

EFFECT OF STEAM AND CARBON DIOXIDE ACTIVATION ON THE MICROSTRUCTURE OF ACTIVATED CARBON FABRICS

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Introduction

In this study, PAN-based activated carbon fabrics were developed from continuous carbonization and activation at temperatures ranging from 900 to 1100°C in steam and carbon dioxide. The microstructure changes in ACFs during different activation processes were studied using wide-angle X-ray diffraction and Raman spectography. The samples were analyzed in original form (fabrics) and powder form, in order to examine both the surface and inner structures.

Experimental

Oxidized PAN fibers (Toho Rayon Co. Ltd.) were woven into fabrics. The fabrics were 51 mm in width. The oxidized PAN fabrics were carbonized and activated at temperatures from 900 to 1100°C by passing through a high-temperature oven in pure nitrogen atmosphere, followed by carbon dioxide, and steam. Three groups of carbonized and activated fabrics were developed using heat-treatment temperatures of 900, 950, 1000, 1050, and 1100°C for 40 minutes and were defined as samples B, C, and H, respectively.

A Model 8536 Diano X-ray diffractometer, providing Ni-filtered Cu K α radiation, was used to measure the crystalline-related properties of the sample. The Raman spectrometer used here was a Renishaw instrument with Raman imaging microscope system 2000, using a 514.5 nm line of an argon ion laser as the incident radiation.

Results and discussion

The X-ray diffraction of all samples are shown in Figure 1. The structural parameters were calculated. It was found that the stacking height of the carbon basal planes (L_c) of samples C and H, which were subjected to activation treatments at 900°C-1050°C, are lower than that of sample B. This is because during the activation treatment, water and carbon dioxide reacted with the carbon at the crystal edge, or the irregular carbon in the carbon fibers, to form carbon monoxide.

In the region of Raman scattering analysis, the C=C bond of the sp² hybridized orbital has a characteristic peak at 1582 cm⁻¹ (so-called G-mode, which is formed by the

ordered region in the carbon layers), as shown in Figure 2. Moreover, there were two secondary characteristic peaks (so-called D-mode, which is caused by the disordered part in the carbon layers) at 1357 cm⁻¹ and 1620 cm⁻¹, respectively. There was also a characteristic peak caused by the non-crystalline carbon in the region between about 1500-1550 cm⁻¹ [1-4]. It is now generally accepted that the dependence between the integrated intensity ratio I_D/I_G and the microcrystalline planar crystal size L_a shows inversely proportional behavior [5].

For sample C, the Raman analysis performed on the activated carbon fabrics revealed that the L_a value for sample C is even smaller than that for sample B, as shown in Table 1. This is because carbon dioxide molecules are larger and can thus easily and continuously attack the crystalline edges of the carbon layer or the non-regular carbon part of the fiber surface, which causes the fiber surface to have larger pores. However, when the analysis is directed to the pulverized activated carbon fabrics of sample C, it can be found that under the same treatment temperature, the crystal size (L_a) of the carbon layer planes is greater than that of sample B (powder form) and sample C (fabric form).

In regard to sample H (fabric form), it was found, from the Raman analysis on the activated carbon fabrics, that the L_a value is higher than in sample B at the temperature range of 950-1100°C. Consequently, the L_a of the fiber surface of sample H is higher than that of samples B and C. When the analysis is directed to the pulverized activated carbon fabrics of sample H, the L_a is likewise greater than that in samples B, C and the surface of sample H. This is because water molecules easily penetrate to the inside structure of the fibers to react with the carbon at the crystal edge or the non-regular carbon. This reaction led to the linking of micropores on the fiber surface into the internal pores. Therefore, the L_a of sample H would generally be greater than that of sample B.

Conclusions

This study indicates that carbon dioxide only reacts with the crystalline edges or the irregular carbon on the fiber surface and that the inner structure of the fibers

was not greatly affected. When carbon fabrics were activated using steam, water molecules reacted not only on the fiber surface but also with the carbon at the crystal edge or the non-regular carbon in the fibers, which led to communicating pore structures on the surface and in the inner portion of the fiber.

Acknowledgement

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References

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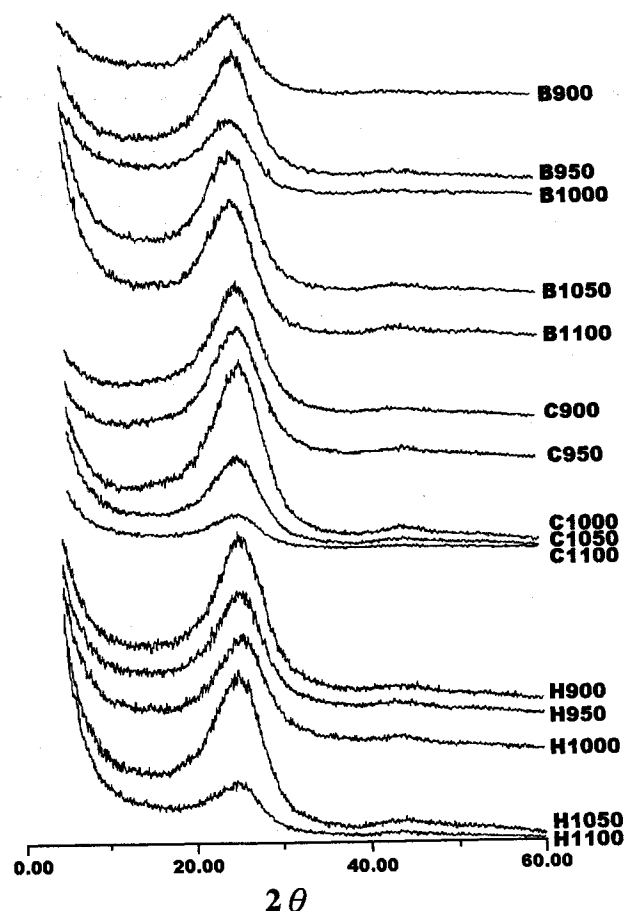


Figure 1 Wide-angle X-ray diffraction pattern of carbon fabric and activated carbon fabrics, which were measured with fabric form.

Table 1. Analysis of Raman spectra from carbon fabrics and activated carbon fabrics

Sample form	Powder		Fabrics	
	I_D/I_G	L_a	I_D/I_G	L_a
B900	6.49	0.68	7.06	0.62
B950	6.70	0.66	6.59	0.67
B1000	6.48	0.68	5.48	0.80
B1050	6.26	0.70	4.89	0.90
B1100	6.24	0.71	2.54	1.73
C900	4.96	0.89	8.19	0.54
C950	4.98	0.88	6.89	0.64
C1000	5.11	0.86	5.50	0.80
C1050	5.21	0.84	5.39	0.82
C1100	4.22	1.04	4.98	0.90
H900	4.44	0.99	7.37	0.60
H950	5.16	0.85	5.15	0.80
H1000	4.68	0.94	4.71	0.93
H1050	4.30	1.02	4.64	0.95
H1100	3.37	1.30	3.87	1.14

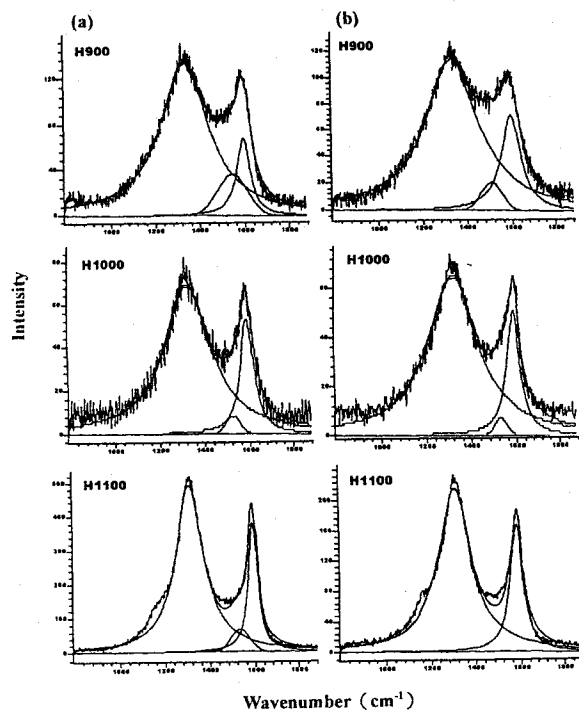


Figure 2 Raman spectra of activated carbon fabric (activated in steam) after various pyrolysis, which were measured with (a) fabric form, (b) powder form.