NERC Centre for Doctoral Training in Oil & Gas (2017 start)

Project Title: Removing organic contaminants from oil/gas waste waters

Host institution: SEES, University of Manchester

Supervisor 1: B. van Dongen

Supervisor 2: S. Boult

Additional Supervisor (s): K. Taylor, R. Wogelius, N. Brown & A. Nabeerasol (Arvia Techn.Ltd)

Project description: Water produced during oil and gas extraction operations is the industry's largest waste stream (14 billion bbls per year). It often contains substantial amounts of organic contaminants that require removal either, depending on the application, to mitigate fouling in steam generators or to allow safe release into the environment. This represents a real challenge for the industry as some organics are persistent in water or cannot be removed by current treatment methods. Recently, Arvia technology Ltd (the case partner in this project) developed a novel water treatment technology that uses a low capacity, proprietary graphitic adsorbent material (NyexTM) that can be electrochemically regenerated, to remove and completely oxidize organic contaminants from aqueous solutions. This technology was successfully applied in the removal of radioactive liquid organic wastes, such as oils, PCBs and chelating agents produced in the nuclear fuel cycle. Although this shows that this technology might provide a simple, flexible and reliable solution to remove organic contaminants, maybe in combination with other techniques, with significantly lower operating costs than traditional alternatives it remains unclear whether it is possible to remove the wide range of (toxic) organic contaminants found in oil/gas waste streams. This since the fundamental molecular scale adsorption processes associated with this technology and the effectiveness of removing target contaminants (e.g. wide range of oil contaminants) are still poorly understood. The main aims of this project are to assess (i) the effectiveness of this process for the destruction of a range of organic contaminants in oil/gas waste streams as well as (ii) the fundamental adsorption processes involved and (iii) to determine if it can be done at an industrial scale.

CDT Research theme(s): Environmental Impact and Regulation

Research context: To assess the effectiveness of the process the student will perform a series of experiments in a small/lab scale set up using a range of synthetic model compounds and well characterised complex industrial water samples. A variety of state of the art analytical and imaging technologies, including techniques that allow detailed information about the organic composition and structure at the single- and sub-particle level to be collected, will be used to examine the fundamental relationships behind the attachment, detachment and possible fragmentation reactions (including the formation of potential toxic break down products) that occur on the adsorbent surface during the process. These will include experiments to characterise starting material and to acquire snapshots of ex situ reacted surfaces. Modelling of adsorbate-organics interactions will be used to produce predictive models for different classes of organic contaminants. In the final part of the project the student will also perform a series of large scale experiments, using industry size units present at Arvia's facility, to determine the effectiveness of the process at an industrial scale. Critically, the synergy of the lab and larger scale experiments, the use of state of the art analytical/imaging techniques and modelling will allow the effectiveness of the destruction process to be deduced, providing a step change in our understanding of this potentially important novel oil/gas waste water treatment method.

Research costs: A normal PhD contribution is required. The additional costs of running the larger scale experiments at Arvia's facility will be covered by the case partner

Career routes: The student will gain a wide breadth of training in research techniques and industrial practice and from instrument design to organic analysis. The techniques will provide a basis for a future career in environmental/petroleum science, in the industrial, government or academic sectors, in a rapidly expanding research area of international importance.