A FEASIBILITY STUDY ON UTILITY OF UNBURNED CARBON IN WASTEWATER TREATMENT

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Abstract

Coal combustion by-products (CCPs) contains a certain amount of unburned carbon partcles (~4% to ~30%) without utility way. For utility of unburned carbon, this study tried to make unburned carbon be adsorbent in wastewater treatment. A activation treatment with high temperature had proceed on unburned carbon sample, and effects on adsorptive capability were appeared with results such as the adsorbed amount of iodine, and dyeing solution of methylene blue. Result shows unburned carbon demonstrated a larger adsorptive capability after applicable treatment; the product can reach a iodine number more than 1000mg/g at a initial amount about 100mg/g, and an adsorbed amount of methylene blue solution (1200ppm) more than 100ml/g at a initial amount about 4ml/g. Conclusively, it is feasible to utilize unburned carbon as adsorbent in wastewater treatment.

Keywords: Activation, Adsorption, Carbon precursor

Introduction

Coal combustion by-products (CCPs) contain up to 70% amount of oxides compounds and a certain amount, roughly about 4% to 30%, of unburned carbon particles. Since its oxides with property of portland cement were found, CCPs were generally used as cement additive in construction. However, the unburned carbon in it causes a harmful effect on cement's solidification. To make CCPs more acceptable in cement utility, commercial carbon separating technologies, such as froth flotation, static electric separation, and etc[E. Tondu 1996], have been proposed to extract the unburned carbon from CCPs; which remains quantity amount of unburned carbon without utility. For utility of unburned carbon, this study is one in serials [M.M. Mercedes Maroto-Valer 2001][Ya-Min Hsieh 2003] which focuses on the feasibility of making unburned carbon as adsorbent in wastewater treatment. An activation treatment with temperature of 850ºC and under steam atmosphere had proceeded on unburned carbon particulars [Ya-Min Hsieh 2004], and the effects on adsorptive capability were appeared with results from tests of iodine number and methylene blue adsorptive capacity. A feasibility of making unburned carbon as adsorbent is then concluded.

Experiments

Sample Examination

Content analyses of water, volatile matter, ash, and fixed carbon were conducted according to the JWWAK113-1985. A Shimadzu Sald-2001 laser diffraction particle size analyzer was employed to measure mean particle diameter; a Micrometeritics Surface Area Analyzer 2200 was used for analysis of the BET specific surface area. Moreover, the analysis of iodine number was according to JWWAK113-1985 method. The analysis of methylene blue adsorptive capacity was conducted according to the "liquid phase adsorptive isotherm acquisition method" of item 5.1 in the JISK1474-1991 activated carbon experiment method, in which a methylene blue solution of 1200ppm was used as adsorbate. A UV/VIS Spectrophotometer was utilized to determine the solution concentration, and the adsorption amounts at various equilibrium concentrations were obtained. The obtained adsorption amount versus equilibrium conc. was plotted as an adsorptive isotherm line at a logarithmic paper, where the methylene blue adsorptive capacity was read at the adsorption amount 0.24ppm.

Activation Experiment

A Lindberg Blue M tube furnace, with a quartz tube at a diameter of 10cm, was set up for the activation experiment, shown as Figure 1. Approximately 50g (±0.1g) of raw material of unburned carbon particles sample was weighed out and placed into a boat-shaped quartz crucible; the crucible was pushed into the preheating zone, where the temperature was about 250°C. After preheating for 1 minute, the crucible was pushed ahead into the reacting zone, which had already reached targeted temperature, 850°C. Simultaneously, the carrier gas, nitrogen gas, was induced into the tube at 220ml/min (at Room Temperature) to import steam to reaction zone, and after the residence time (0~3.5hr), the crucible was moved back to the cooling zone to lower down temperature for 5 minutes. After that, the crucible was removed from the tube, cooled to room temperature in the air, and then the activated matter in crucible was obtained. After the deashed treatment in HF solution, activated product preparation was completed.

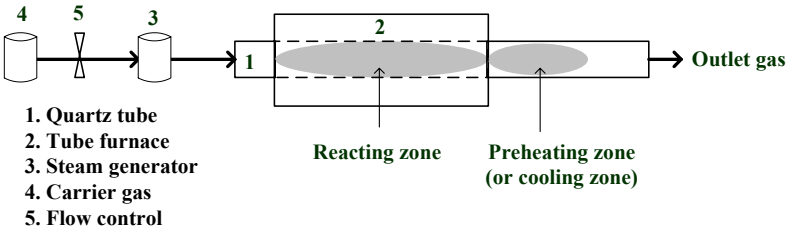

Figure 1. Experimental apparatus in actiovation

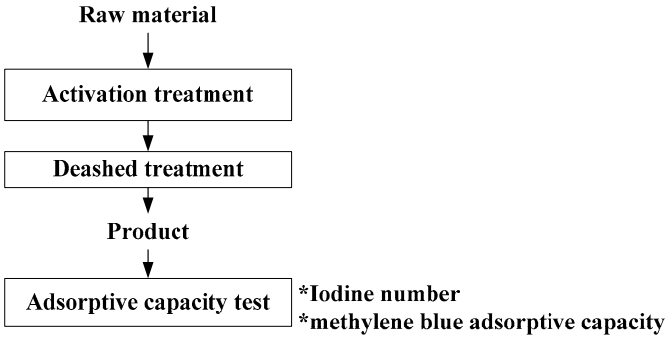

Fig. 2 Experimental flow

Result and discussions

Sample Property

Sample in this study is gathered from over float product of a CCPs froth flotation plant in southern Taiwan. It is consisted of fine particles at a mean particle size about 10μm and most of the sample size distributed in 71μm. As shown at Table 1, except the great part of water, it contains fixed carbon about 56%, ash about 38%, and some minor volatile content. Its ash is mostly composed of silica, alumina or their complex; those were considered stable before and after activation experiment.

Table 1. Assay of unburned carbon particles from froth flotation plant of CCPs

	Assay (%)
Water content	44
Dry residual	56
Fixed carbon	56.8
Ash	38.0
Volatile matter	5.1

Activation yield

Table 2 shows activation results. As activation duration increases, yield decreases meanwhile the specific surface area of product increases. The yield decreases because of the carbon oxidize with steam and causes the weight lost. For determining prior activation duration, a factor of enhanced value in whole surface area against to raw material is calculated and also listed in Table 2. Factors of all products are larger than 1; which means activation is a significant treatment to enlarge sample's whole surface area as well as capacity for accepting adsorbates. The prior factor is about ~5.4 at duration of 1.5hr, while a yield is about 54% and a specific surface area about 432m^2/g.

Table 2. Activation results: yield and factor of enhanced value in whole surface area

Activation Duration (hr)	Yield (%)	Specific Surface area (m^2/g)	Factor of enhanced value in whole surface area *
Raw material	--	43	1.0
0.5	80.1	243	4.5
1	66.9	335	5.2
1.5	54.0	432	5.4
2	41.9	483	4.7
2.5	31.5	549	4.0
3	22.1	587	3.0

* Factor of enhance value in whole surface area = (Yield×Specific Surface area)÷(100%×43)

Adsorptive capacity of products

Two standard test methods of commercial adsorbents, methylene blue adsorptive capacity and iodine number, were proceed on activation products. Result in Fig.3 shows that the methylene blue adsorptive capacity and iodine number of product are both enhanced after activation. And, adsorptive capacities of products are considered in dependence on their specific surface areas. While the product with specific surface area up to 500m^2/g, its iodine number becomes more than 1000mg/g from the initial ~100mg/g, as well as its methylene blue adsorptive capacity becomes 90ml/g from less than 10ml/g. In comparison with commercial adsorbents, products in this study belong among higher performance adsorbents such as active carbons which generally possess iodine number up to 1000mg/g and methylene blue adsorptive capacity up to 100ml/g.

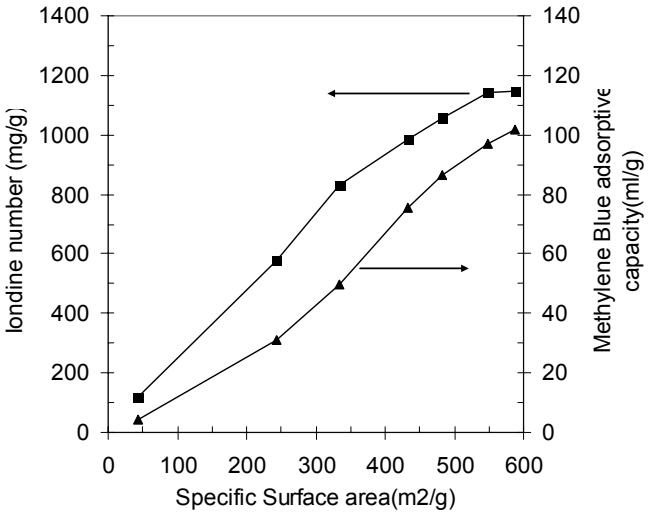

Fig. 3 Adsorptive capacity of products.

Conclusions

According to results, unburned carbon is a feasible material to make high performance adsorbents in wastewater treatment after appropriate activation process. The product can reach a specific surface area up to 500m^2/g, its iodine number becomes more than 1000mg/g from ~100mg/g, and its methylene blue adsorptive capacity becomes 90ml/g from ~10ml/g.

Acknowledgement

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