

CARBONACEOUS COMBUSTION WASTE AS PRECURSOR FOR ACTIVATED CARBONS

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Introduction

The concentration of unburned carbon present in fly ash has risen drastically over the last years, resulting in increased combustion waste generated from utilities. This is due to the implementation of more stringent Clean Air Act Regulations, that is mainly addressed in coal combustion furnaces by installation of low-NO_x burners [1,2]. In 1997, around 5-8 million tonnes of unburned carbon were disposed, due to the present lack of efficient routes for its utilization. However, this carbonaceous material is a very attractive precursor for the production of activated carbons, since it has gone through a devolatilization process while in the combustor, and therefore, only requires to be activated. However, no attempt to activate this carbonaceous waste has been conducted thus far. Accordingly, this work addresses the potential use of unburned carbon from coal combustion as precursor for the production of adsorbent carbons.

Experimental

Two unburned carbon samples (UC-A and UC-B), obtained from different U.S. power plants, were investigated. The activation was carried out using steam at 850°C for periods of 60 minutes, as previously described [3]. N₂ adsorption isotherms at 77K were conducted using a Quantachrome adsorption apparatus Autosorb-1.

Results and Discussion

Figure 1 shows the N₂-77K adsorption isotherms for both UC samples and illustrates the inherent porosity of these materials. Both adsorption isotherms are Type II according to the BDDT classification and they are typical for nonporous or macroporous adsorbents, on which unrestricted monolayer-multilayer adsorption can occur. The extensive and rapid devolatilization that coal undergoes in the combustor, seems to promote the generation of meso- and macropores. Table 1 lists the BET surface areas (SA) and total pore volume (V_{TOT}) for the precursors. Both UC samples have surface areas ~ 40 m²/g, that are due to the generation of macro- and mesopores by the combustion process.

The solid yields of the UC samples activated for 60 minutes are also listed in Table 1. Despite the low particle

size of the UC samples, the solid yields are relatively high, since the UC has already gone through a devolatilization process in the combustor. This makes the UC an attractive precursor for the production of activated carbons, since they present much higher solid yields than conventional precursors, such as wood. UC-A presents higher solid yield than UC-B (73% vs. 55%), due to its larger particle size (200 μm vs. 45 μm). Previous studies have shown that the particle size of the precursor strongly affects the solid yields of the resultant activated samples, with higher yields for bigger particle size fractions [3].

Figure 2 shows the N₂-77K adsorption isotherms for the steam activated UC samples. Both isotherms are Type I, with the typical concave shape to the P/P₀ axis. However, the isotherms do not reach a plateau at high relative pressures. Figure 3 compares the meso- and micropore volume for the precursors and the activated samples. As previously described, the inherent porosity of the UC samples is highly mesoporous, with the mesopore volume accounting for ~ 66% of the total pore volume. The activation process promotes the development of micropores, with the micropore volume now accounting for over 60% of the total. Pore size distribution studies and CO₂ porosity measurements will be reported.

Conclusions

The work reported here has demonstrated for the first time the ability of unburned carbon from coal combustion waste to generate activated carbons by steam activation. The activation of the UC can tailor the inherent mesoporosity of these materials into the desired porosity for a specific application.

References

1. Maroto-Valer MM, Taulbee DN and Hower JC. Prepr. Am. Chem. Soc. Fuel Division 1997, 43(4): 1014-1018.
2. Maroto-Valer MM, Taulbee DN and Hower JC. Energy & Fuels 1999, In Press.
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Acknowledgments

The authors wish to thank the Research Council of the Basque Government for support.

Table 1. Solid yield, BET surface area and total pore volume for the unburned carbon samples and their activated counterparts¹.

Sample	Activation time / min	Solid yield / % weight	BET S.A. / m ² /g	V _{total} / cc/g
UC-A	--	--	40	0.03
UC-B	--	--	38	0.03
UC-A-60	60	73	332	0.15
UC-B-60	60	55	443	0.14

¹ The solid yields and surface areas are expressed in ash free basis.

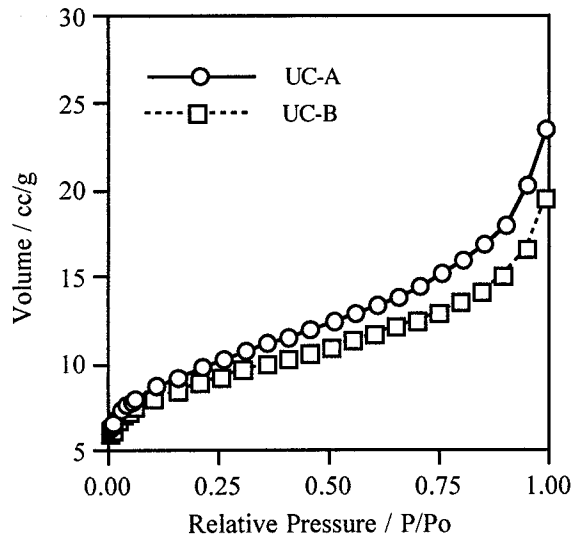


Figure 1. N₂-77K adsorption isotherms for the UC samples.

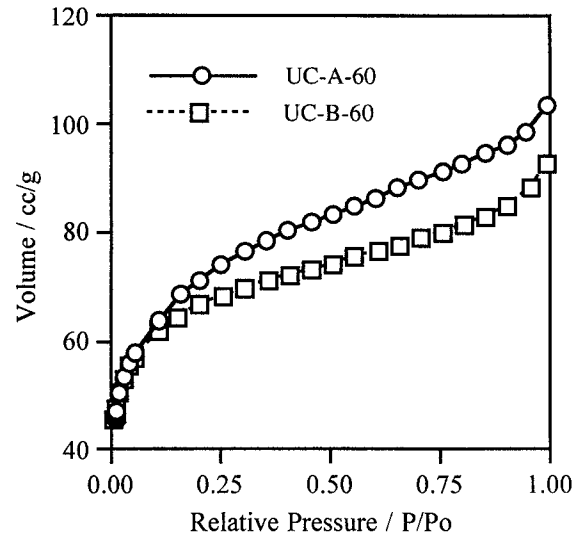


Figure 2. N₂-77K adsorption isotherms for the activated samples.

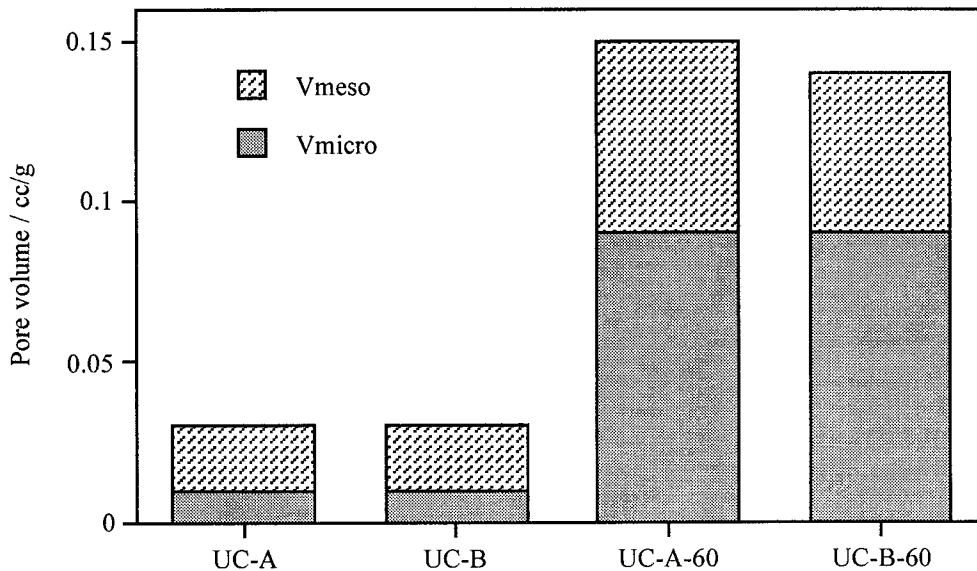


Figure 3. Distribution of the micro- and mesopore volume of the UC and their activated samples.