SEMS: RESEARCH PROJECT DESCRIPTION

1. Project Background and Description

Fluidisation of Granular Activated Carbons (GAC) for sustainable drinking water treatment applications

To supply sufficient and safe drinking water, water utilities use a treatment train consisting of several unit process operations. One of these treatment unit processes is filtration using granular activated carbon (GAC), Fig.1. This is a crucial unit operation widely used for its adsorption capabilities as a barrier for undesired macro- and micro-pollutants. Traditionally, water companies have been using GACs from fossil fuel resources such as coal. However, due to climate change considerations, there is a strong push to abandon coal and explore new sustainable GAC filter media, obtained from sustainable agricultural waste materials, such as coconut shells and rice husks [2]. These sustainable GACs, however, display different filtration properties, as witnessed by their expansion behaviour in Fluidised Bed Reactor (FBR) filtration experiments. It has been suggested that this may be due to the difference in micro-structural material properties and wetting properties between fossil fuel and sustainable GACs. GAC particles have a very high internal surface area and a mean pore size of the order of a few nm, see Fig. 1b, as witnessed by gas adsorption experiments. For this reason, the wetting of GAC particles is slow and may influence the FBR filtration experiments.

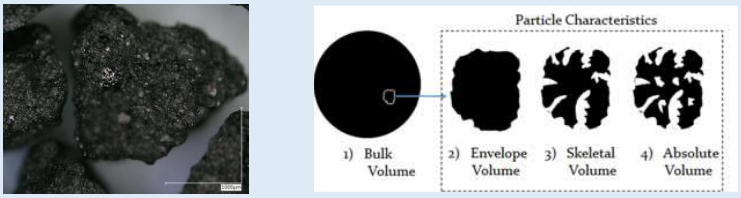
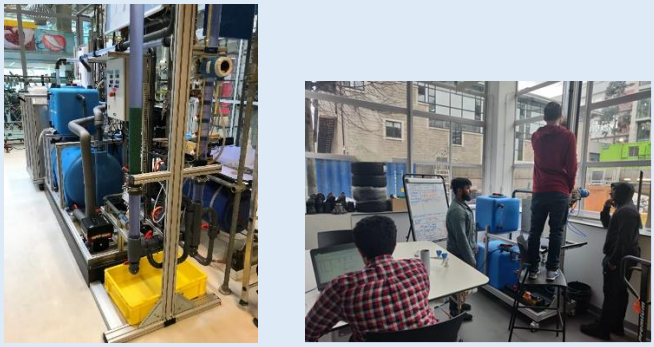


Figure 1: GAC pellets (left) and internal material GAC structure (right).

For these reasons, we will use our new purpose-built Fluidised Bed Reactor (FBR) / expansion column [1], commissioned in collaboration with our industrial colleagues from Waternet, Amsterdam (NL). Based on our experience in FBR experiments [1], we propose here to investigate the expansion and wetting properties of a range of sustainable GACs, in comparison with fossil fuel GACs. This expansion column is an important part of our research equipment and is used for both UG and PG research and teaching purposes, see Figure 2.



We have a collection of more than 10 perfectly wetted GAC samples from different sources available to be tested on their filtration and expansion properties.

To support the experimental investigation of the expansion and wetting behaviour of the GAC particles, we propose here to carry out, in addition, detailed Molecular Dynamics [3], Lattice-Boltzmann [4] and CFDEM calculations. This combination of experimental and computational methods will lead to new insights in the quest for elucidation of the wetting and expansion behaviour of complex carbon materials with an average pore size of order 1 nm.

Most water utility companies are facing the transition from fossil to sustainable GACs for their drinking water supply [5]. Therefore I believe that we are in an excellent position to offer a unique PhD research project with strong industrial support from Waternet in Amsterdam, the Netherlands.

[1] O.J.I. Kramer, J.T. Padding, W.H. van Vugt, P.J. de Moel, E.T. Baars, E.S. Boek, & J.P. van der Hoek (2020), "Improvement of the Carman-Kozeny model for liquid-solid fluidisation systems based on Reynolds and Froude numbers", https://doi.org/10.1016/j.ijmultiphaseflow.2020.103261, International Journal of Multiphase Flow 127 01 Jun 2020.

[2] Mäkelä, M., Volpe, M., Volpe, R., Fiori, L. and Dahl, O., (2018). Spatially resolved spectral determination of polysaccharides in hydrothermally carbonized biomass. Green chemistry, 20(5), pp.1114-1120.

[3] E.S. Boek, J.T. Padding, T. Headen (2010), "Multi-scale simulation of asphaltene aggregation and deposition in capillary flow", Faraday Discussions 144, 271.

[4] Zacharoudiou, I., Boek, E.S., & Crawshaw, J. (2018), "Impact of drainage displacement patterns and Haines jumps on CO2 storage efficiency", Nature Scientific Reports, 8:15561 DOI:10.1038/s41598-018-33502-y

[5] Kramer OJI, de Moel PJ, Padding JT, Baars ET, Hasadi YMFE, Boek ES, van der Hoek JP. Accurate voidage prediction in fluidisation systems for full-scale drinking water pellet softening reactors using data driven models Journal of Water Process Engineering 37 07 Mar 2020

2. Project Scope

Three research project objectives

1) Develop and use experimental methods to determine the expansion and wetting behaviour of GACs.
2) Use and develop computational modelling methods to support the experiments.
3) Elucidate the expansion behaviour of sustainable GAC materials as a function of their structural and wetting properties.

3. Desired Skills from the Student

Key skills needed for the PhD project

1) Undergraduate degree in science or engineering
2) Interest in developing pilot-scale experimental equipment, including Fluidised Bed Reactors.
3) Interest in using / developing computational methods

4. Supervisory Team

Add supervisory team details

Primary supervisor: Dr Edo Boek, SEMS, e.boek@qmul@ac.uk

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