The specific objectives are (a) to review the best available technologies for offshore PW treatment, (b) to identify, synthesis and characterise potential nano-particles for adsorption of dissolved hydrocarbons and heavy metals from PW and (c) to evaluate the efficiency and cost effectiveness of these nano-particles.

Research Methods

Recent research by Lei et al. (2013) suggests that the Porous Boron Nitride (BN) nanosheets have a great potential to remove hydrocarbons from wastewater. These BN nanosheets have been synthesised by our collaborators in Deakin University Australia. Currently batch experiments are being carried out in the laboratory to investigate efficiency of BN nanosheets to adsorb dissolved hydrocarbons and heavy metals from wastewater. In addition to BN nanosheets some other nanomaterials are also selected for this experiment including Zinc oxide (ZnO), Iron oxide (Fe_3O_4) and Titanium Oxide (TiO_2).

In batch experiments a known mass of nanomaterials is mixed with synthetic produced water containing known concentrations of selected hydrocarbons (such as Benzen, Toluene, Ethylebenzene and Xylenes, collectively called as BTEX) and heavy metals. After mixing the water samples are filtered and stored until further analyses. Water samples will be analysed for hydrocarbons using Gas Chromatograph – Mass Spectrometer (GC-MS) **(Fig. 1)** and for heavy metals using Inductively coupled plasma atomic emission spectrometer (ICP-AES) **(Fig. 2)**.

Fig. 1. GC-MS for analysis of hydrocarbons in water samples

Fig. 2. ICP-AES for analysis of heavy metals in water samples

Future work

Future work involves the;

- Continuation of the batch experiments
- Analysis of water samples for hydrocarbons and heavy metals with GC-MS and ICP-AES respectively
- Comparison of efficiencies of different nanomaterials to remove dissolved hydrocarbons and heavy metals from produced water
- Comparison of various technologies or combination of technologies suitable for the treatment of produced water for offshore facilities

Acknowledgements: This research project (No: IS13/06) is funded by the Petroleum Infrastructure Program (PIP), Ireland.

References

- Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000, establishing a framework for Community action in the field of water policy.
- Lei, W., Portehault, D., Liu, D., Qin, S., Chen, Y., 2013. Porous boron nitride nanosheets for effective water cleaning. Nat. Commun. DOI: 10.1038/ncomms2818.
- Pollestad, A., 2005. The Troll oil case—practical approach towards zero discharge. In Tekna Produced Water Conference, 18–19 January 2005.

PIP Petroleum Infrastructure Programme

TRINITY COLLEGE DUBLIN | THE UNIVERSITY OF DUBLIN
COLÁISTE NA TRÍONÓIDE

CRANN

King Abdulaziz University

DEAKIN UNIVERSITY AUSTRALIA Worldly