

# ACTIVATION OF AN ACTIVE CARBON BY IRREVERSIBLY ADSORBED CO<sub>2</sub> AND SO<sub>2</sub>

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## Introduction

The author has recently reported that the heats of adsorption of O<sub>2</sub> on an active carbon Chemviron BPL are substantially increased after treatment of the carbon by CO<sub>2</sub> (1). The treatment consisted of adsorption of CO<sub>2</sub> from the carrier followed by desorption by the same carrier at room temperature. The desorption was not complete leaving a small amount of CO<sub>2</sub> apparently irreversibly adsorbed on the carbon. These results appeared related to CO<sub>2</sub> adsorption irreversibly reported previously by M. Inagaki and N. Sunahara (2) for active carbons produced from phenolic resins.

A similar treatment of the carbon with SO<sub>2</sub> resulted in an increased affinity in the carbon for CO<sub>2</sub>.

This paper describes continuation of the heat of adsorption studies with the use of an online thermal conductivity detector (TCD) permitting simultaneous determination of the heats and of adsorption of various adsorptives from helium carrier gas.

## Experimental

The heats and amounts of adsorption were determined by Microscal Flow Adsorption Microcalorimeter (FAMC) described previously (1). The FAMC system included a Valco TCD producing linear response to concentration changes of the various gases adsorbed out of or desorbed with helium carrier. The amounts of the adsorptions and desorptions were measured at 22°C at constant He flow rates of 1 ml min<sup>-1</sup>.

Gases used in this work were supplied by Aldrich Chemical Co. and had a purity better than 99.9%. Active carbon used in the work was Chemviron BPL having a BET (N<sub>2</sub>) surface area of 1000 m<sup>2</sup>g<sup>-1</sup>. Approximately 0.07 g of the granulated carbon was accurately weighed and placed in the calorimeter cell. The carbon was purified by passing helium carrier through it at 1 ml/min for 4 hours at 180°C. The adsorption experiments were carried out at 22°C and

atmospheric pressure after overnight cooling of the FMC with He passing continuously through the carbon.

## Results and Discussion

A typical series of experiments is shown in Figure 1 recording heat effects for a series of adsorptions and desorptions of O<sub>2</sub> on the active carbon before and after contact with CO<sub>2</sub>. Table 1 lists the heats of adsorptions for CO<sub>2</sub> and SO<sub>2</sub>.

The molar heat of CO<sub>2</sub> adsorption is 91 kJ mol<sup>-1</sup> indicating that the initial carbon - CO<sub>2</sub> interaction is partly chemical in nature. This is supported by the amounts of CO<sub>2</sub> adsorbed and desorbed, the desorption being about 3 times greater than the adsorption. This can be partly explained by a reaction between carbon and CO<sub>2</sub> yielding gaseous products which augment the amount of gas that can be desorbed by He carrier. Details of the reaction are not known at present, but may involve production of CO and additional CO<sub>2</sub>. Additionally displacement by CO<sub>2</sub> of some gaseous compounds not displaced by He purge at 180°C is possible

Interaction of the carbon with O<sub>2</sub> adsorbed after the desorption of CO<sub>2</sub> gives a much higher heat effect than the similar adsorption on the carbon before the contact with CO<sub>2</sub>. The molar heats of adsorption are 90 kJ mol<sup>-1</sup> and 26 kJ mol<sup>-1</sup> respectively. The CO<sub>2</sub> - carbon interaction activates the surface towards the adsorption of O<sub>2</sub> and at the same time the interaction releases a small amount of gases detected by TCD. The activation effect is not evident in subsequent O<sub>2</sub> adsorption cycles which produce heats of adsorption very similar to those obtained during the adsorption cycles carried out before the contact with CO<sub>2</sub>.

A similar situation develops after an adsorption/desorption cycle of SO<sub>2</sub>. In this case the initial heat of adsorption is very much higher than that obtained during the subsequent adsorption cycles with second cycle yielding only 44% of the heat obtained during the first interaction as shown in Table 1.

Table 1

Heat effects produced during sequential  
Adsorption/Desorption of SO<sub>2</sub> and CO<sub>2</sub> from Helium  
on Active Carbon BPL at 25°C

No.	Gas Adsorbed or Desorbed	Time of Adsorption/Desorption, min	Heat of Adsorption J/g
1	SO <sub>2</sub>	48	389
2	He	50	-90
3	SO <sub>2</sub>	24	171
4	He	48	-126
5	CO <sub>2</sub>	104	202
6	He	8	-13
7	CO <sub>2</sub>	5	13
8	He	8	-12

Following the desorption of SO<sub>2</sub> in the second cycle, the adsorption of CO<sub>2</sub> from He becomes much more energetic, but the activating effect of the SO<sub>2</sub> treatment disappears in the subsequent CO<sub>2</sub> adsorption cycles. A similar increased heat of CO<sub>2</sub> adsorption is shown again however after the carbon is heated to 180°C in He for several hours.

## Conclusions

The surface of activated carbons can be rendered more reactive toward O<sub>2</sub> by treatment with CO<sub>2</sub>, and more reactive towards CO<sub>2</sub> by treatment with SO<sub>2</sub>. The adsorption of CO<sub>2</sub> on the activated carbon seems to displace gaseous products that are not desorbed with He even at 180°C. These effects are likely to affect the determination of specific surface area of active carbons from CO<sub>2</sub> adsorption data.

## References

1. Groszek, A.J., preprints of paper presented at 211th ACS Meeting, New Orleans, LA, 1996, 41, p. 317.
2. Inagaki I., and Sunahara N., COPS-IV, Abstracts, University of Bath, UK., 1996, p L24

Figure 1

### Adsorption and Desorption of Oxygen and Carbon Dioxide from Helium on Carbon BPL

