Treatment of wastewater from offshore oil and gas industry by using nanotechnologies

L. Xiao[1], H. Zhang[2], Z. Asam[1], M. O'Connor[1], C. O'Driscoll[1]

[1] Department of Civil, Structural and Environmental Engineering, Trinity College Dublin, Dublin 2
[2] CRANN, Naughton Institute, Trinity College Dublin, Dublin 2

Contact detail: Prof. Liwen Xiao (Liwen.xiao@tcd.ie; +353 1 896 3741)/ Prof. Hongzhou Zhang (Hongzhou.zhang@tcd.ie; +353 1 896 4655)

INTRODUCTION

Water treatment is quickly emerging as one of the most significant challenges facing the offshore oil/gas industry. With large volumes of water used in the oil/gas production process, water is increasingly moving from an operational issue to one of strategic significance. Water produced during oil and gas extraction operations, referred as produced water (PW), constitutes the industry's most important waste stream on the basis of volume. 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).

Nanomaterial, with relative large surface areas and extremely high surface reactivity, could be an inexpensive and effective solution to treat PW and facilitate the achievement of "a zero environmental harmful discharge" goal in oil/gas industries.

The overall objective of this project is to study the feasibility of using nanomaterials to treat PW from offshore oil and gas industry. The specific objectives are (1) to review the best available technologies for offshore PW treatment, (2) to identify, synthesise and characterise potential nanomaterial for PW treatment and (3) to evaluate the efficiency and cost effectiveness of these nanomaterial

MATERIALS, METHODS AND PRELIMINARY RESULTS

Potential nanomaterials will be chosen for the project based on the following: (1) have high sorption capacity of heavy metals, oil and other organic matters; (2) can be easily collected from water after wastewater treatment; and (3) can be easily cleaned for re-used. The porous boron nitride (BN) nanosheets have bee reported to have great potential for effective cleaning of oil mixed wastewater (Lei et al., 2013). A number of nanomaterials fabricated in CRANN at TCD may have potential to be used for treatment of PW. The chosen nanomaterials will then be used to treat synthetic PW using batch experiments. The removal efficiencies and the impact of parameters such as pH and temperatures on the efficiencies will then be assessed. Nanomaterials re-use after treatment will also be investigated.

The compositions of PW varies from site to site. In this project, the synthetic PW will be made based on Table 1 (Ekins et al., 2005), which shows the typical material composition of PW discharged from oil fields in the Norwegian sector of the North Sea. Figures 1 and 2 show the scanning electro microscopy of the potential nanomaterials and XRD patterns of the nanostructures of potential nanomaterials, respectively.

Sources		Seawater			Produced water			Ratio Produced water: seawater (mid)
		Range	*Mid*	*Unit*	*Range*	*Median*	*Unit*	
Sources: Frost 1998, Section 1.2	Dispersed oil	-	-	-	15-60	44	mg/1	-
	BTEX	-	-	-	1-67	6	mg/1	-
	NPD	9-185	88	ng/1	0.06-2.3	1.2	mg/1	13,636
	PAH	1-45	22	ng/1	130-575	468	µg/1	21,273
	Organic Acids (<C6)	-	-	-	55-761	368	mg/1	-
	Phenols(C0-C4)	-	-	-	0.1-43	8	mg/1	-
	Barium (Ba)	22-80	29	µg/1	0.2-228	87	mg/1	3,000
	Cadmium (Cd)	4-23	10	ng/1	0.5-5	2	µg/1	211
	Copper (Cu)	20-500	240	ng/1	22-82	10	µg/1	42
	Mercury (Hg)	1-3	2	ng/1	<0.1-26	1.9	µg/1	950
	Lead (Pd)	20-81	31	ng/1	0.4-8.3	0.7	µg/1	23
	Zinc (Zn)	0.3-1.4	0.6	µg/1	0.5-13	7	mg/1	12,727
	Iron (Fe)[1]	1.8	1.8	µg/1	0.1-15	4.3	mg/1	2,389
Source: E&P 1994, p.4					4.5-6	5.25	mg/1	2,917
	Radium (^{226}RA)				1.66	1.66	Bq/1	Seawater concentrations not available
	Radium (^{228}RA)				3.9	3.9	Bq/1	
	Manganese (Mn)				0.1-0.5	0.45	mg/1	
	Berllium (Be)				0.02	0.02	mg/1	
	Nickel (Ni)				0.02-0.3	0.14	mg/1	
	Cobalt (Co)				0.3-1	0.35	mg/1	
	Vanadium (V)				0.02-0.5	0.24	mg/1	

[1] Second row from E&P 1994
Note: The medians for the produced water numbers were provided in the source, whereas the mid points for the seawater concentrations are calculated from the ranges.

Table 1
Typical material composition of produced water discharged from oil fields in the Norwegian sector of the North Sea (Ekins et al., 2005)

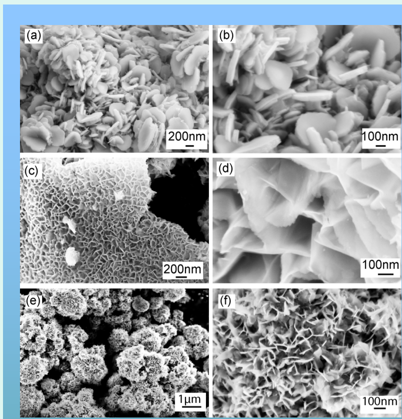

Figure 1
Scanning electron microscopy (SEM) images of the milled MnO2 (a, b), SnO2 (c, d) and rutile TiO2 (e, f) after the hydrothermal treatment in 2 M NaOH aqueous solution at 120 ° C for 4 h

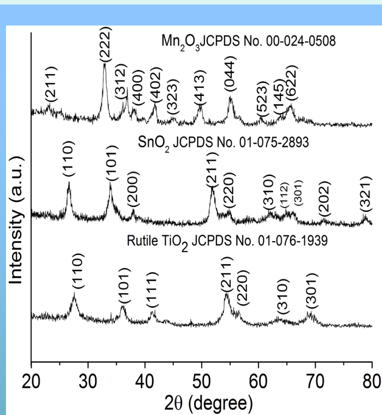

Figure 2
XRD patterns for the resulting nanostructures of potential nanomaterials

Reference

- 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.
- Ekins Paul, Vanner Robin, Firebrace James. 2005. Management of produced water on offshore oil installations: A comparative assessment using flow analysis. Final report. Plolicy Studies Institute.
- 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.

TRINITY COLLEGE DUBLIN
COLÁISTE NA TRÍONÓIDE
THE UNIVERSITY OF DUBLIN

CRANN