Conference or Workshop Item:

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Synthesis of selective CO_2 sorbents for post-combustion capture: The key role of the intrinsic basicity originated from oak wood

A. Salituro *[1], A. Westwood [1], A. Ross [2] and R. Brydson[1]

*Presenting author's email: pmasal@leeds.ac.uk

[1] *Institute for Materials Research; School of Chemical and Process Engineering, University of Leeds, Leeds, LS2 9JT, UK*
[2] *Energy Research Institute; School of Chemical and Process Engineering, University of Leeds, Leeds, LS2 9JT, UK*

Abstract

Selective CO_2 sorbents were successfully synthesized through the physical (CO_2) activation of oak wood-based chars. Raw material was previously carbonized either by pyrolysis at 800 °C and by hydrothermal synthesis (HTC) at 250 °C. A more dramatic development of texture was attained for the hydrothermally carbonized biomass, therefore promoting HTC as a cost-effective route for the preparation of porous activated carbons (ACs). ACs thus synthesized along with a commercial carbon included for comparison purposes were tested for CO_2 capture by using a thermogravimetric analyser (TGA). Under pure CO_2 and 35 °C, although having much lower surface areas (highest S_{BET} = 627 m^2/g), oak wood-derived carbons exhibited uptakes as large as those achieved by the commercial AC (S_{BET} = 1231 m^2/g). This finding was attributed to the comparable ultramicropore volume (d<0.7 nm) measured for all the samples. This suggests that carbon dioxide is mostly adsorbed onto the narrowest pores. On the other hand, upon changing to post-combustion conditions (ca. 53 °C, 15 % CO_2/85 % N_2), oak wood-based sorbents exhibited similar (OW250PA) or even greater (OW800PA) sorption capacity than the commercial AC. The higher selectivity shown by oak wood derivatives was associated with their substantial amount of Ca-based inorganic fraction. This was revealed by EDX and was evidently related to the outstanding basicity measured by Boehm's titrations on the synthesized sorbents' surface (up to 93 %). Conversely, commercial AC is characterised by a far poorer inorganic content, thus showing lower basicity (ca. 67 %). Accordingly, it was proved that under post-combustion conditions the contribution of a more favoured (basic) surface chemistry outweighs the texture effect. Basic functionalities ensured stronger interactions with the carbon dioxide molecule, therefore implying a more selective sorption at lower gas concentration. Therefore, it was demonstrated how selective CO_2 sorbents could be prepared exploiting the advantageous properties of the raw biomass rather than applying expensive and environmentally unsustainable chemical treatments.

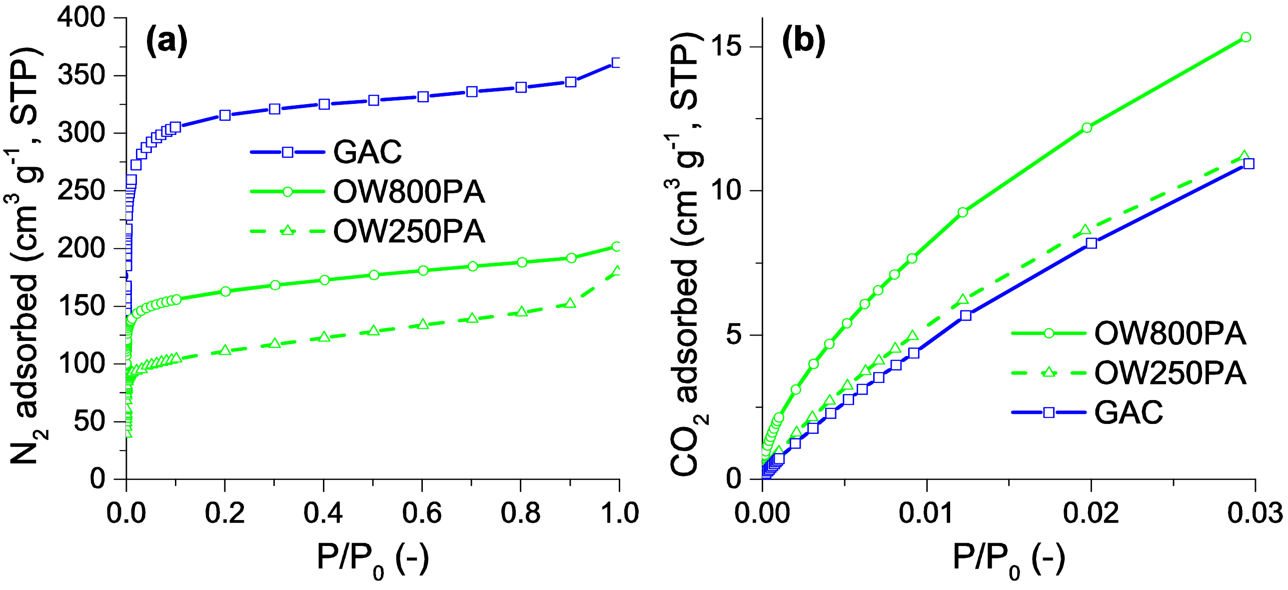

Figure 1. N_2 (a) and CO_2 (b) adsorption isotherms for oak wood-derived and commercial carbons

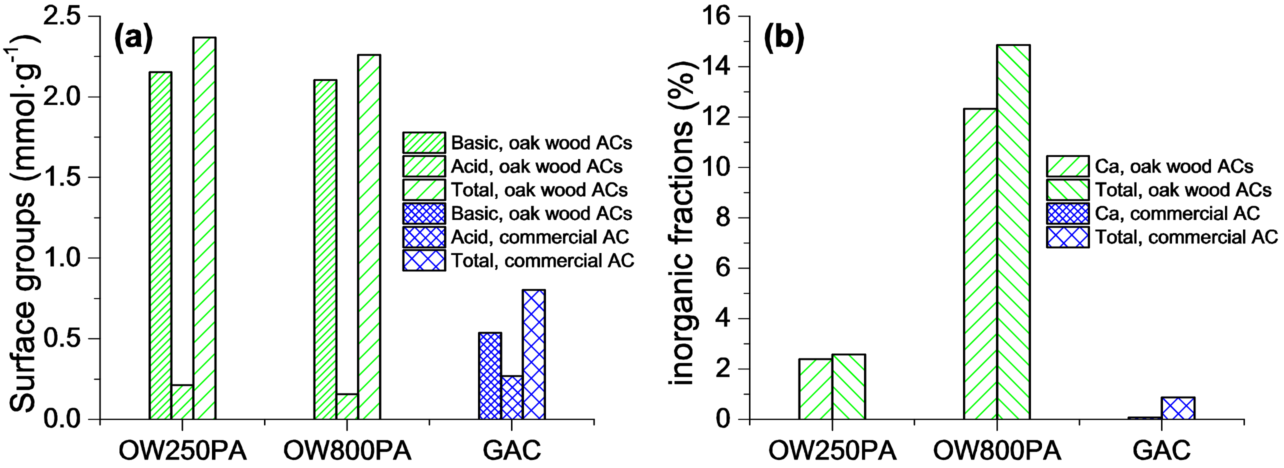

Figure 2. Surface groups number (a) and inorganic content (b) for oak wood-derived and commercial carbons

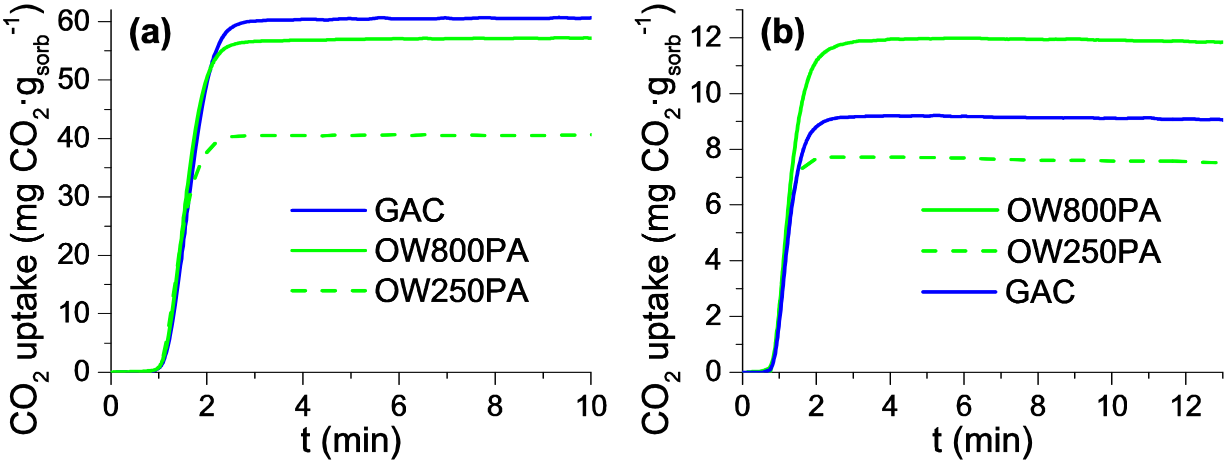

Figure 3. CO_2 uptakes measurements for oak wood-derived and commercial carbons: pure CO_2 and 35 °C (a), and 15% CO_2 and 53 °C (b)

	CO_2 uptakes, TGA		N_2 and CO_2 adsorption isotherms			Boehm's titrations		EDX	
Sample ID	Pure CO_2, 35 °C (mgCO_2/gs$_{orb}$)	15% CO_2, 53 °C (mgCO_2/g_{sorb})	S_{BET} (m^2/g)	V_{mi} (cm^3/g)	V_{umi} (cm^3/g)	Basic surface groups (mmol/g)	Basic/Total (%)	Ca (wt. %)	Total (wt.%)
GAC[1]	60.6	9.0	1231	0.474	0.026	0.54	67	0.08	0.88
OW800PA[2]	57.1	11.8	627	0.240	0.040	2.11	93	12.32	14.86
OW250PA[3]	40.6	7.2	415	0.173	0.028	2.15	91	2.39	2.58

Table 1. CO_2 Uptakes, textural parameters and basicity for oak wood-derived and commercial carbons

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[1] Commercial carbon.

[2] Oak wood, pyrolysed at 800 °C, physically activated.

[3] Oak wood, hydrothermally carbonized at 250 °C, physically activated.