EFFECTS OF STABILIZATION CONDITIONS ON MECHANICAL PROPERTIES AND ELECTRICAL RESISTIVITY OF MESOPHASE PITCH-BASED CARBON FIBERS

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Introduction

A considerable interest has been focused during recent years on the electrical conductivity of carbon fibers. Most studies were concentrated on the measurement of electrical conductivity of these materials, either original carbon fibers or after intercalation. [1][2] Yet little work was published on the relationship between preparation condition and electrical conductivity.

In our recent works, we tried to disclose the correlation between the stabilization time and electrical conductivity, by measuring series of carbon fibers prepared by different stabilization conditions.

Experimental

A naphthalene-derived mesophase pitch with softening point of 239℃was melt spun at 315℃ and 325℃respectively, using a round-shaped spinneret of L/D=1:1(L=0.3mm). The diameter of as-spun fibers were around 9±1 μ m. The as-spun fiber was stabilized in air with the heating rate of 0.5~5℃/min to final temperature for some time, and then carbonized at 1000 ℃ for 20min with a heating rate of 10℃/min under nitrogen. The electrical resistivity of all fibers were determined using a standard four-probe technique[3]. Approximate 30 filaments were measured and averaged to estimate the electrical resistivity and mechanical properties of resultant carbon fibers.

Results and Discussion

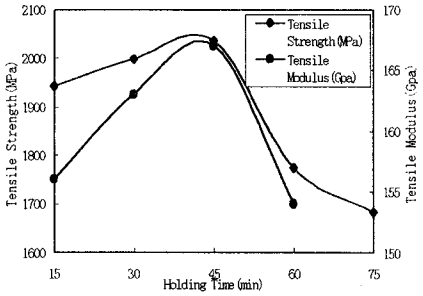

Fig.1 The Relationship between tensile properties and holding time at 250 ℃ of carbon fibers

The influence of holding time at 250 ℃ on the tensile properties and electrical resistivity of resultant carbon fibers are illustrated in Fig.1 and Fig.2 respectively, while the spinning temperature was 315 ℃, stabilization heating rate was 0.5 ℃/min. The tensile strength and modulus increased firstly, reaching their maximum values at 45min; then decreased due to the excess decomposition of oxygen-containing functional

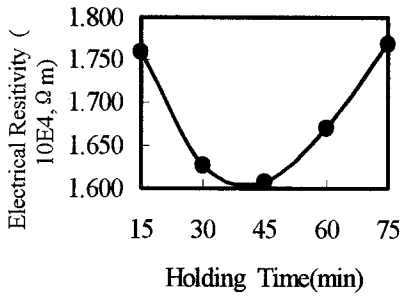

Fig.2 Relationship between electrical resistivity and holding time at 250℃of carbon fibers

groups during stabilization or carbonization. Meanwhile, the electrical resistivity of carbon fibers reached the lowest value at 45min, indicating the electrical resistivity was strongly influenced by its structures since the oxidative stabilization conditions had the same effects on the structures.

Table 1 summarizes the electrical and tensile properties of carbon fibers which were stabilized at 260 ℃for 30 minutes through different heating rates. Slower heating rate may deduce skin-core structure and was beneficial for both mechanical properties and higher electrical conductivity of carbon fibers[4].

Table1. Effects of heating rates on the fiber properties

	Heating Rate	Electrical Resistivity	Tensile Strength	Tensile Modulus
A	0.5℃/min	1.355E-04	2077MPa	156GPa
B	2℃/min	1.534E-04	1937MPa	153GPa
C	5℃/min	1.559E-04	1365MPa	146GPa

Note: Spinning temperature:325℃, final temperature 260℃, holding time 30min

Table2 shows the electrical resistivity of carbon fibers stabilized through two-stage stabilization with a definite heating rate of 5 ℃/min. Pre-oxidation at relative low temperature of 140~200 ℃ for 30min could slightly enhance the electrical conductivity as well as mechanical properties of final carbon fibers.

Table2. Effects of two-stage stabilization on fiber properties

Holding Time and Temperature	Electrical Resistivity	Tensile Strength	Tensile Modulus
260℃,30min	1.559E-04	1365MPa	146GPa
200℃,30min 260℃,30min	1.459E-04	1606MPa	150GPa
180℃,30min 260℃,30min	1.395E-04	—	—
160℃,30min 260℃,30min	1.364E-04	—	—
140℃,30min 260℃,30min	1.330E-04	1716MPa	152GPa

Note: Spinning temperature: 325℃, heating rate 5℃/min

References

[1]W. D. Lee, et al, Carbon vol. 23, 731-737(1985)

[2]J. R. Gaier, et al, Carbon vol.26, 381-387(1988)

[3]D. D. Dominguez, et al, Carbon vol. 24, 1-13(1986)

[4] I. Mochida, et al, Carbon vol.28, 193-198(1990)