



Development of Fly Ash Derived Sorbents to Capture CO₂ from Flue Gas of Power Plants

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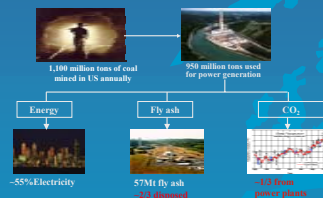
1. INTRODUCTION

Anthropogenic emissions have increased the CO₂ concentration on the atmosphere with over 30% compared to preindustrial levels. There is a general agreement in the scientific community that doubling the CO₂ emissions will have a serious detrimental effect on the environment.

Most of these anthropogenic emissions are caused by fossil fuel utilization.

Fossil fuels have been the main energy supplier in the US for over a century.

Carbon capture technologies must be developed to achieve zero emissions from fossil fired power plants.

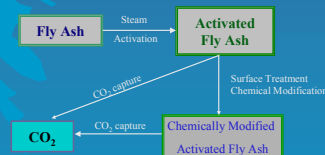


Current chemical absorption technologies are very energy intensive. Physical and chemical adsorption processes for CO₂ capture using high-surface area solids have also been proposed. However, the sorbents used thus far are very expensive and hinder the economical viability of the process.

Therefore, there is a need to find cost-effective precursors that can compete with expensive commercial sorbents.

Activated fly ash carbon, which is a byproduct of coal combustion, is a low-cost sorbent that can be used for CO₂ capture.

2. EXPERIMENTAL DESIGN



3. RESULTS AND DISCUSSION

3.1 Porosity of fly ash carbon samples prior to activation

Table 1. Porosity of the fly ash carbon samples prior to activation.

Sample	BET Surface Area m ² /g	Pore Volume ml/g	Average Pore Size/nm
WE	48	0.04	3.33
PO	51	0.046	3.60
SH	39	0.036	3.76
FA1	123	0.077	2.43
CFA	13	0.019	4.31
FB	733	0.708	3.87

- The fly ash carbon samples collected from different combustors and gasifier units have already generated some porosity while in the combustor or gasifier prior to the activation process.
- The studied fly ash carbon samples present different surface areas and porosity, probably due to the different combustion/gasification conditions, and the parent coal used.

3.2 Porosity of the activated fly ash carbon samples from one-step activation process

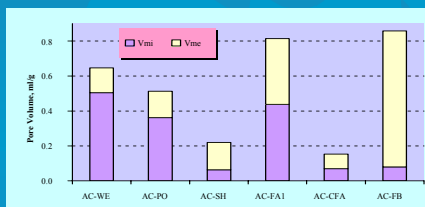


Figure 1. Pore volume distribution of activated fly ash carbon

- For all the studied samples, one-step activation can successfully increase the surface area and pore volume compared to their counterparts prior to activation. In contrast, conventional activated carbons need a two-step process that involves devolatilization and activation.
- The activated fly ash carbon samples present micropores (<2nm, Vmi), but they are also rich in mesopores (2-50nm, Vme).

3.3 Effect of pretreatment conditions on the porosity of activated fly ash carbons

Table 2. Porosity of the activated fly ash carbon samples after pretreatment.

Sample	Pretreatment Time, hr	S _{BET} , m ² /g	V _{me} , ml/g	D _{av} , nm
FA1-851B	0	646	0.460	2.85
FA1-LP1-831	1	1130	0.613	2.16
FA1-LP2-831	3	1131	0.666	2.36
FA1-LP3-851	5	969	0.558	2.30

- The surface area and pore volume of the resultant activated carbons generally increase with the activation/treatment time.
- Additionally, the average pore size (D_{av}) can also be tailored during the activation process.
- Therefore, it is possible to tailor fly ash carbons into activated carbons with different properties (surface area and pore diameter) during the activation process.

3.4 Comparison of fly ash derived sorbents with commercial activated carbons.

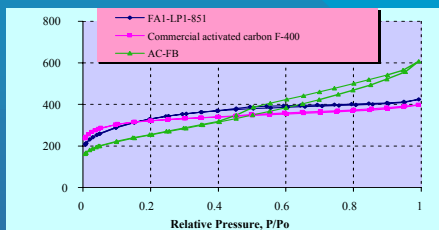


Figure 2. Isotherms of activated fly ash carbons and commercial activated carbon

- The activated carbons produced from fly ash carbon samples present similar adsorption isotherms to that of a commercial activated carbon.
- Therefore, the activated carbons produced from fly ash samples could have potential applications in CO₂ capture.

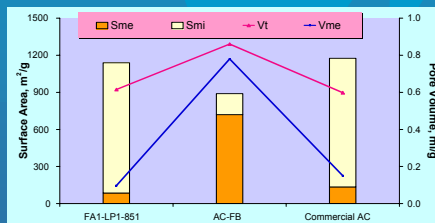


Figure 3. Porosity of activated fly ash carbons and commercial activated carbon. AC-FA1: Activated carbon from a fly ash sample collected from a pulverized coal combustor. AC-FB: Activated carbon from a fly ash sample collected from a gasifier.

- Activated carbons from pretreated fly ash samples can have surface areas comparable to commercial activated carbons.
- Molasses removal efficiency for the activated carbon from fly ash is higher than that of commercial activated carbons, indicating that they have excellent mass transport structures that will allow for rapid adsorption in applications like CO₂ capture.

4. CONCLUDING REMARKS

- The extensive and rapid devolatilization that coal undergoes in the combustor and gasifier seems to promote the generation of meso- and macropores in fly ash samples.
- One-step activation can increase the surface area of the produced activated carbon from fly ash, where the produced activated carbons are not only rich in micropores, but they also present a high content of mesopores.
- All the different pretreatment conditions studied promote the porosity of resultant activated carbons, where the surface area increases ~50-76%, and also promote the development of microporosity.
- Activated carbons from pretreated fly ash samples can have surface areas as high as 1,139m²/g (including micropore 1,053m²/g), that are comparable to 1,176m²/g (including micropore 1,041m²/g) for commercial activated carbons.
- The fly ash derived sorbents have similar porosity to commercial activated carbons for CO₂ capture.

5. ACKNOWLEDGEMENTS

The authors wish to thank CBRC (Combustion Byproducts Recycling Consortium) for supporting this work.