Effect of Copper and Zinc Impregnation on Thermal Stability of Activated Charcoal

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Summary: Effect of copper (Cu) and zinc (Zn) impregnation on the thermal stability of charcoal has been studied utilizing thermogravimetry (TG) and differential thermal analysis (DTA) techniques. The results indicate towards a decrease in thermal stability of charcoal upon impregnation. Energies of activation for decomposition of Cu and Zn impregnated charcoal calculated from TG are 17.4 kJ/ mole and 20.2 kJ/ mole respectively.

Introduction

Activated charcoal has microporous structure with high porosity and selective adsorption for ions [1]. Metal impregnation of charcoals results in modification of chemical properties [2] allowing utilization in various industrial applications. Activated charcoal has found wide spread applications as catalysts [3,4], catalyst supports [5] and as adsorbents [4-7].

This paper elaborates thermal properties of charcoal upon Cu and Zn impregnation by employing TG and DTA as analytical techniques.

Results and Discussion

Details of thermal analysis of activated charcoal used in the present studies have been reported in a previous publication [8]. The initial weight loss was due to adsorbed moisture. The decomposition of charcoal sample started at 415 °C. Energies of activation for dehydration and decomposition were reported as 62 and 43kJ/ mole respectively [8]. Figures 1 and 2 depict the TG and DTA curves for Cu and Zn impregnated charcoals respectively. Cu impregnated charcoal shows dehydration at 132 °C followed by decomposition starting at 290 °C with a total weight loss of 39 % at 1000 °C. Similarly, TG curve of Zn impregnated charcoal has dehydration commencing at 134.5 °C and decomposition at 298 °C. The total weight loss at 1000 °C was 40 %. Total weight loss in both samples is almost similar due to the fact that oxides of Cu and Zn decompose at temperatures beyond 1000 °C, as after decomposition of carbon, the residue left is in the form, of metal oxides.

DTA curve of activated charcoal showed a broad dehydration endotherm at 132.4 °C followed by exotherm at 510 °C and small endotherms at 661.5 °C and 810 °C [8]. Charcoal sample impregnated with
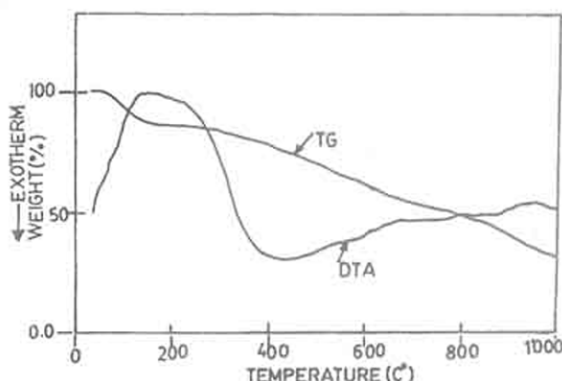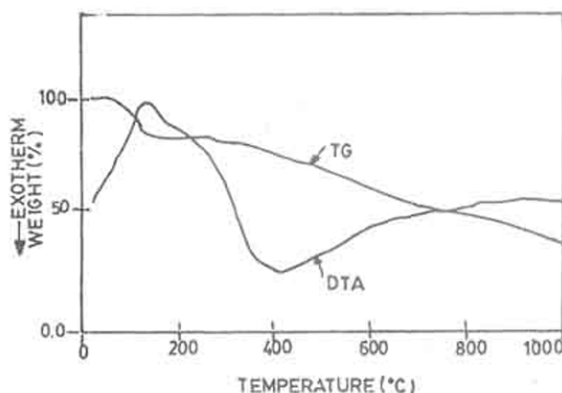

Fig. 1:

Fig. 2:

Cu (Figure 1) shows a broad endothermic peak due to dehydration with maximum at 145.4 °C proceeded by decomposition exotherm at 433 °C. Similarly, Zn impregnated charcoal (Figure 2) has endotherm and exotherm maxima at 134.5 °C and 419 °C respectively.

Results of TG and DTA are supported by the activation energies calculated for decomposition steps observed in TG. Energy of activation was calculated by Horowitz method [9]. Details of using this method for present studies have been explained in detail elsewhere [8]. Activation energies for dehydration and decomposition are presented in Table-1. These values supplement the previous discussion regarding the lowering of thermal stability of charcoal upon metal impregnation. Similar trends have been reported by McKee [10] during studies on catalytic thermal decomposition of pure graphite. This effect may be explained on the basis that mobile oxygen atoms formed on the metal surface migrate rapidly to metal-carbon interface creating gasification of carbon substrate in the vicinity of catalyst particles. Details of this generalized oxygen transfer mechanism have been elaborately explained by Walker et.al., [11] and Lewis [12].

Table-1 Activation energies values of metal impregnated charcoal

| Sample | Activation energy (kJ/mole) | |
	Dehydration	Decomposition
Pure charcoal [8]	62.0	43.0
Cu-charcoal	64.0	17.4
Zn-charcoal	61.0	20.2

Experimental

Doping of Charcoal

100 ml of 2 % w/v solutions of Cu and Zn nitrates (Panreac; Cat. Nos. 131267 and 121784) were used to soak pre-determined quantity of activated charcoal (BDH, Cat.No.33032) for 8h. The mixture was heated at 100 °C to slurry before drying in a vacuum oven for 1h. Blank sample of charcoal was given similar treatment with de-ionized water for comparison.

Metal content in impregnated charcoals was determined on a wavelength dispersive X-Ray Fluorescence Spectrometer, Model SRS200 manufactured by Siemens, Germany.

NETZSCH Simultaneous Thermal Analyzer, Model STA429 was utilized for recording TG and DTA curves. 40mg of each sample was heated at the rate of 20 °C/ min in air from ambient temperature to 1000 °C.

Conclusions

The present study reveals that the temperature for decomposition of activated charcoal is decreased upon impregnation of copper and zinc. This fact is supported by results of TG, DTA and values of energies of activation during decomposition determined from thermogravimetric results.

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