

## X-ray Characteristic of Non-graphitizing-type Carbons

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X-ray data of non-graphitizing-type carbons such as acetone-furfural resin carbon, phenol-formaldehyde resin carbon, 3-methylphenol-formaldehyde resin carbon and cellulose carbon heat treated over the range of  $500^{\circ}\text{C}$  to  $3000^{\circ}\text{C}$  were obtained. The X-ray profiles of these non-graphitizing-type carbons show a characteristic difference in comparison with those of graphitizing-type carbon such as petroleum coke carbon and 3,5-dimethylphenol-formaldehyde resin carbon. From X-ray data of  $d(002)$ ,  $d(004)$ ,  $d(110)$ ,  $L_c(002)$ ,  $L_c(004)$  and  $L_c(110)$ , it is observed that the progress of graphitization is slow in non-graphitizing-type carbon and furthermore all these non-graphitizing-type carbons show composite (002) profiles over the range of heat treatment temperature about  $2400^{\circ}\text{C}$  and  $3000^{\circ}\text{C}$ , while the graphitizing-type carbons are graphitized more rapidly and show no composite profile. All these composite profiles were considered to be composed of three components by comparing these profiles each other, so they were divided into three peaks, that is, a broad peak at about  $26^{\circ}(2\theta)$  and two sharp peaks at about  $26^{\circ}$  and  $26.5^{\circ}(2\theta)$  respectively. The value of  $2\theta$  and the line broadening are almost constant and only the ratio of relative peak intensity for them changes with increase of heat treatment temperature. From the change of the composite (002) profiles with heat treatment temperature, the graphitization process of the non-graphitizing-type carbons is deduced as follows. The  $d(002)$  spacing of crystallite of original non-graphitizing-type carbon decreases gradually with increase of heat treatment temperature. When the values of  $d(002)$  spacing and  $L_c(002)$  thickness of the crystallite of non-graphitizing-type carbons reach to about  $3.43 - 3.44 \text{ \AA}$  and  $20 - 40 \text{ \AA}$  respectively, small amounts of another two components appear abruptly in the crystallite. The one is a large crystallite having  $d(002)$  spacing of about  $3.43 - 3.44 \text{ \AA}$  and  $L_c(002)$  thickness of several hundred angstrom, and the other is a large crystallite having  $d(002)$  spacing of about  $3.36 \text{ \AA}$  and  $L_c(002)$  thickness of several hundred angstrom. And the amount of the latter graphitic component gradually increases with increase of heat treatment temperature. On the other hand, the graphitizing-type carbon such as petroleum coke and 3,5-dimethylphenol-formaldehyde resin carbon do not show such a stepwise transformation in their graphitization process. Fig. shows the relation between  $d(002)$  and  $L_c(002)$ , and three components of non-graphitizing-type carbons.

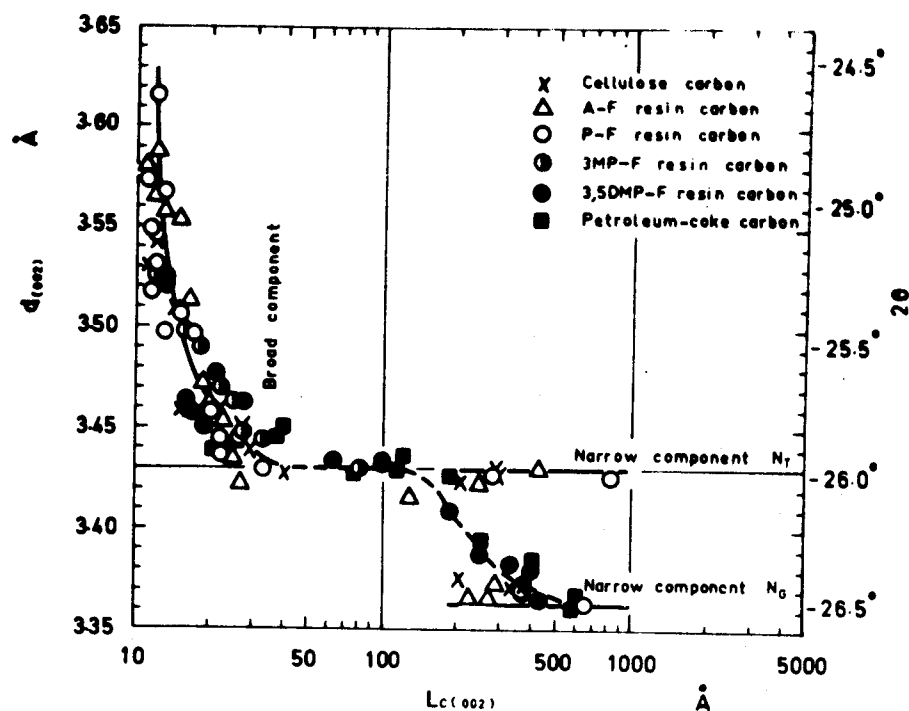


Fig. The relation between  $d(002)$  and  $L_c(002)$ , and three components of non-graphitizing-type carbons.