Introduction of KMFC and KMFC graphite powder, using for high density carbon block and anode material of lithium ion secondary battery.

Katsuhiro Nagayama
Carbon Material R&D Center , Chemical Research Lab, JFE Chemical Co.
1, Kawasaki-cho, Chuo-ku, Chiba 260-0835, Japan katsuhiro-nagayama@jfe-chem.

JFE Chemical(JFEC) has been developing KMFC (Kawasaki Mesophase Fine Carbon) to add value to coal-tar pitch. In 1977, the Government Industrial Research Institute Kyushu reported that the separated mesophase spheres from heat-treated pitch, showed excellent self-sintering property [1]. Based on this result, JFEC conducted studies from basic research to commercialization, and succeeded in manufacturing the KMFC on an industrial scale for the first time in the world by its own technology. In 1987, JFEC began to manufacture and sell the KMFC as a raw material for high-density, high-strength carbon blocks. In addition, the graphitized KMFC powder was found to have excellent performance as the negative electrode material for lithium ion secondary batteries, and application in this field began in 1991.

Figure 1 shows the manufacturing process of KMFC and KMFC graphite powder. Coal-tar pitch is used as the raw material and mesophase spheres formed during the heat treatment step. KMFC is manufactured through the steps of solvent extraction and filtration, drying and calcination, and classification. KMFC is then baked, pulverized and classified into specified particle sizes. After classifying, graphitization is performed to obtain graphite powder[2],[3]. The quality of coal-tar pitch as the raw material affects the properties of KMFC and graphite powder, so strict quality control is required for stable manufacturing. JFEC has established technology for controlling the quality of coal-tar pitch in the binder pitch manufacturing process, and so applied it to the quality control of KMFC.

KMFC is used as a raw material for high-density and high-strength carbon blocks. Figure 2 shows the self-sintering mechanism of KMFC compact proposed by JFEC[3],[4],[5]. During heat treatment of 400-600℃, due to the fusion of binder component and sintering in liquid phase, large reduction of pore volume and binding of KMFC compact are achieved.

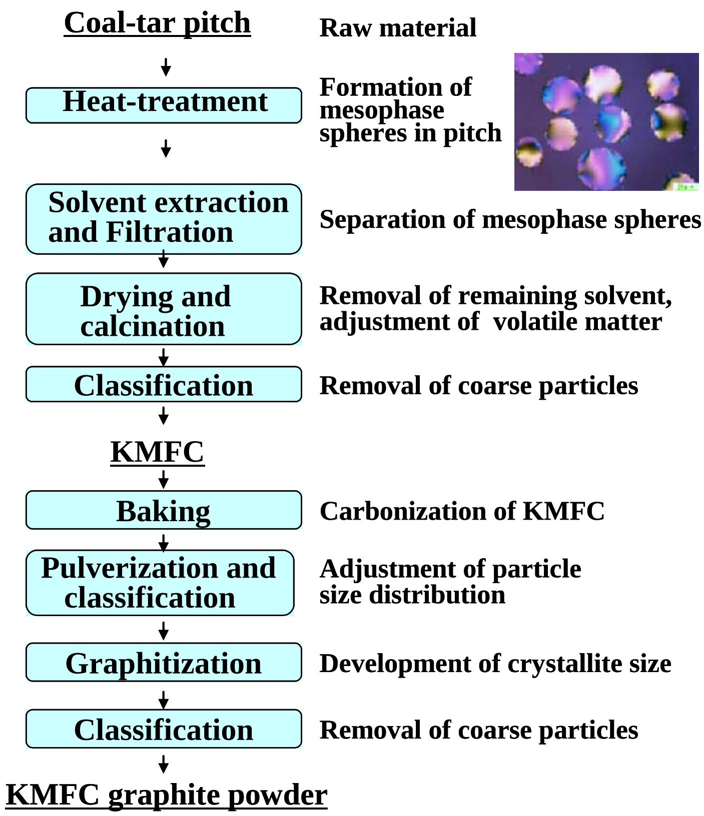


Fig. 1 Manufacturing process of KMFC

A large shrinkage of KMFC in solid phase is occurring 600-1000℃, high-density and high-strength carbon block is obtained as a result.

KMFC graphite powder has excellent performance as a negative electrode material, giving high charge/ discharge efficiency and good discharge rate and cycling properties[6]. To increase the discharge capacity, JFEC has conducted R&D to improve the crystallinity without affecting the favorable performance. JFEC succeeded in developing high-capacity KMFC graphite powder by selecting coal-tar pitch and optimising the manufacturing conditions. Figure 3 shows the relation between the discharge capacity and the graphite layer distance (d-spacing) d(002) as an index of the crystallinity of graphite, measured by X-ray diffraction. Developed KMFC graphite powder generates a discharge capacity of 350 mAh/g which is higher than that of the conventional grade by about 40 mAh/g. Demand for higher capacity lithium ion secondary batteries is increasing year after year, and so a higher capacity negative electrode material is required. JFEC has the world's largest KMFC manufacturing facilities, which assure stable supply of products, and the operating period of the facilities is also the longest in the world. JFEC is continuing R&D to ensure the delivery of products with stable quality that meet customers' requirements.

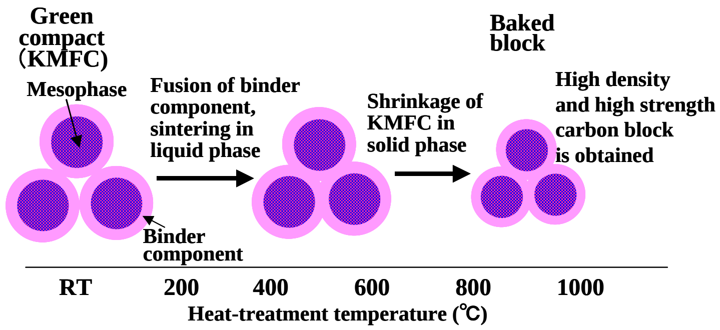
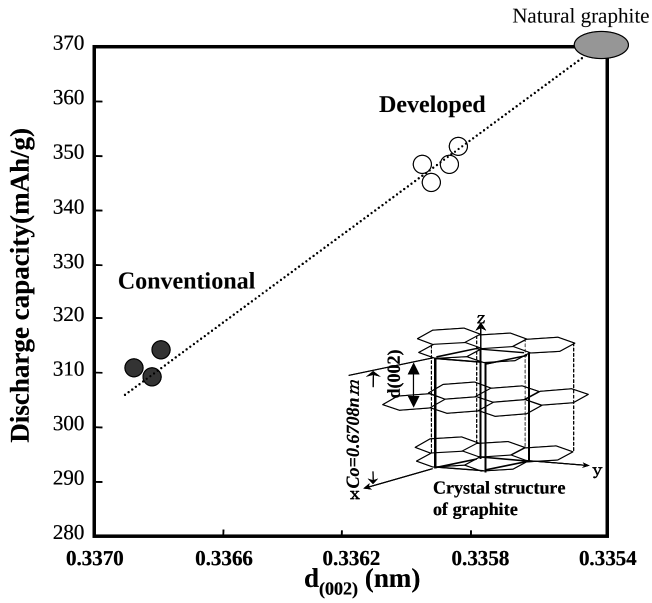


Fig.2 Self-sintering mechanism of KMFC compact



Measurement conditions of discharge capacity ;
Electrolyte; 1M $LiPF_6$ in EC/EMC (1:2 vol)
Discharge; Constant current to 1.5V(cut off)
(Discharge rate:0.1C)

Fig. 3 Relation between d-spacing $d_{(002)}$ and discharge capacity of developed and conventional KMFC graphite powders

References

[1] Y. YAMADA, K. SHIBATA, E. HONDA, TANSO VOL.88 (1977) 2

[2] N. FUKUDA, S. HONMA, K. NAGASAWA Y. MURANISHI, H. ABE KAWASAKI-SEITETSU-GIHO VOL.18 NO.3 (1986) 289

[3] K. NAGAYAMA, M. Honma, N. FUKUDA, Tanso Zairyo Gakkai 15 (1988) 138

[4] K. NAGAYAMA, T. Torii, H. Hatano, N. FUKUDA, Internatinal Sympoium of carbon (1991) 710

[5] K.NAGAYAMA, S.HONMA, N.FUKUDA, KAWASAKI-SEITETSU-GIHO VOL.29 NO.4 (1997) 233

[6] K.NAGAYAMA, M.SAKAI, Y.TAJIMA, JFE TECHNICAL REPORT NO.6 (2005) 76