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Microstructure and properties of charcoal in mawangdui tomb in Chinese Han-dynasty

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Abstract

Some corpses were found to be fresh for about two thousands years in Han-Dynasty tomb. Archaeologist and geologist proposed that it is due to be the tomb texture and geological conditions. A large amount of charcoal was found at the outside of coffin. It was studied with HRTEM, XRD, SEM, XRS and XRF. Except turbstatic carbon, some spherical balls were found by FEM, and some curled carbon was found by TEM, which was supposed to be a reason to keep the corpse fresh for 2000 years in the tomb. The elements were estimated by X-ray Photoelectron Spectroscopy and X-Ray fluorescence spectrometry.

***Keywords*:** A. Charcoal; C. Transmition Electron Microscopy; X-ray Diffraction; X-ray Photoelectron Spectroscopy, Scanning Electron Microscopy; X-Ray fluorescence spectrometry; D. Microstructure**.**

1. INTRODUCTION

A fresh women corpse of a good muscle of good toughness and face (Fig.1) was found in Mawangdui Han-Dynasty tomb in Hunan province in 1972[1,2]. It was a marvel that it has been kept fresh for about two thousands years. Several fresh corpses were found last year. Archaeologists and geologists proposed that it is due to the tomb texture and geological conditions [2-4]. A large amount of charcoals of about 10000 kg were found at the outside of coffin in the tomb. With high-resolution transmission electron microscopy (HRTEM), X-ray diffractometry (XRD), X-ray Photoelectron Spectroscopy and Scanning Electron Microscopy and X-Ray fluorescence spectrometry, the charcoal was examined and presented in the present paper.

Fig. 1 A fresh corpse 2000 years ago was found Mawangdui tomb in Hunian province in 1972 [1].

2. EXPERIMENTAL

The charcoals in Mawangdui tomb were examined with X-ray diffractmeter using CuKα radiation firstly. The phase and morphology of charcoal clicked on the copper grid were observed with optical microscopy, HRTEM and SAD at 200kV with a point-to-point image resolution of less than 0.2 nm, and Scanning Electron Microscopy. Its elements were estimated by X-ray Photoelectron Spectroscopy (axis ultra) and X-Ray fluorescence spectrometry (S4-Explorer, Rh bar). Its adsorption property was measured by Micromesities ASAP 2010.

3. RESULTS

3.1 morphology of charcoal in Han-Dynasty tomb

The black charcoals in Han-Dynasty tomb (Fig. 2) were hard and couldn't dye the hands. Some clear annual rings were observed in the charcoals.

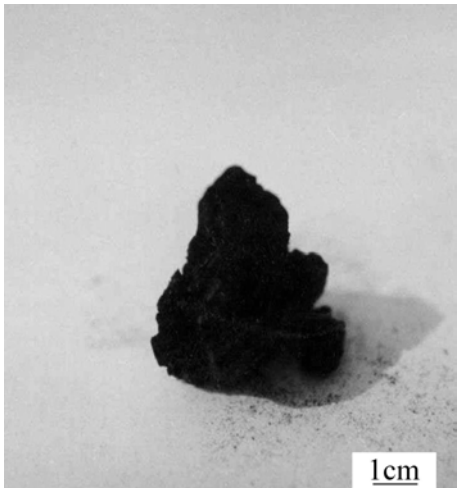
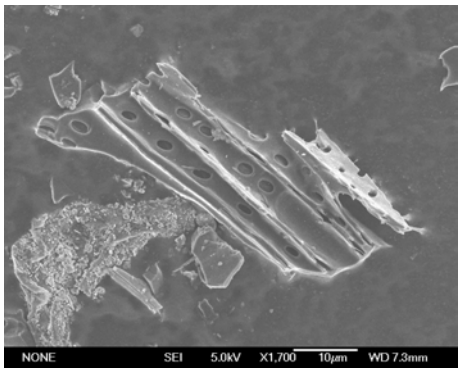
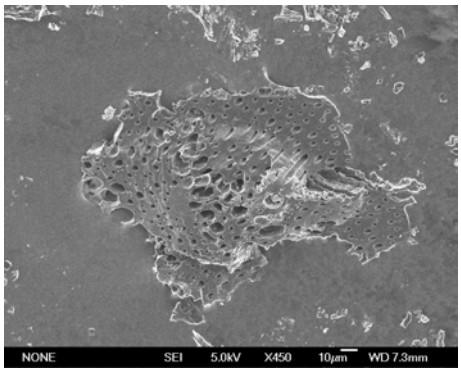


Fig. 2 Photo of Charcoal in Han-Dynasty tomb

There are mesopore and macropores in a large quantity in the charcoals (Fig. 3). They are organized in some channels (Fig. 3A) and also irregular directions (Fig. 3b) like that in normal wood. But it is surprise to find lots of spherical balls inside the channel. The size of spherical balls is from about several nm to 300 hundreds nanometers (Fig. 3c and 3d).



(a)



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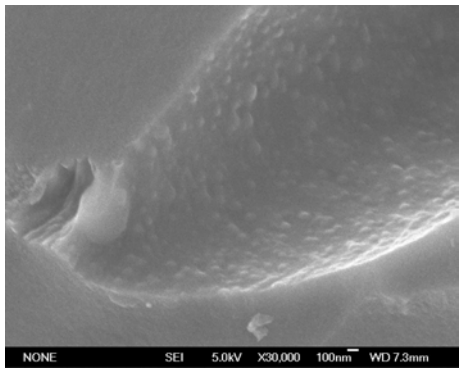

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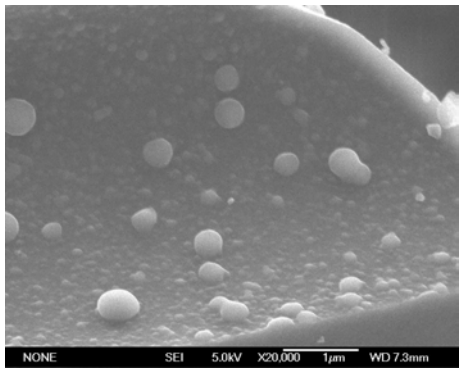


(d)

Fig. 3 Photograph of charcoals by Scanning Electron Microscopy in Han-Dynasty tomb. (a) wood-like breathing channel; (b) normal pores; (c) inside the channel; (d) spherical balls inside the channel.

3.2 Chemical elements of charcoal in Han-Dynasty tomb

Only pure carbon was detected by X-Ray fluorescence spectrometry (S4-Explorer, Rh bar). With X-ray Photoelectron Spectroscopy, beside of carbon, little amount of Al, Ca, N and O (0.48, 0.43, 0.65 and 9.38, atomic ratio %) was detected. It should come from contamination of clay at the outside of charcoal in the Han-Dynasty tomb [2].

3.3 XRD characterization of charcoal in Han-Dynasty tomb

Its XRD pattern is shown in Fig. 4. The profile of 002 diffraction peak is obtuse and its interlayer spacing values keep a range from 0.320nm to 0.467 nm in its half height. But there is a sharp peak in 0.336nm (Fig.4b), which assigned to graphene Therefore, the charcoal was supposed to consist of a large amount of turbostatic carbon with a small amount of

graphene.

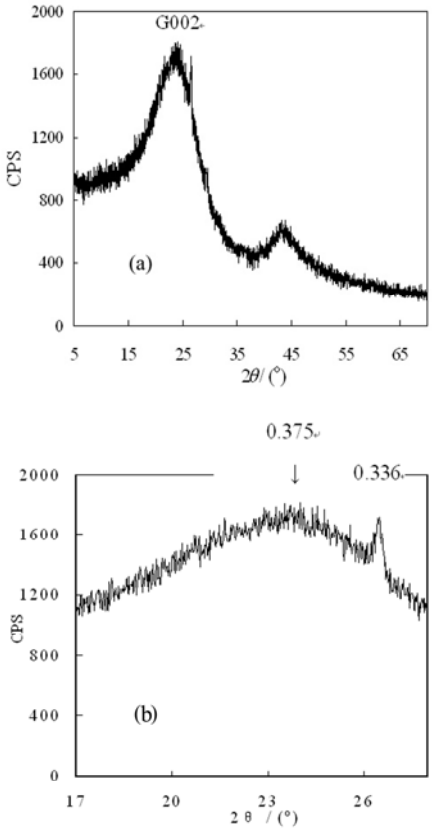
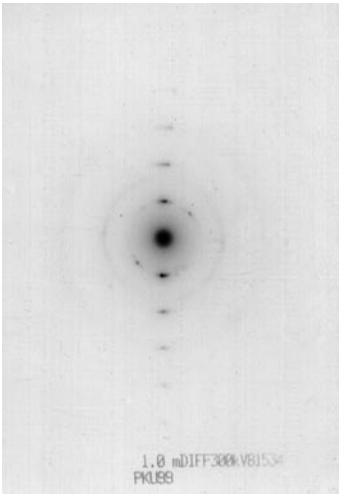


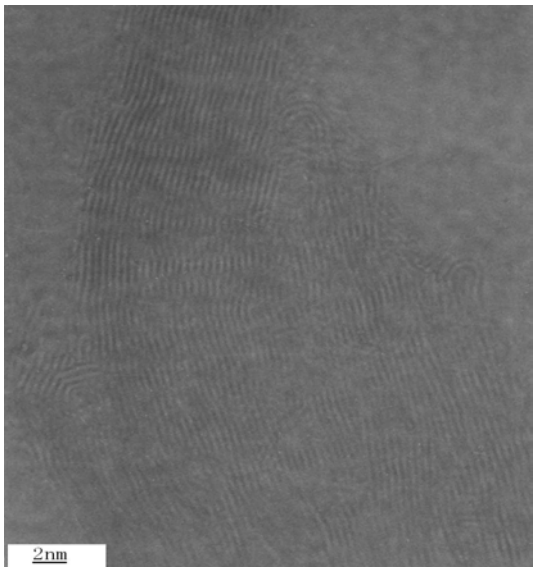
Fig. 4 The X-ray diffraction pattern of the charcoal in Mawangdui tomb of the Han Dynasty, (a) total diffraction pattern; (b) The 002 peak.

3.4 SAD pattern and lattice fringes of charcoals in Han-Dynasty tomb

In its representive SAD pattern (Fig. 5a), there are some sharp diffraction spots arrayed in a line ascertained to basal plane of graphene beside some rings induced by turbostatic carbon. Its lattice fringes are shown in Fig. 5b. Besides some straight lattice fringes of graphite and turbostatic carbon, some curled lattice fringes were found in the charcoal under TEM. They were sphericity in shape of 4.75nm diameter at the outside. The averaged interlayer spacing was about 0.383nm with 4 lattice fringe layers.



(a) The SAD pattern



(b) The curled lattice fringe image of the charcoal

Fig. 5 The image of charcoals in Mawangdui Han-Dynasty tomb, (a) the SAD pattern; (b)lattice fringes.

4. DISCUSSION

A large amount of charcoal around the coffin in the tomb was supposed to be important to keep corpse fresh in Mawangdui Han-Dynasty tomb. Carbon materials were found to have high adsorption capacity of gas [5,6].

The charcoals with curled texture and spherical ball might have some adsorption property for gas in the tomb. A charcoal layer of 100 cm formed a special adsorption layer and a

deoxidizing environment around the coffin (Fig. 6). It became a shielding area for oxygen in air. It kept air and oxygen away from the corpse. But there might actually be some air to come from the outside of coffin and CO gas made by corpse to get out. But the exchanged speed was very low between the outside and inside of coffin. It might be main reason for natural occurrence of corpse kept fresh for about two thousands years in China. The researches on adsorption properties and other properties would be helpful to explain the rare phenomenon in Mawangdui Han-Dynasty tomb. The technology of synthesis of ancient charcoal might be useful in modern medical field.

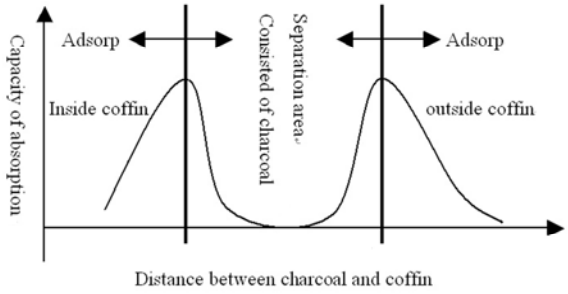


Fig. 6 Function of the area of separation in the Mawangdui Han-dynasty tomb

5. CONCLUSION

Not only turbostatic carbon but also some curled carbon of sphere shape existed in the charcoal phase in Mawangdui. A special shielding area was formed by charcoals around the coffin. The curled carbon was supposed to one of reasons to keep the corpse fresh for 2000 years in a special environment.

ACKNOWLEDGEMENTS

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