Potential of using nanomaterials to removal of heavy metals from oil industry wastewater

Z. Asam[1]., F. Gao[1]., L. Xiao[1].,H. Zhang[2]., W. Lei[3]., Y. Chen[3]

[1] *Department of Civil, Structural and Environmental Engineering, Trinity College Dublin, Dublin, Ireland*

[2] *CRANN, School of Physics, Trinity College Dublin, Dublin, Ireland*

[3] *Institute for Frontier Materials, Deakin University, Warun Ponds, Victoria 3216, Australia*

Introduction

Treatment of wastewater from oil and gas industry is one of the most significant challenges of today's and future generations. 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). Current researches are paying more attention to the removal of dissolved organic components and heavy metals from wastewater and, therefore, efficient and cost effective ways to remove these hydrocarbons and heavy metals are being explored.

Nanoparticles, with large surface areas and extremely high surface reactivity, could be an inexpensive and effective solution to adsorb hydrocarbons and heavy metals from wastewater and facilitate the achievement of "a zero environmental harmful discharge" goal in oil/gas industries. Recent researches suggest a number of nanomaterials have the potential to remove hydrocarbons and heavy metals from wastewater. Some of these materials include porous Boron Nitride (BN) nanosheets, Zinc Oxide (ZnO), and Iron Oxide (Fe_3O_4).

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. In this paper, a set of batch experiments was conducted in order to assess the heavy metals adsorption efficiencies of these nano-materials.

Methods

In this batch experiment, three nanomaterials were selected and tested for their efficiencies to adsorb heavy metals. These materials were Porous Boron Nitride nanosheets (BN nanosheets), Iron Oxide (Fe_2O_3) and Zinc Oxide (ZnO) nanoparticles.

Firstly, equilibrium solutions were prepared with known heavy metals concentrations. Secondly, 4 different mass levels of each Nano-material were taken in glass bottles (5, 10, 20, 50mg). After that, the Nano-materials were mixed with 60ml of heavy metals solutions. The bottles were then shaken on a reciprocating shaker at 250 rpm for 2 h and were left to equilibrate for 22 h, after which the suspensions were shaken again for 5 min. The suspensions were then filtered (0.45 µm) and analyzed using ICP-AES.

Results and Discussion

As it shown in Figure 1, The BN nanosheet average adsorption of Cd, Cr, Cu, Fe, Ni, Pb and Zn are 19.0, 13.8, 58.6, 0.1, 15.6, 0.1 and 24.6 (mg/g), respectively, while average adsorption of those are 1.5, 1.5, 5.3, 0.4, 1.1, 0.2 and 2.8 (mg/g) for Fe_2O_3 nanoparticle; and the ZnO average adsorption of those are 4.9, 0.7, 8.9, 0.4, 1.5, 0.2 and 0 (mg/g).

It can be seen that the BN nanosheet has significantly higher absorption capacity compared to the other two nanomaterials, especially on Cd, Cr, Cu, Ni, and Zn. The average adsorption of Fe and Pb are lower probably due to their concentrations in the original solution were lower as they might have precipitated.
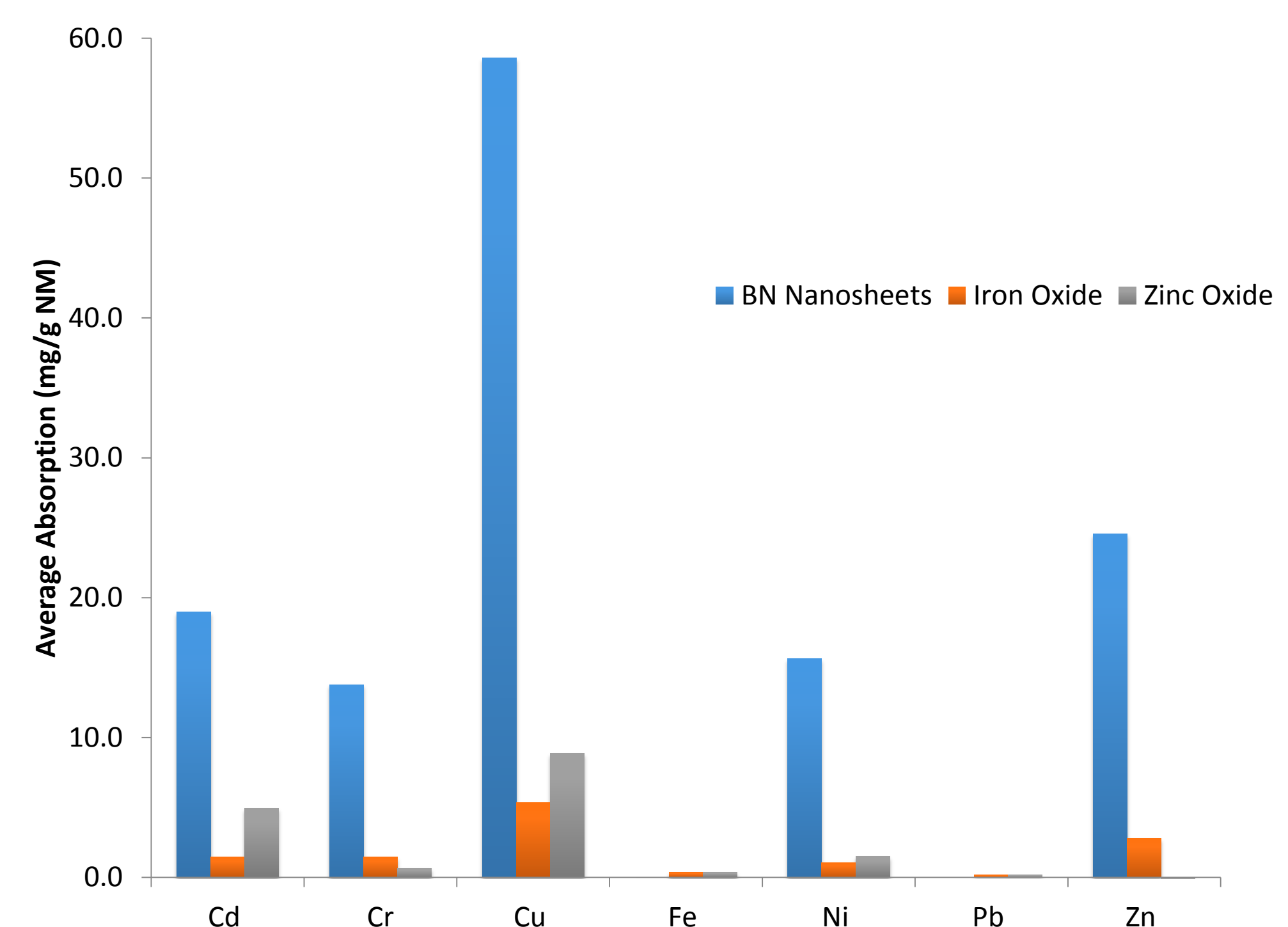

Figure. 1. Average absorption of heavy metals (mg/g NM) by BN nanosheets, Fe_2O_3 and ZnO

Conclusion and Future works

It can be concluded that these three nano-materials can be used to adsorb many different heavy metals of wastewater. The BN nanosheet shows higher adsorption efficiency on heavy metals compared with Fe_2O_3 and ZnO nanoparticles. More work is needed to support these findings.

Future work involves the

- Continuation of the batch experiments
- Analysis of water samples for hydrocarbons and heavy metals with GCMS 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

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.

Acknowledgements

PIP
Petroleum Infrastructure Programme

TRINITY COLLEGE DUBLIN
COLÁISTE NA TRÍONÓIDE

THE UNIVERSITY OF DUBLIN

CRANN

DEAKIN UNIVERSITY AUSTRALIA
Worldly