Brunel University London

UKCCS RESEARCH CENTRE

UKRI Engineering and Physical Sciences Research Council

Biomass Combustion Ash in CO_2 Capture

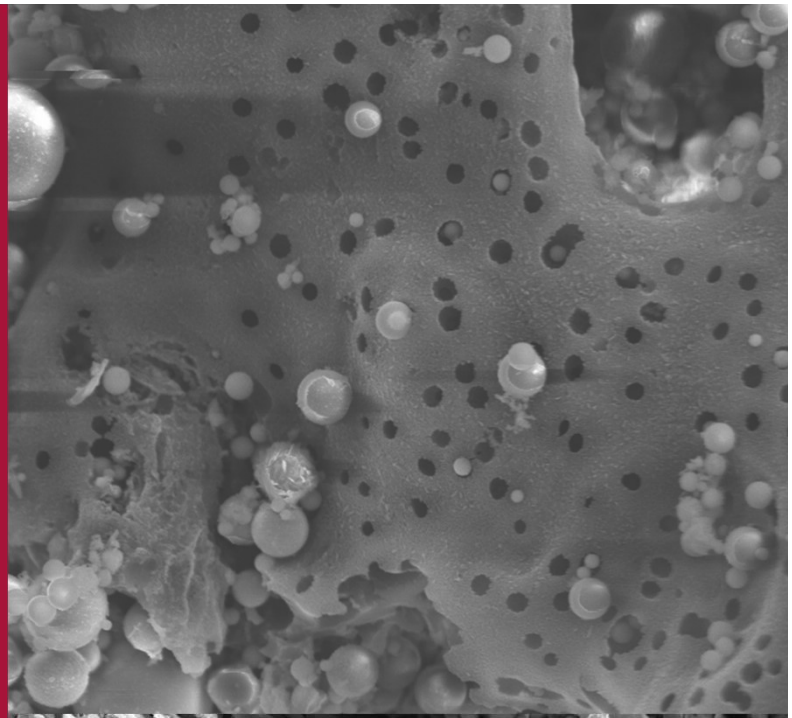
Mikhail Gorbounov, MSc, *AMIChemE*

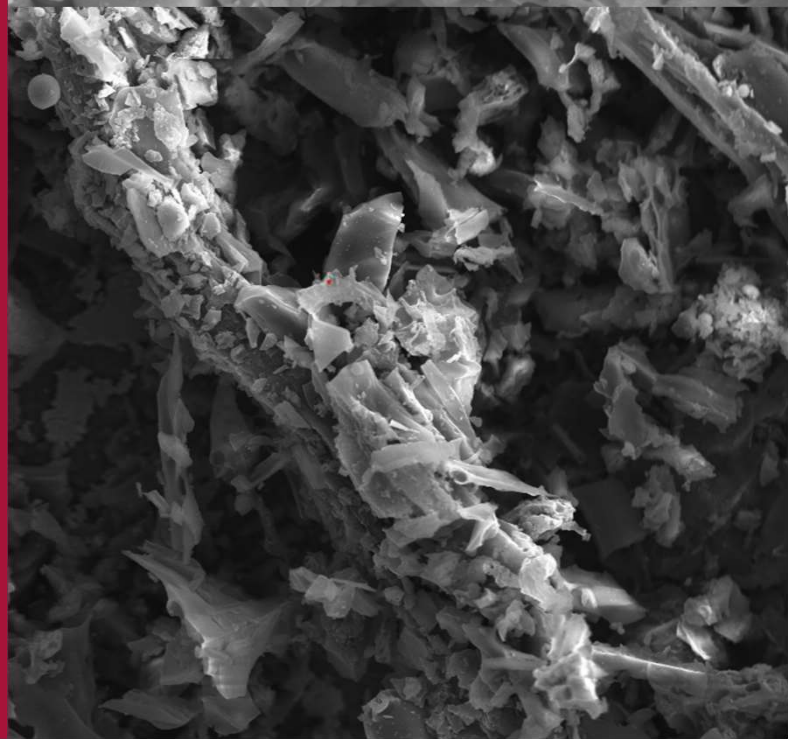
Ben Petrovic, BEng, *AMIChemE*

Dr. Salman Masoudi Soltani (Principal Investigator)

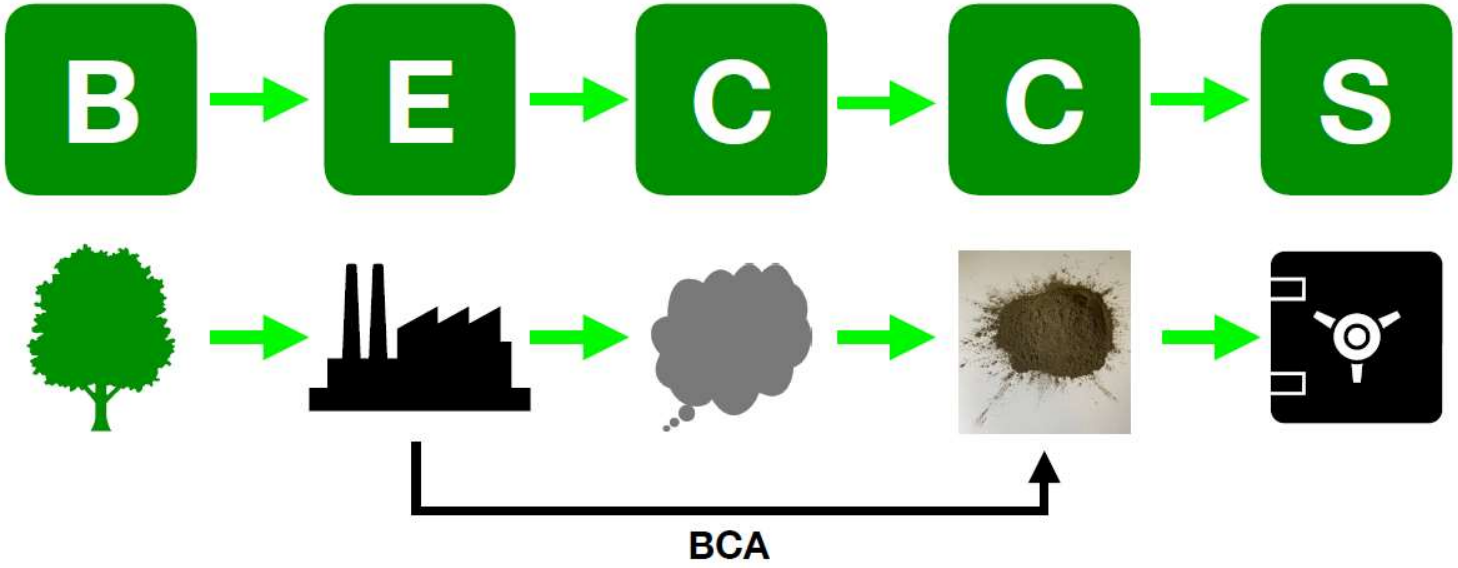
E: salman.masoudisoltani@brunel.ac.uk

T: +44 (0)1895 265884





Biomass Combustion Ash – BCA



- Estimated **5 – 8 Gt** biomass produced globally with potential for energy applications;
- Mean combustion ash yield of **6.8%** [1].
- Production of approximately **500 Mt BCAs annually**.

1. Vassilev S V., Baxter D, Andersen LK, Vassileva CG. An overview of the composition and application of biomass ash. Part 1. Phase-mineral and chemical composition and classification. Fuel [Internet]. 2013;105:40–76. Available from: http://dx.doi.org/10.1016/j.fuel.2012.09.041

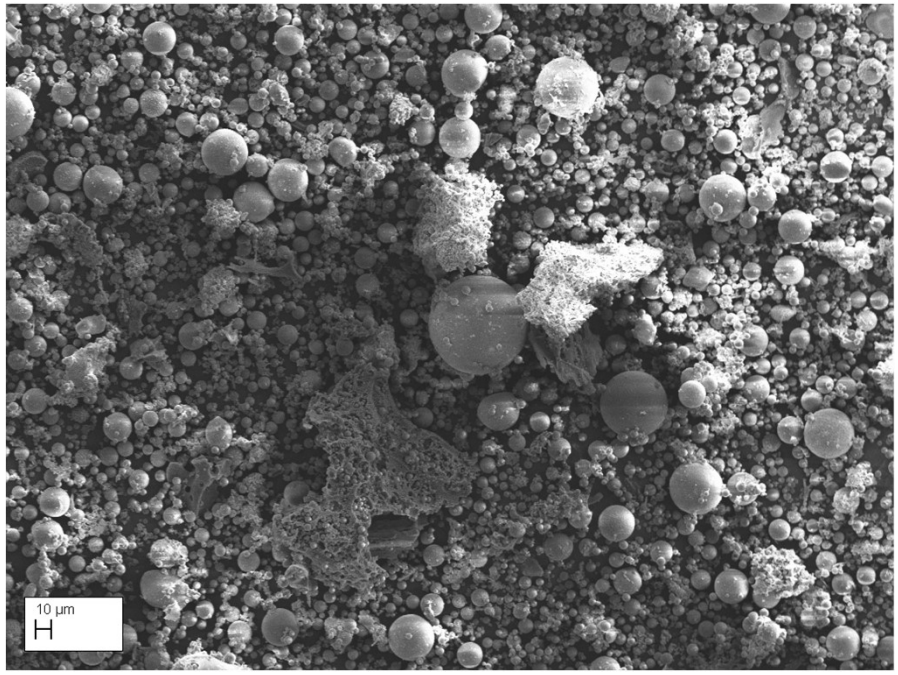
Investigated Materials

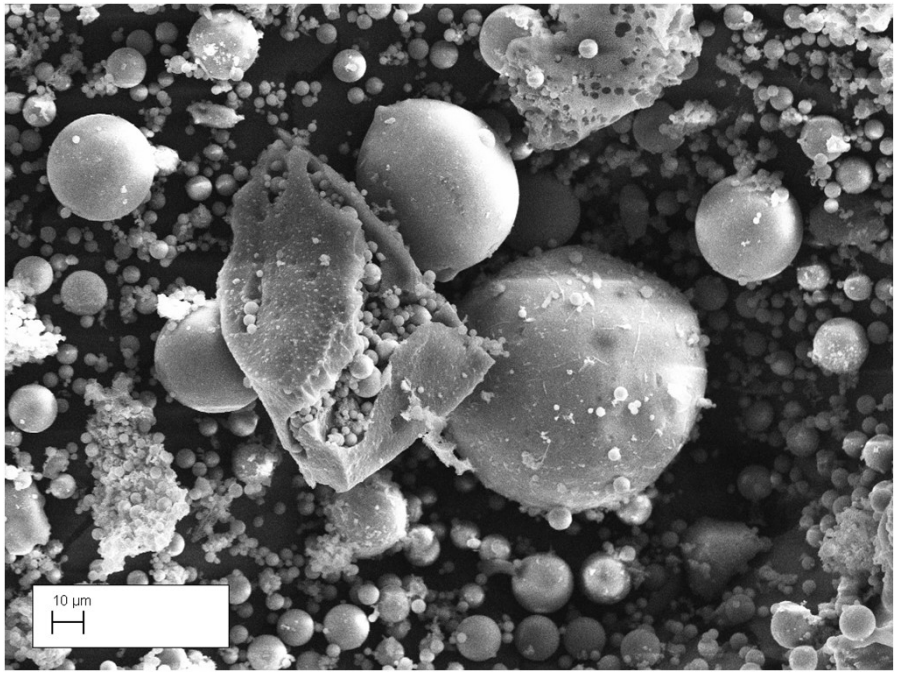
Fly Ash – **FA**

Bottom Ash – **BA**

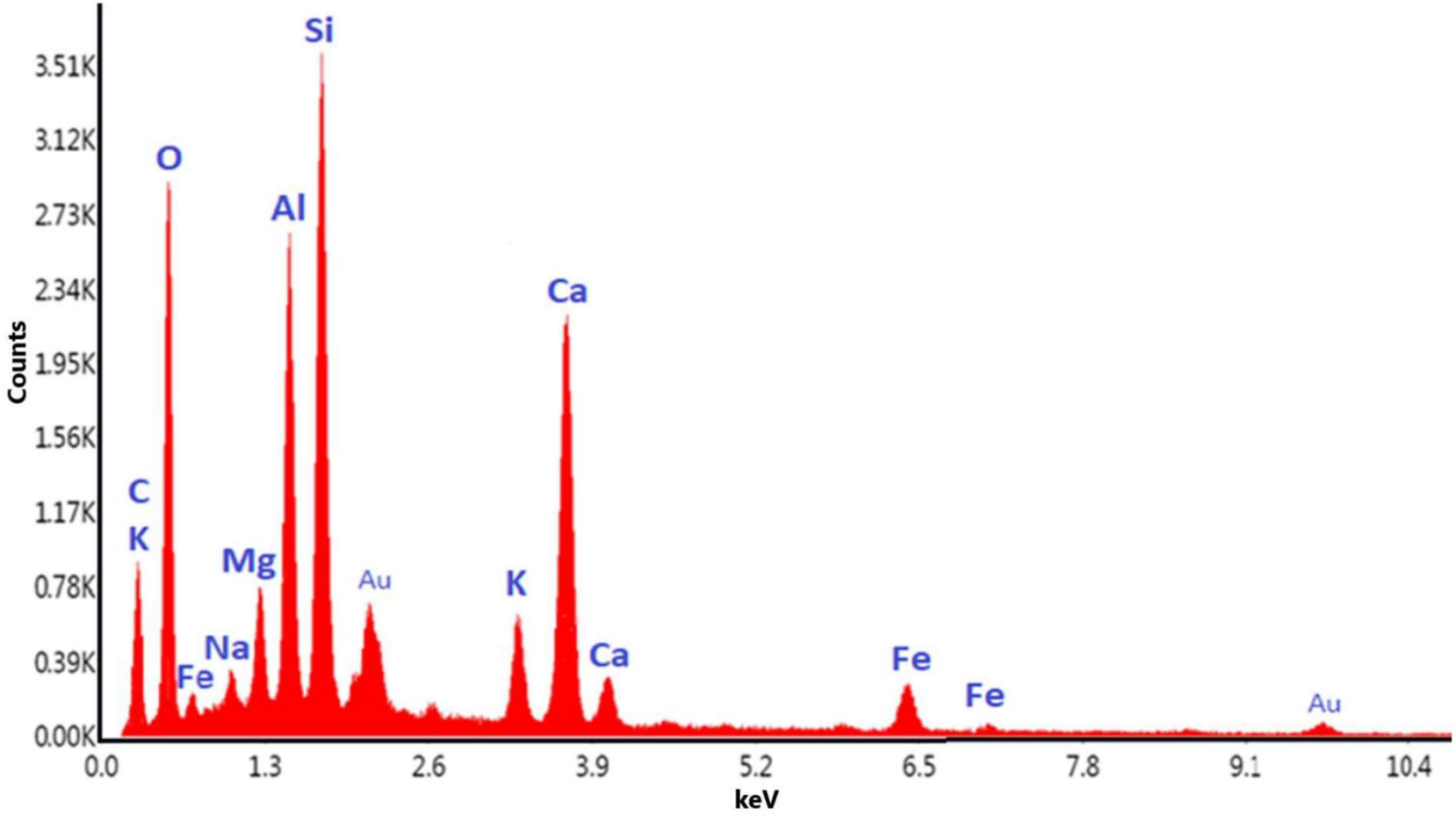
Scanning Electron Microscopy – FA

25 February 2021

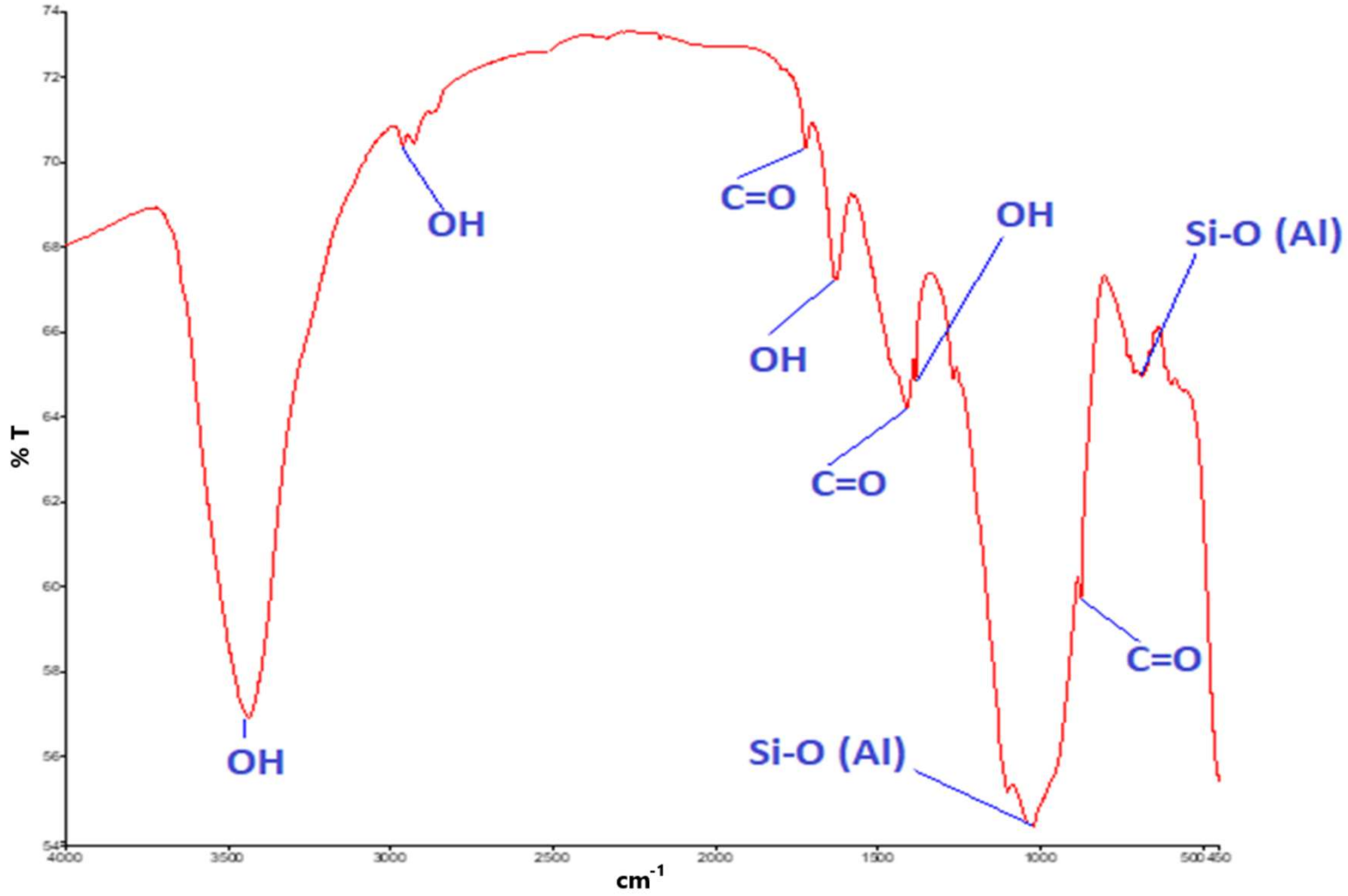




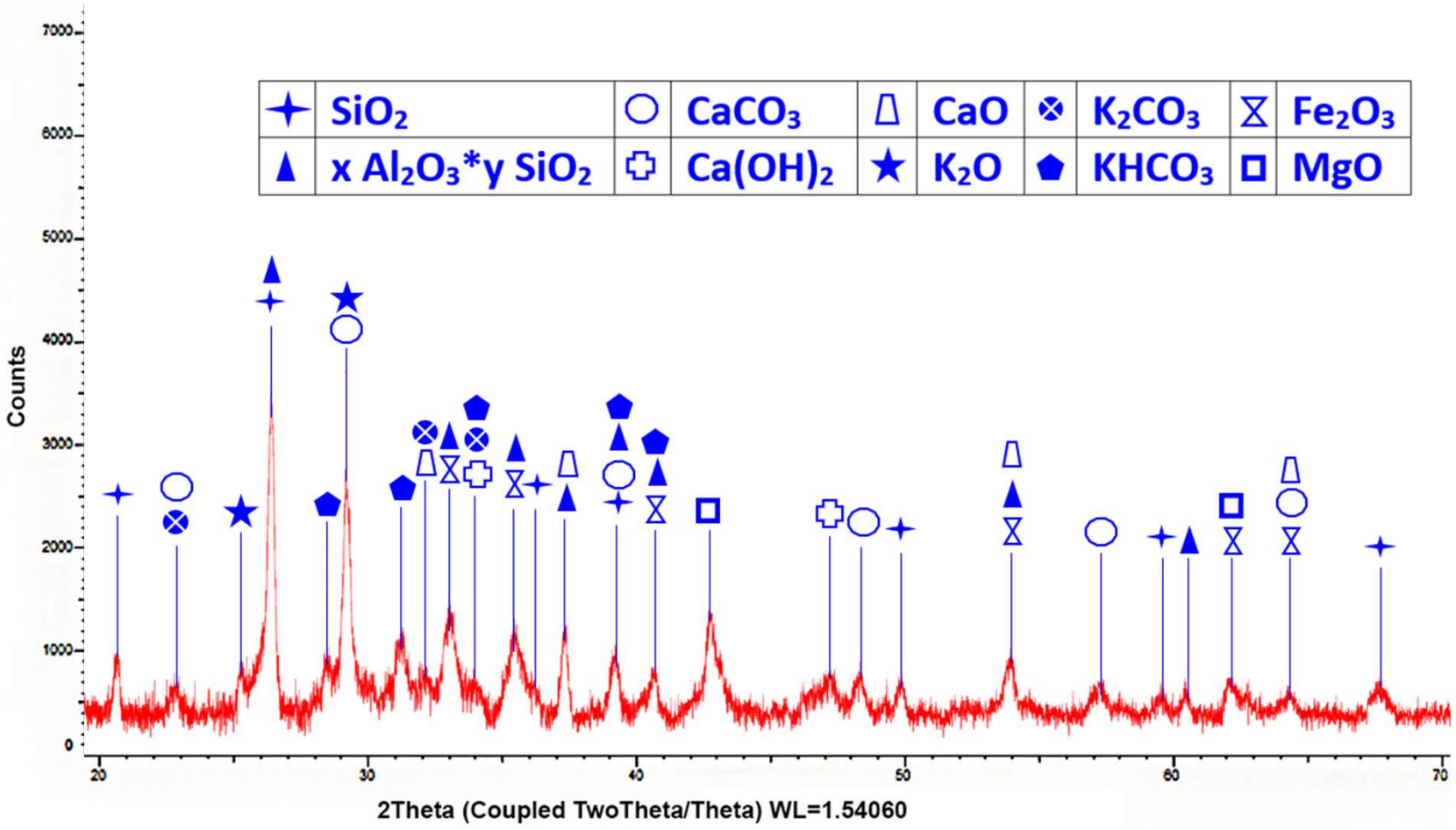
Energy-Dispersive X-ray Spectroscopy – FA



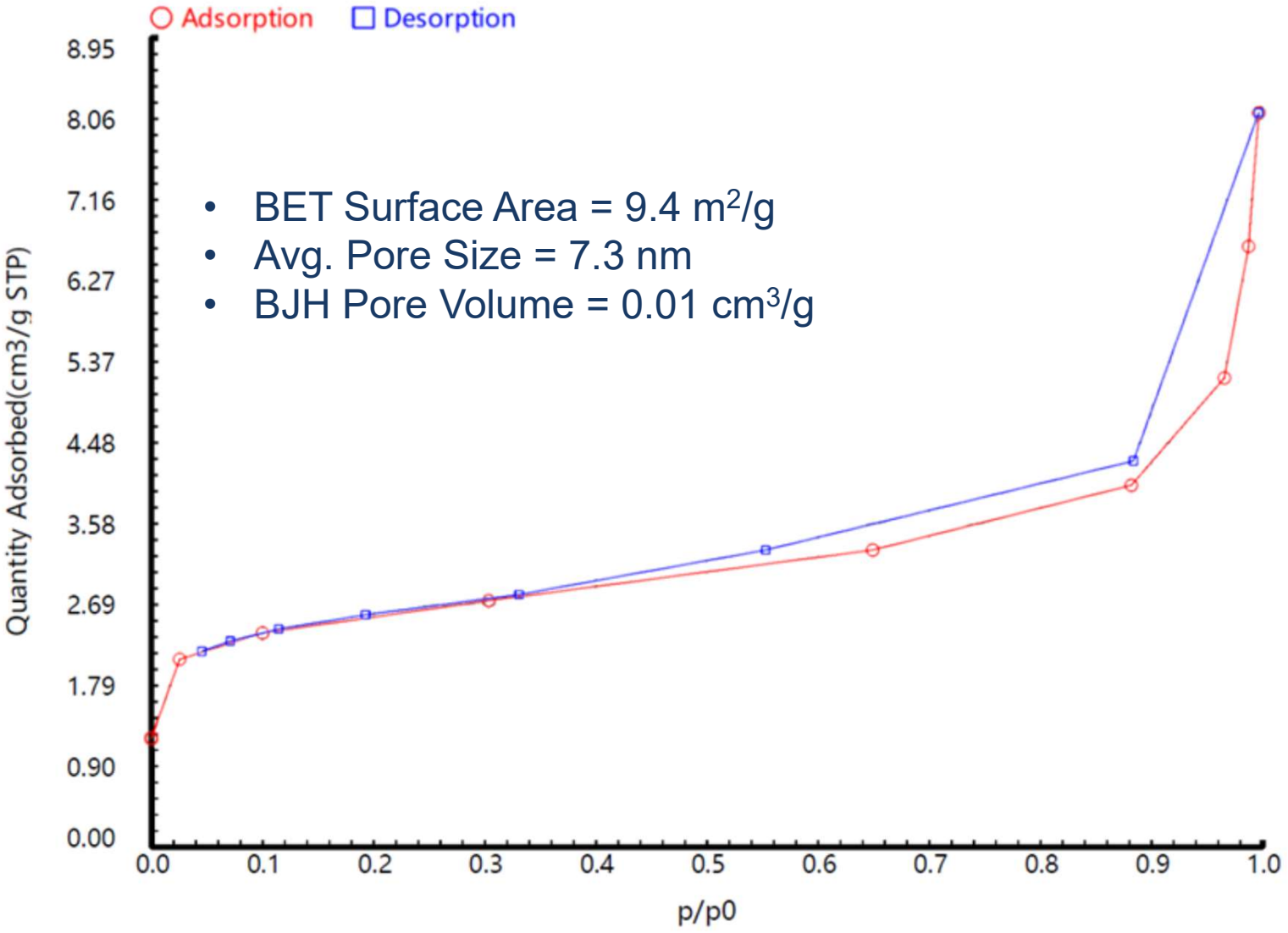
Fourier-Transform Infrared & Raman Spectroscopy – FA



X-ray Diffraction Analysis – FA

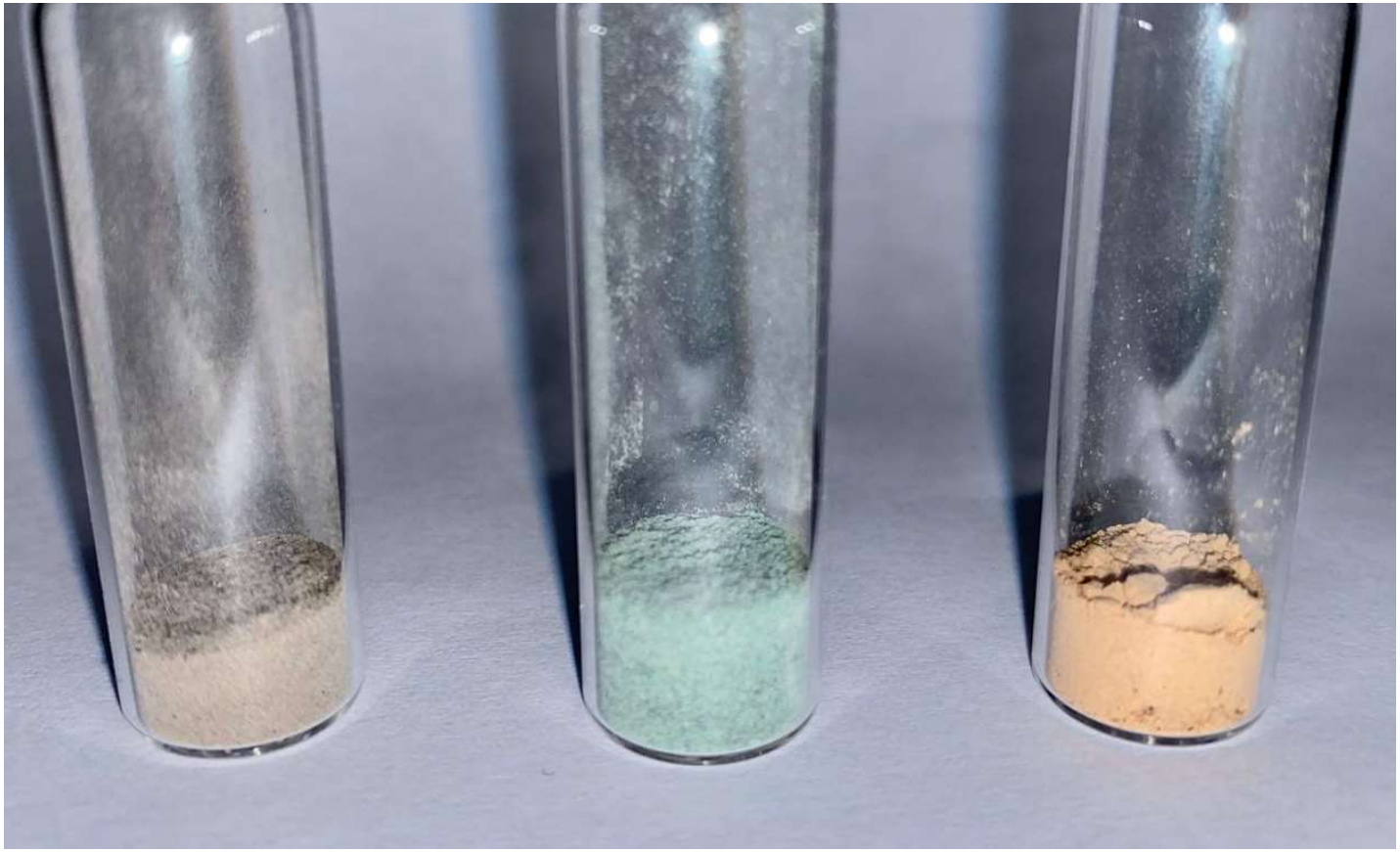


BET + BJH – FA



- BET Surface Area = 9.4 m^2/g
- Avg. Pore Size = 7.3 nm
- BJH Pore Volume = 0.01 cm^3/g

Zeolite synthesis – FA



Fly Ash | Fusion Product | Zeolite

Investigated Materials

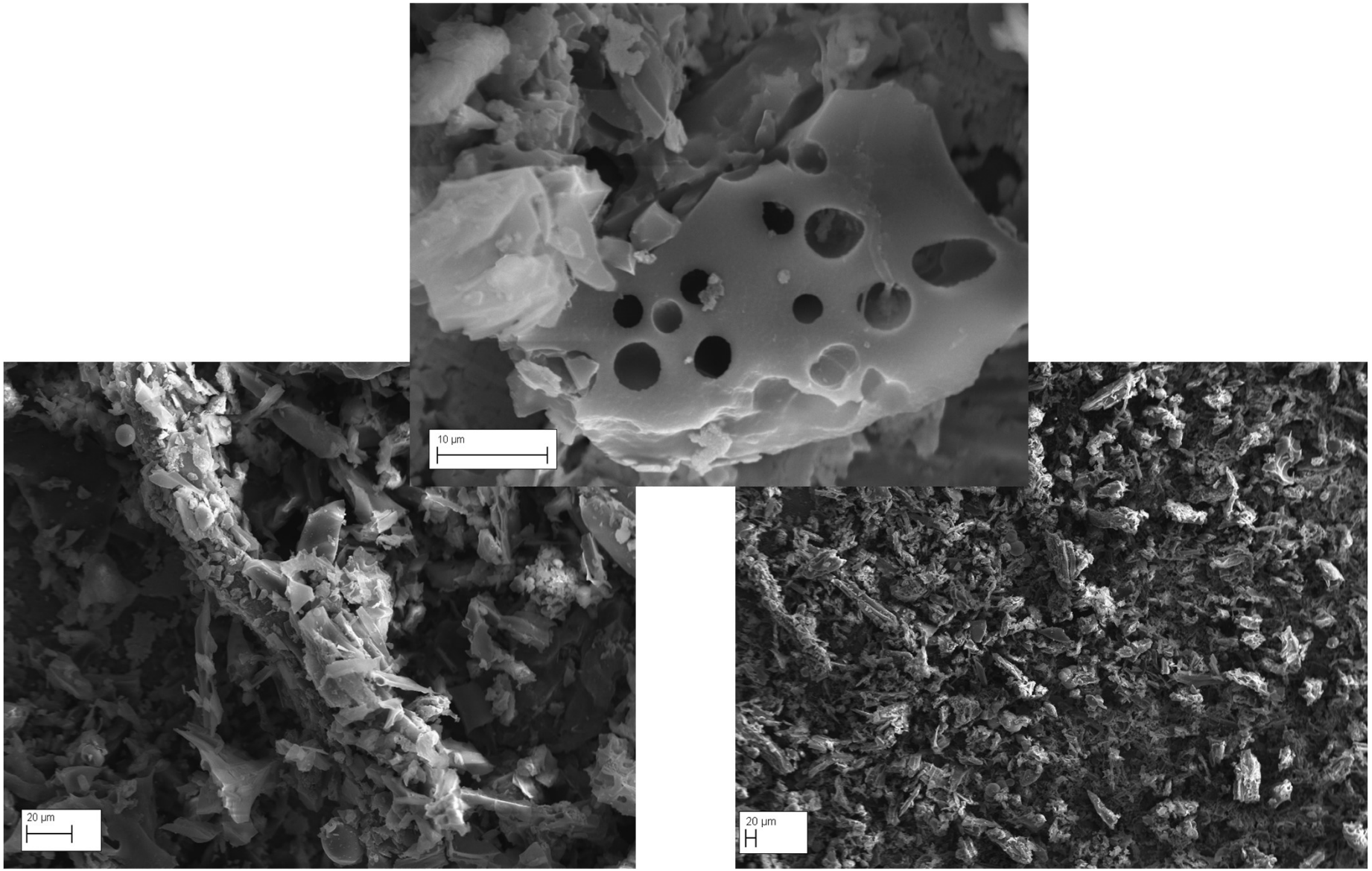
Bottom Ash – **BA**

Bottom Ash (carbon) – **BA-63**

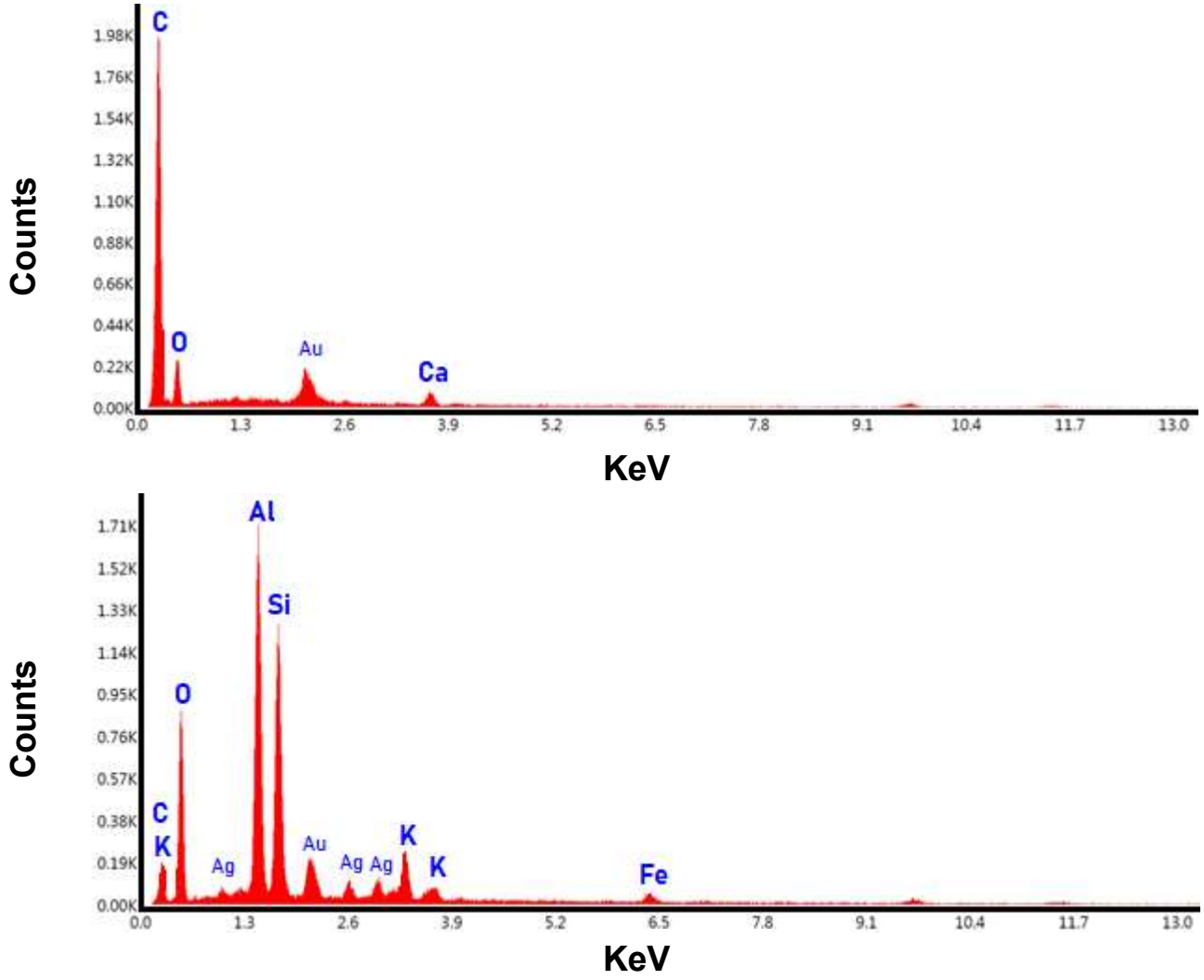
H_2O	VOC	C	Ash
6 %	35 %	52 %	7 %

SEM – BA-63

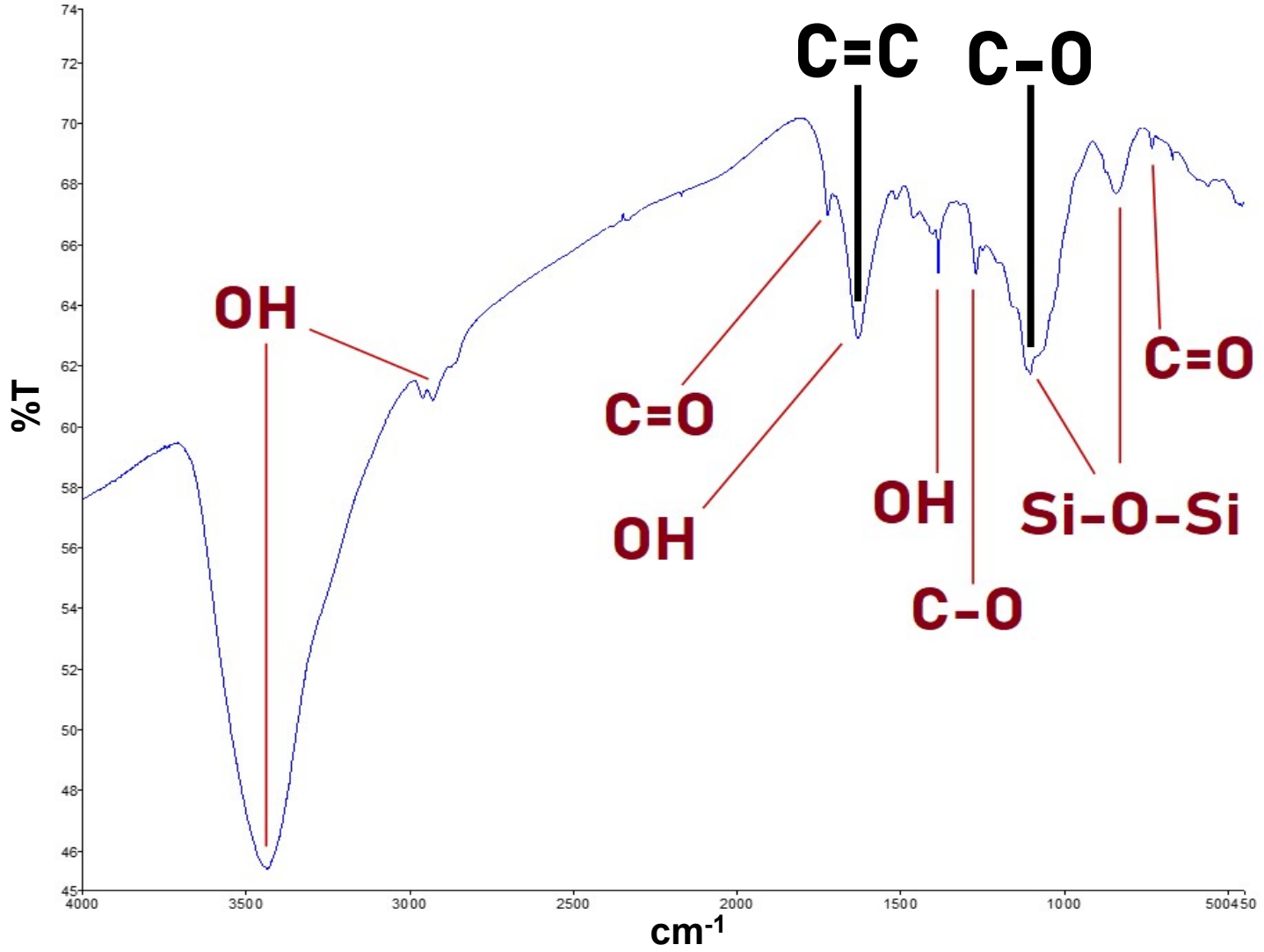
25 February 2021



Energy-Dispersive X-ray Spectroscopy – BA-63

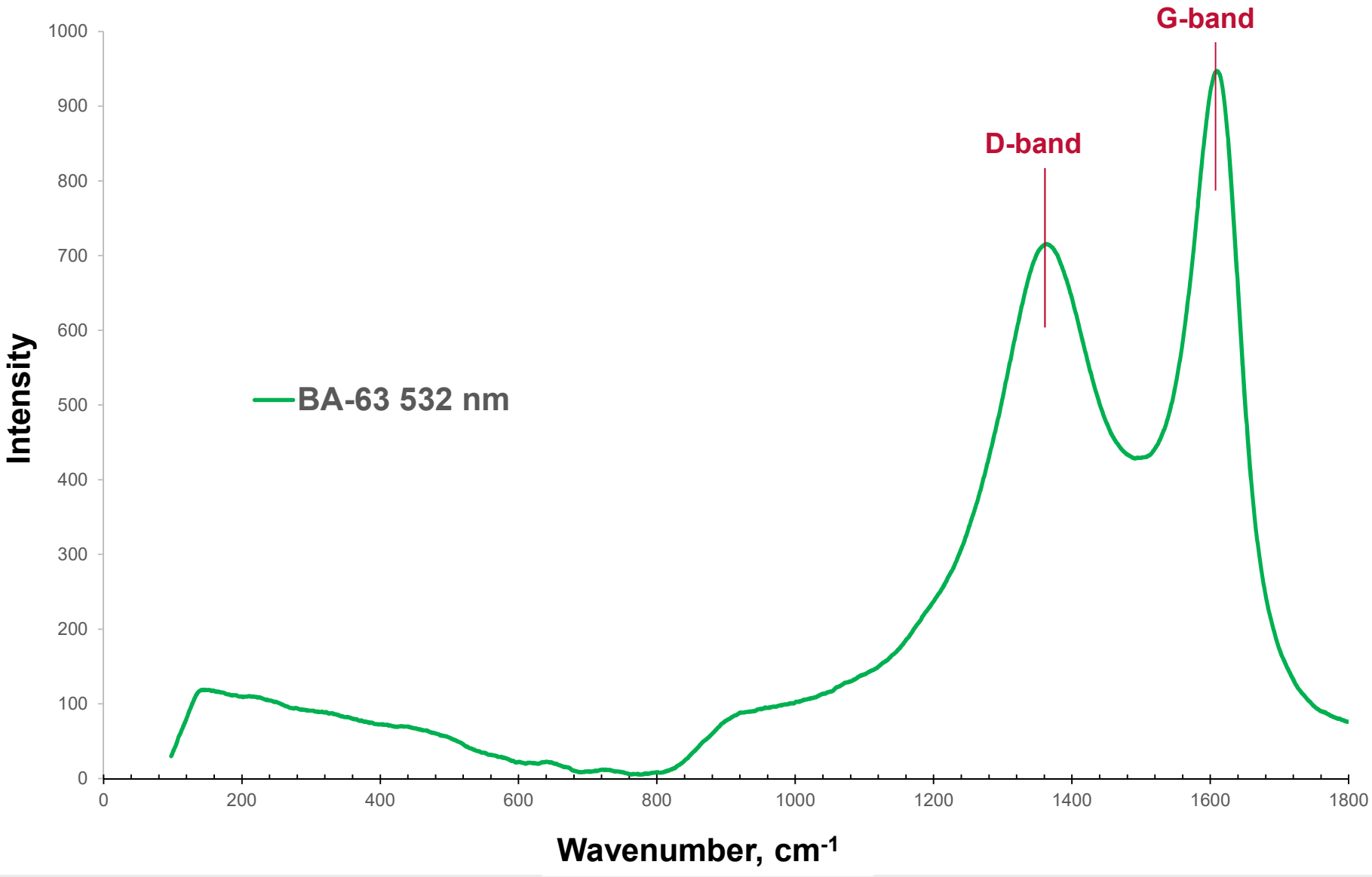


Fourier-Transform Infrared Spectroscopy – BA-63



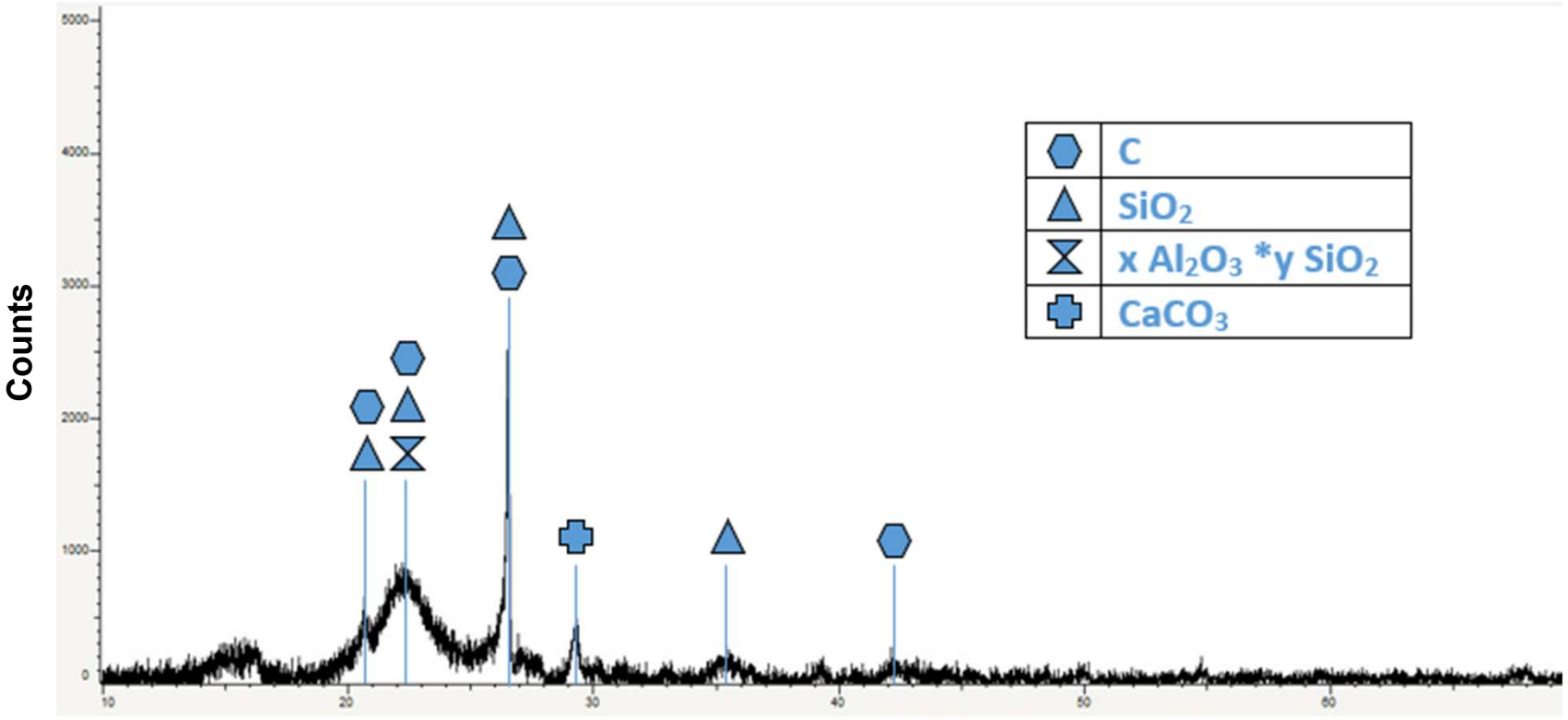
Raman Spectroscopy – BA-63

25 February 2021

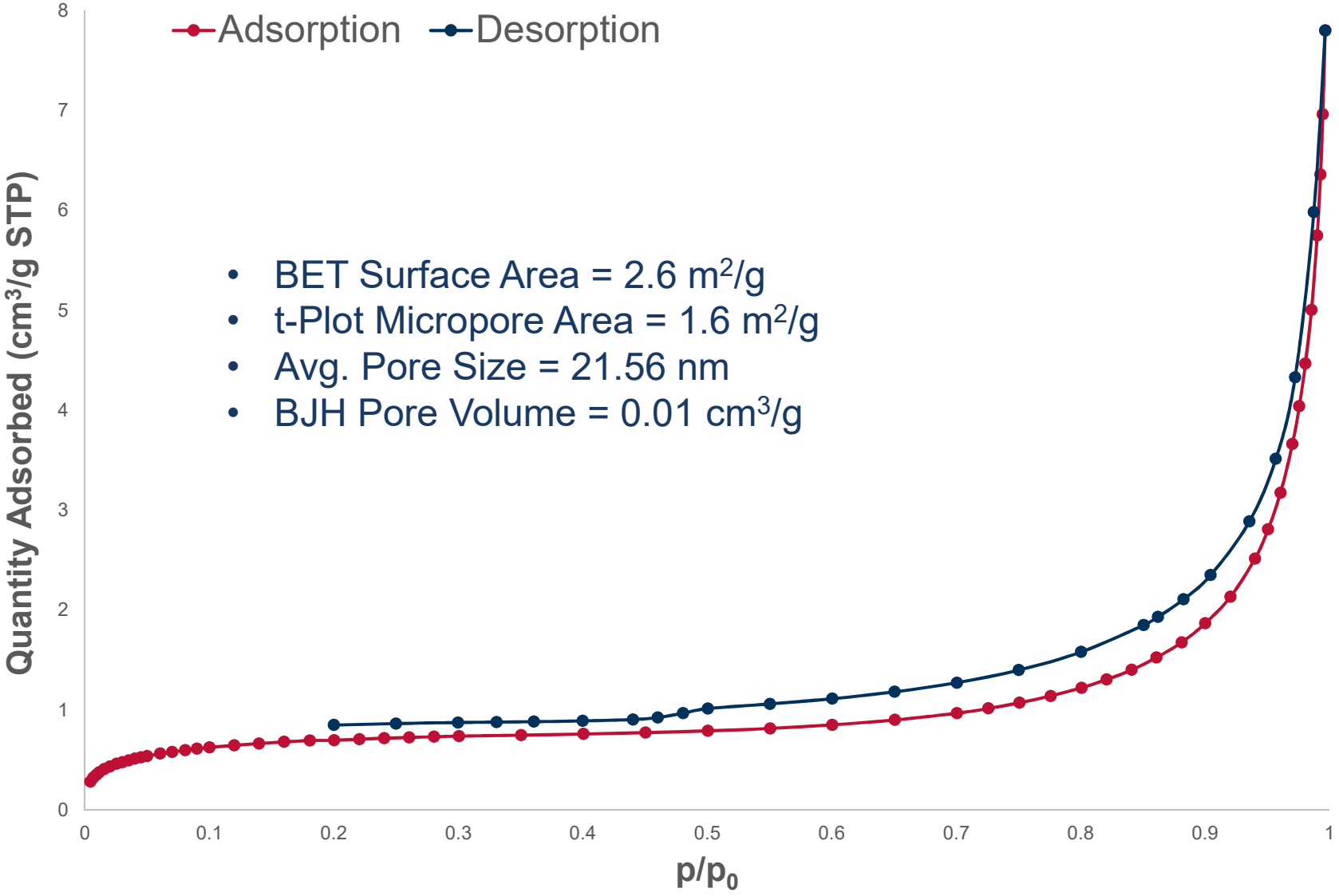


X-ray Diffraction Analysis – BA-63

25 February 2021



BET + BJH – BA-63

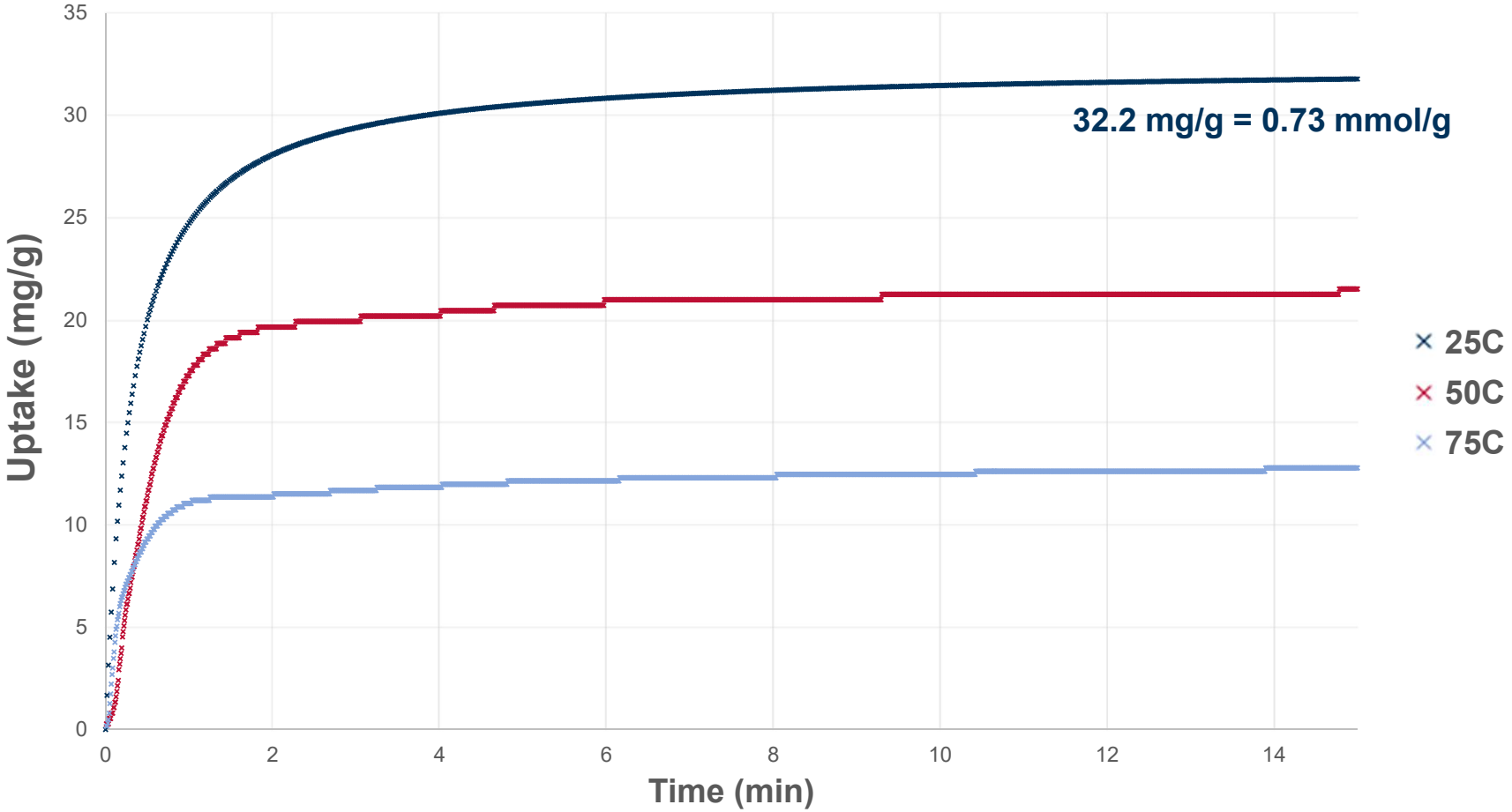


- BET Surface Area = 2.6 m^2/g
- t-Plot Micropore Area = 1.6 m^2/g
- Avg. Pore Size = 21.56 nm
- BJH Pore Volume = 0.01 cm^3/g

Equilibrium and Kinetic Studies – BA-63

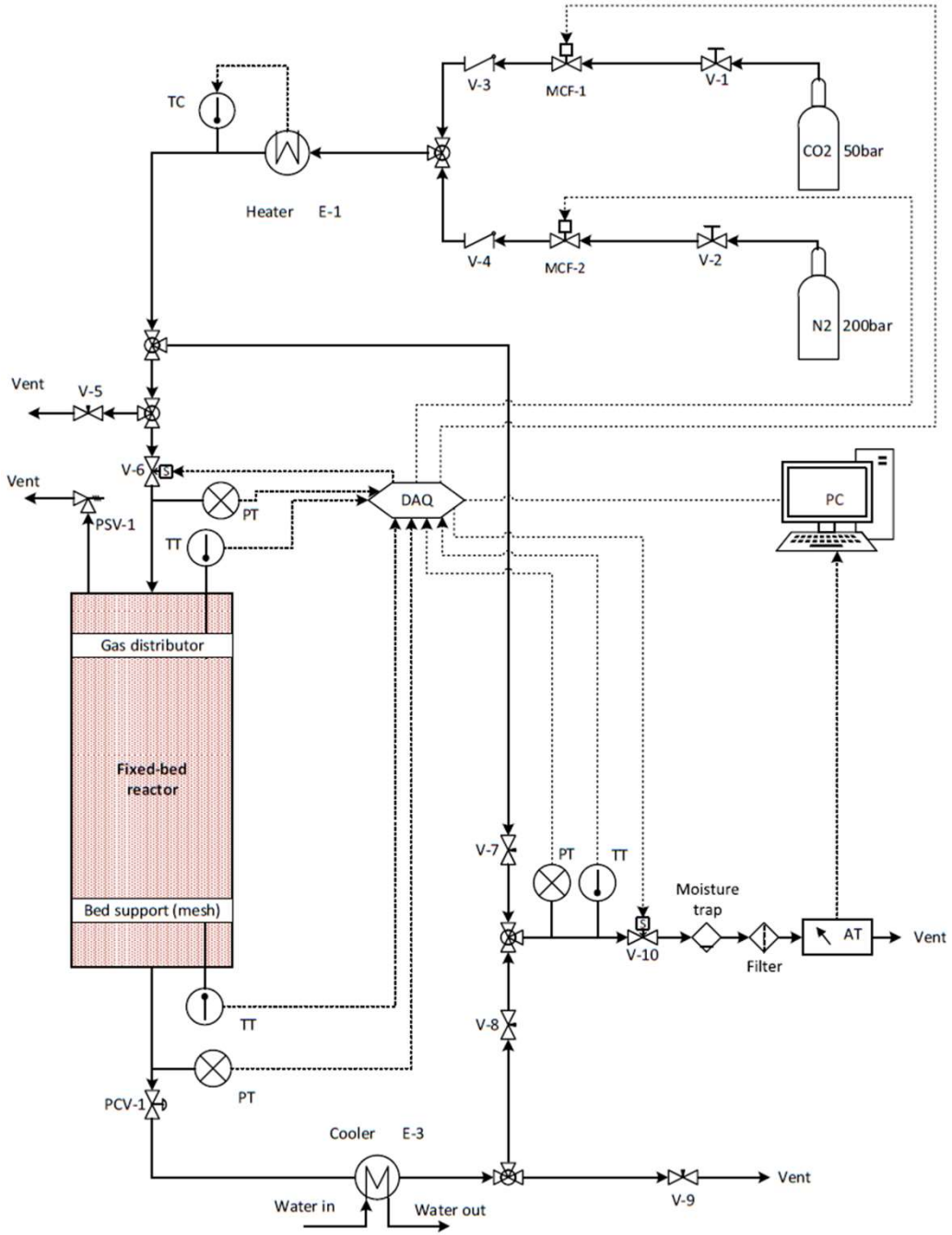
Effect of Temperature

The adsorption kinetics follow the Pseudo-Second order with $R^2 > 0.999$

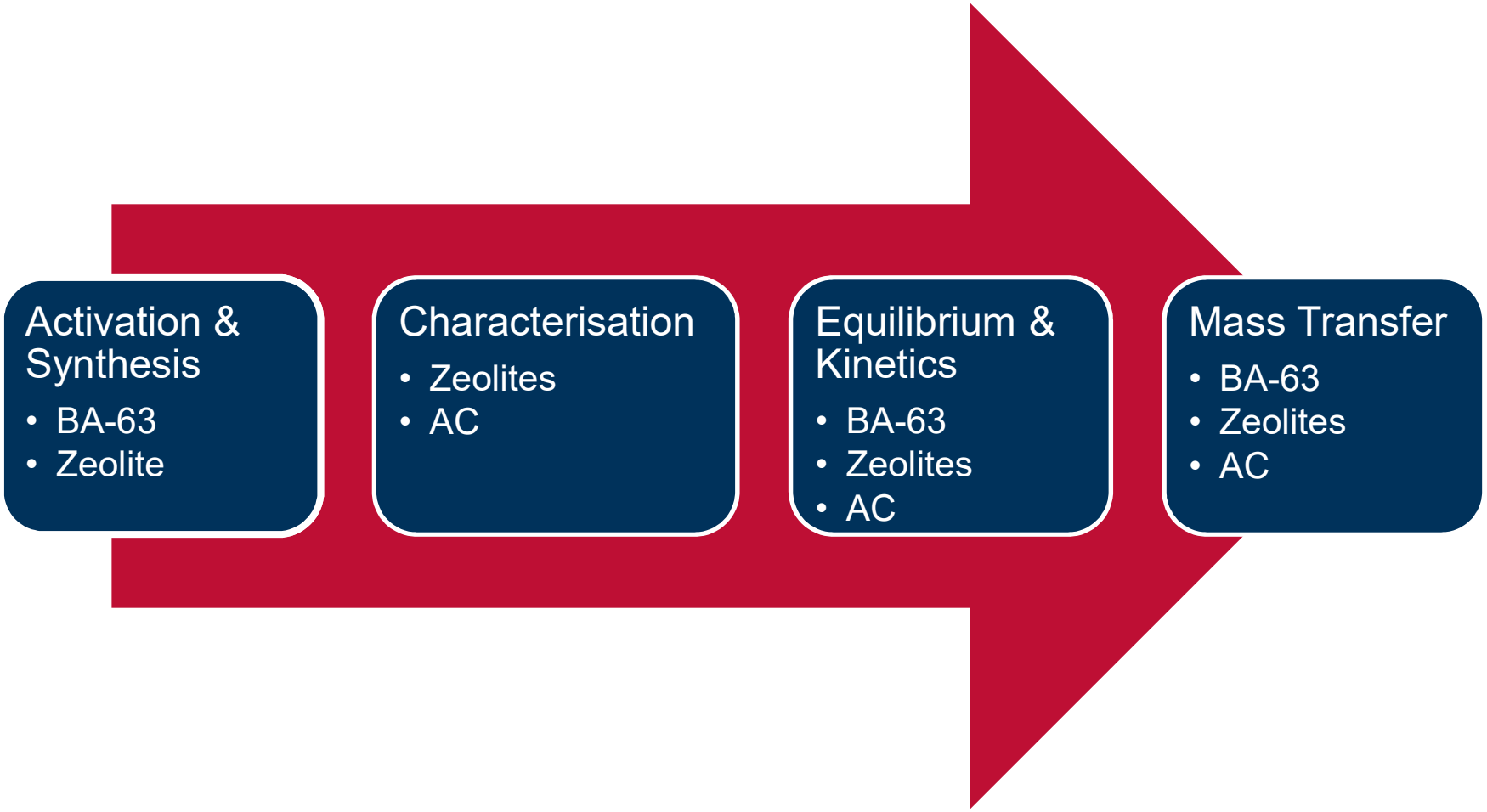


P = 1 atm; $C_{(CO_2)}$ = 100%

The Adsorption and Desorption Fixed-bed Reactor



Future Work

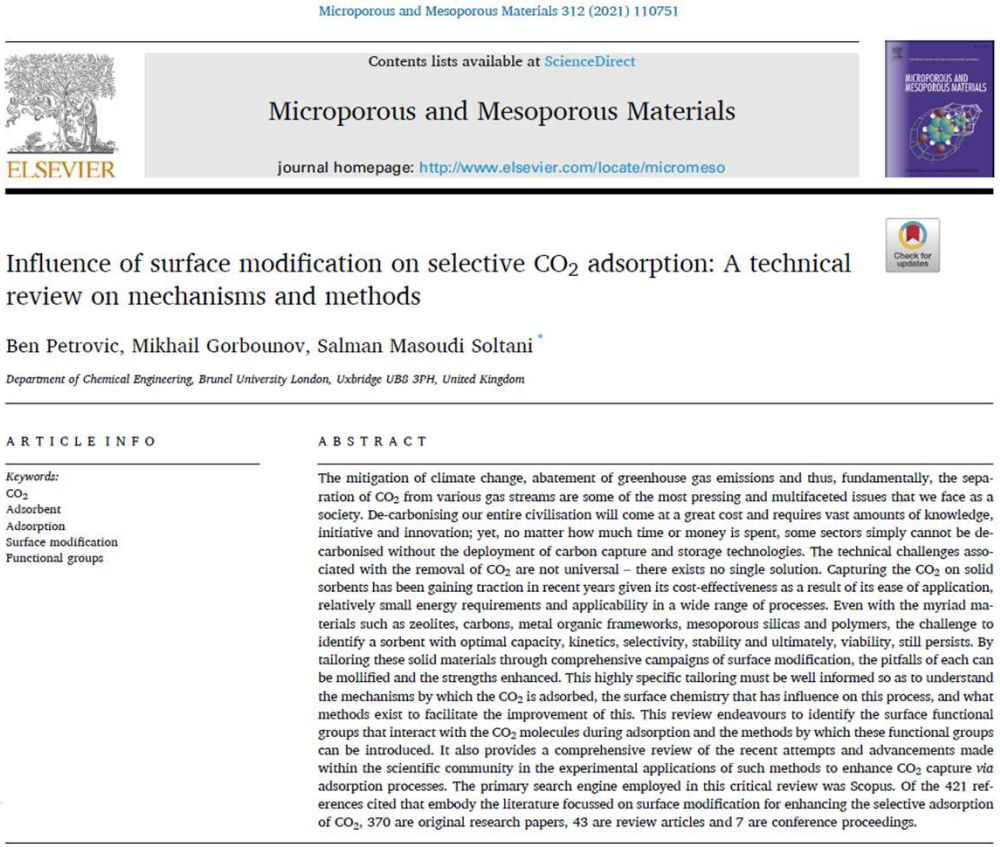

Activation & Synthesis
• BA-63
• Zeolite
Characterisation
• Zeolites
• AC
Equilibrium & Kinetics
• BA-63
• Zeolites
• AC
Mass Transfer
• BA-63
• Zeolites
• AC

Papers Published

25 February 2021

Petrovic, B.A.; Gorbounov, M.; Masoudi Soltani, S.

- Influence of Surface Modification on selective CO_2 Adsorption : A Technical Review on Mechanisms and Methods.
  - > Published in '**Microporous and Mesoporous Materials**' journal in 2021.
  - > Available online; **DOI: 10.1016/j.micromeso.2020.110751**


Microporous and Mesoporous Materials 312 (2021) 110751
Contents lists available at ScienceDirect
Microporous and Mesoporous Materials
journal homepage: http://www.elsevier.com/locate/micromeso

Influence of surface modification on selective CO_2 adsorption: A technical review on mechanisms and methods

Ben Petrovic, Mikhail Gorbounov, Salman Masoudi Soltani *

Department of Chemical Engineering, Brunel University London, Uxbridge UB8 3PH, United Kingdom

ARTICLE INFO

Keywords:
CO_2
Adsorbent
Adsorption
Surface modification
Functional groups

ABSTRACT

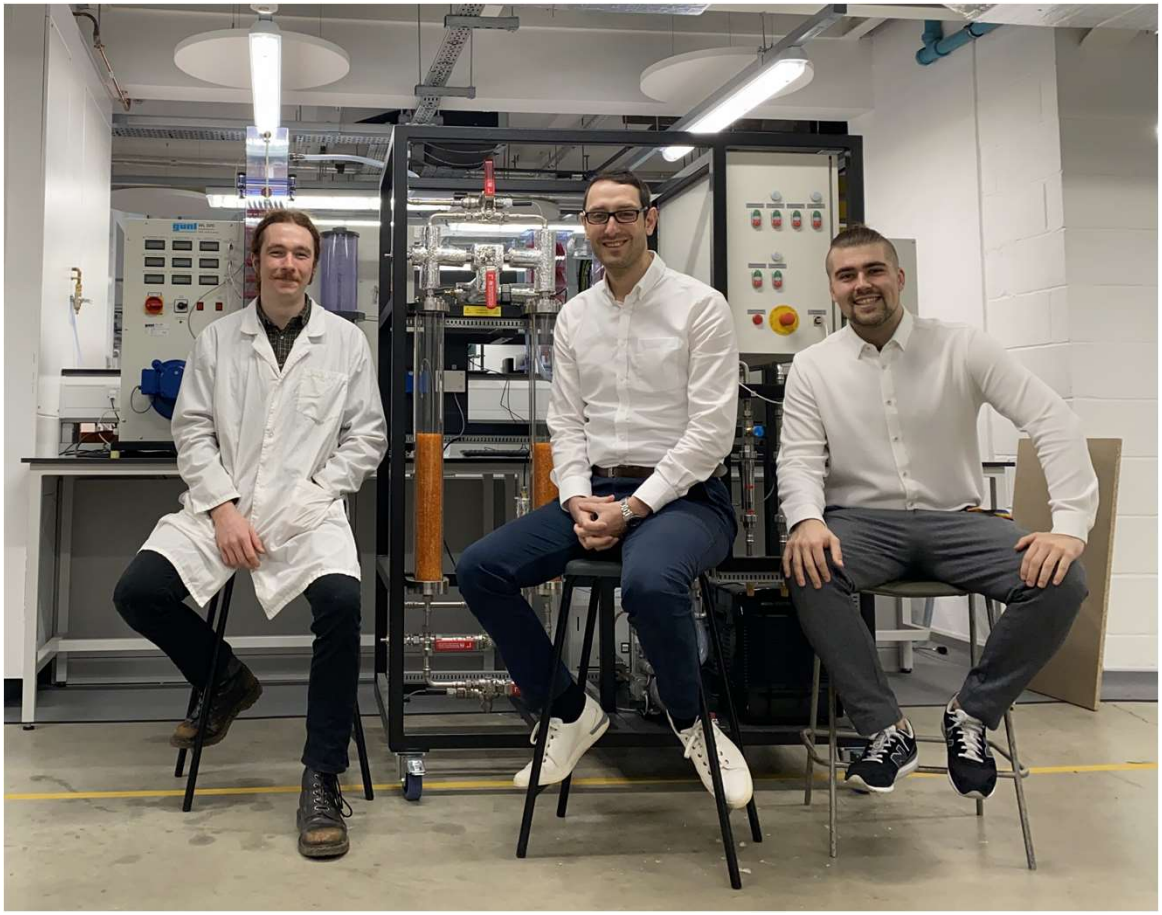
The mitigation of climate change, abatement of greenhouse gas emissions and thus, fundamentally, the separation of CO_2 from various gas streams are some of the most pressing and multifaceted issues that we face as a society. De-carbonising our entire civilisation will come at a great cost and requires vast amounts of knowledge, initiative and innovation; yet, no matter how much time or money is spent, some sectors simply cannot be de-carbonised without the deployment of carbon capture and storage technologies. The technical challenges associated with the removal of CO_2 are not universal – there exists no single solution. Capturing the CO_2 on solid sorbents has been gaining traction in recent years given its cost-effectiveness as a result of its ease of application, relatively small energy requirements and applicability in a wide range of processes. Even with the myriad materials such as zeolites, carbons, metal organic frameworks, mesoporous silicas and polymers, the challenge to identify a sorbent with optimal capacity, kinetics, selectivity, stability and ultimately, viability, still persists. By tailoring these solid materials through comprehensive campaigns of surface modification, the pitfalls of each can be mollified and the strengths enhanced. This highly specific tailoring must be well informed so as to understand the mechanisms by which the CO_2 is adsorbed, the surface chemistry that has influence on this process, and what methods exist to facilitate the improvement of this. This review endeavours to identify the surface functional groups that interact with the CO_2 molecules during adsorption and the methods by which these functional groups can be introduced. It also provides a comprehensive review of the recent attempts and advancements made within the scientific community in the experimental applications of such methods to enhance CO_2 capture *via* adsorption processes. The primary search engine employed in this critical review was Scopus. Of the 421 references cited that embody the literature focussed on surface modification for enhancing the selective adsorption of CO_2, 370 are original research papers, 43 are review articles and 7 are conference proceedings.

Acknowledgements

This work has been funded by the UK Carbon Capture and Storage Research Centre (EP/P026214/1) through the flexible funded research programme “Biomass Combustion Ash in Carbon Capture”. The UKCCSRC is supported by the Engineering and Physical Sciences Research Council (EPSRC), UK, as part of the UKRI Energy Programme. The authors are grateful to the Research Centre for providing this funding.

Thank you!

Q&A



E: salman.masoudisoltani@brunel.ac.uk
T: +44 (0)1895 265884