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Removal of Unburned Carbon from Municipal Solid Waste Fly Ash by Column Flotation

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1. Introduction

Municipal Solid Waste(MSW) fly ash has recently attracted much attention because of its large quantity and enrichment of heavy metals with low boiling point and trace organic contaminants such as dioxin. Unburned carbon (UC) is one of the residues of burned MSW. Although it takes a low content in the fly ashes, it contained large amounts of organic contaminants. The quantity of organic contaminants increases with the increase of UC in the fly ash[1]. Therefore, most parts of the organic contaminants such as dioxin can be effectively removed by the removal of UC from fly ash.

Column flotation is a technique making use of surface properties, surface energy and surface excess to separate different materials. This technique has been widely used for separations of various types of mineral and coal cleaning[2]. In this paper, we report our works on using column flotation technique to remove the UC from MSW fly ash.

2. Experimental Method

Two kinds of fly ash: fly ash A (with adding activated carbon), fly ash B (without adding activated carbon) were sampled from electrostatic precipitators (ESP) in stoker type MSW incinerators. The concentration of UC and metal ions were measured by total organic carbon meter (TOC-5000A/SSM-5000A: Shimadzu) and ICP-AES (ICP-8000: Shimadzu) respectively, see table 1. Their UC contents were measured as 6.3% and 5.1% respectively.

Table 1 Chemical analysis of fly ash (w%)

	UC	Na	Mg	Al	K	Ca	Ti	Cr	Mn	Fe	Co	Ni	Cu	Zn	Se	Mo	Cd	Sb	Hg	Pb
Fly ash A	6.3	5.32	0.68	6.42	4.17	4.78	1.11	0.01	0.13	1.3	0	0	0.13	1.81	0.02	0	0.02	0.11	0.03	0.07
Fly ash B	5.11	6.37	0.6	7.45	4.87	4.81	1.23	0.01	0.13	1.76	0	0	0.17	2.13	0.02	0	0.02	0.1	0.05	0.09

The fly ash sample (10g) was mixed with 750 ml distilled water and collector kerosene for 10 minutes by jar-tester. The pH value of the slurry was adjusted by using HCl or NaOH solutions.

The structure of the flotation column is schematically drawn in Fig 1. The slurry was fed into the column from the upside after starting the air compressor.

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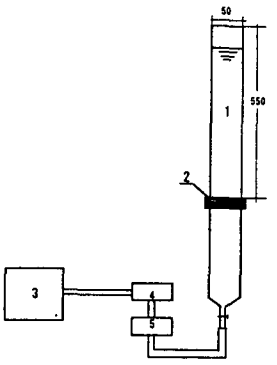
Methyl iso-butylcarbinol (MIBC) was added as the frother. The compressed air with the pressure of 0.7kgf/cm^2 was passed through the porous plate and sheared into small bubbles. The flotation time was 30 mins. Hydrophobic particles attached to the air bubbles were transported to the upside of the column, and formed a froth phase. The froth and residue were collected and dried at 105℃ for 24 hours before TOC measurement.



Figl Schematic diagram of the flotation column

1 column
2 gas distributer (porous plate)
3 air compressor
4 mass flow controller
5 mass flow meter

3. Results and Discussion

In order to systematically study the feasibility to use column flotation technique to remove UC, four column flotation parameters i.e.: volumetric gas flow rate, pH value, collector kerosene dosage and the kinds of fly ash were chosen and their influence on the UC recovery efficiency were shown in Fig.2.

Fig.2(a) represents the influence of the volumetric gas flow rate (VJ_g) on the UC recovery efficiency. It shows that the recovery efficiency increases with the increase of VJ_g in the regime of VJ_g < 0.7 L/min. Above this value, the recovery efficiency decreases. In our experiments, a maximum UC recovery efficiency of 61.7% was achieved at the point of VJ_g = 0.7 L/min, as shown in Fig.2(a). This can be understood by the following equation[3]:

$$R = R^*(1 - e^{-k_c t}) \qquad k_c = 1.5 J_g E_k d_b^{-1} \qquad (1)$$

Where R is the recovery efficiency of flotation, R^* is the ultimate recovery efficiency and k_c is the collection rate constant, J_g is the volumetric flow rate VJ_g per unit cross-section, E_k is the collection efficiency, and d_b is the bubble diameter. The UC recovery efficiency depends on the value of k_c. While the increase in J_g increases k_c, it increases the bubble diameter d_b and decreases the collection efficiency E_k which reduces k_c. Therefore with the two opposite influence of J_g on k_c, there will be an optimum gas flow rate J_g in flotation process.

The pH value of the slurry is a critical parameter in flotation. Adjusting the pH value can take reactions between the hydroxonium, hydroxyl ions provided by pH reagents and the functional groups on the surface of UC, which will change the zeta potential and the contact angles of the UC particles[2]. The influence of pH value on the UC recovery efficiency is shown in Fig.2(b). The maximum UC removal value of 61.7% was achieved at the pH value of 5.95.

Fig.2(c) illustrates the collector kerosene dosage's influence on the UC recovery efficiency. When the dosage was 4 ml/L, 57.5% of UC was removed. This

is attributed to the enhancement of kerosene to the hydrophobicity of the carbon particles by covering the surface of UC during flotation process.

The UC recovery efficiency of different kinds fly ash is shown in Fig 2(d). Among them, the UC recovery efficiency was highest in fly ash B whereas it was lowest in fly ash A screened by a sieve of 500 μ m. This is the reason that the UC particle size in fly ash B is much larger than that in fly ash A, and the porous plate set up in our column flotation equipment is more suitable for the removal of coarse carbon particles.

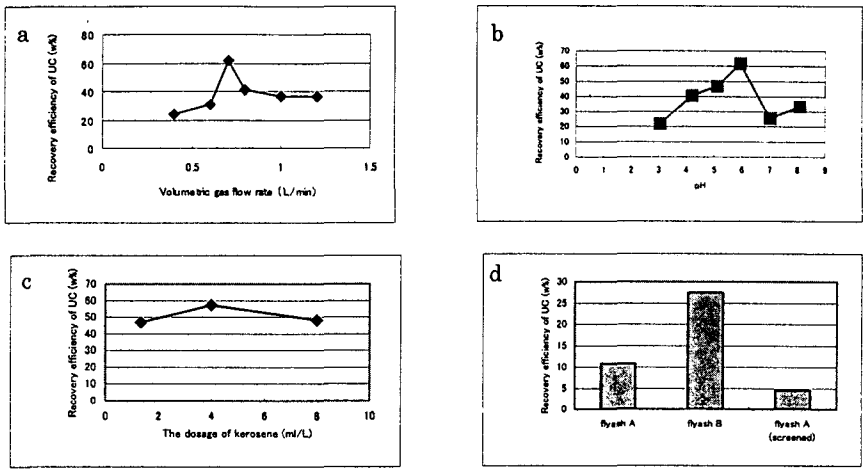


Fig 2. Influence of column flotation parameters on the recovery efficiency of UC:(a) gas flow rate (kerosene=4ml/L slurry, MIBC=0.8ml/L slurry, pH=5.8), (b) pH value (kerosene=4ml/L slurry, MIBC=0.8ml/L slurry, VJ =0.7L/min), (c) kerosene dosage (MIBC=0.8ml/L slurry, VJ =0.7L/min, pH=5.8), and (d) different kinds of fly ash (kerosen=4ml/L, MIBC=0.8ml/L slurry, VJ =0.7L/min, pH=5.8).

4. Conclusion

1. We firstly used column flotation technique to remove the UC from MSW fly ash. The UC recovery efficiency is influenced by the flotation parameters such as the volumetric gas flow rate, pH value, collector kerosene's dosage and the kinds of the fly ash.
2. By optimizing the flotation parameters with the values of collector kerosene dosage=4ml/L, MIBC dosage=0.8ml/L, gas flow rate=0.7L/min and pH=5.95, 61.7% UC has been successfully removed from the MSW fly ash with 5.1% UC content.

References

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