MICROWAVE PERMITTIVITY AND PERMEABILITY OF ACTIVATED CARBON FIBERS IMBEDDED IN PARAFFIN WAX

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Introduction

Activated carbon fibers (ACFs) have been studied efficiently since it appeared, and much work has been reported on the preparation, pore structures and adsorption properties of ACFs[1-2]. The pores formed on the surface of the fibers make cross-section irregular, that is, ACFs is non-circle in terms of microstructure, especially for the ACFs with high surface area. It is found that non-circular carbon fibers have good microwave-absorbing properties because of its non-circular surface. Therefore, to some extent, ACFs may have microwave-absorbing properties. In this presentation, microwave permittivity and permeability of ACFs imbedded in paraffin wax were studied.

Experimental

Isotropic pitch-based carbon fibers were activated with steam (steam/N_2 = 1:1) at 950℃ for 30 min. Specific surface area (SSA) and pore structure of the resultant ACFs were determined by Micromeritics ASAP2000 (N_2 adsorption at 77K). The microwave permittivity and permeability of ACFs imbedded in paraffin wax were measured by the method, which is based on measurement of the reflection and transmission moduli between 8.2GHz and 12.4GHz, in the fundamental waveguide mode TE_{10}, using rectangular samples(10.16×22.86mm^2) set in a brass holder which fills the rectangular waveguide. After calibrated with an intermediate of a short circuit and blank holder, reflection and transmission coefficients were obtained with the help of an automatic measuring systems (HP8510C network analyzer). Both the real and imaginary parts of the permittivity and permeability were calculated. For dielectric materials (μ'=1, μ"=0), the relative error varies between 1%(pure dielectric) and 10%(highly conductive materials). The ACFs were dispersed in melting paraffin wax, and then mixtures were cast into molds(10.16×22.86×2mm^3). The sample consisted of 5wt% ACFs and 95wt% paraffin wax.

Results and Discussion

The SSA, pore volume and mean pore size of the resultant ACFs are 2031m^2/g, 0.9306mL/g and 0.6nm, respectively. It is well known that electrical properties can be determined at various frequencies[3,4].The interaction between electronmagnetic waves and condensed matter can be described by using complex permittivity, ε*(ε*= ε'+iε", whereε'is the real part, ε" the imaginary part), and conductivity,σ*. The relation between the real part of the polarization conductivityσ'(ω) and the imaginary part of the permittivityε"(ω) isσ'(ω)=ωε"(ω), where ω is the angular frequency. The permeability is described by μ*= μ'+μ", where μ' is the real part, μ" the imaginary part. The microwave permittivity and permeability of ACFs imbedded in paraffin wax were measured at a frequency range of 8.2 to 12.4GHz. The ε' and ε" of paraffin wax are 2.26 and 0 at this frequency range respectively(μ'=1, μ"=0). As indicated in Fig.1, the real part(ε') of the ACFs and paraffin wax mixture ranges from 15.69 to 18.69, and the imaginary part(ε") ranges from 8.47 to 10.72. The loss tangent (or dissipation factor), tgδε(=ε"/ε') ranges from 0.47 to 0.61. The real part(μ') of permeability of the mixture ranges from 0.93 to 1.07, and the imaginary part(μ”) ranges from 0.08 to 0.26. The loss tangent tgδμ(= μ”/μ’) ranges from 0.083 to 0.25 , which are shown in Fig.2. The microwave permittivity and dissipation factor will be improved when the ACFs are loaded with metal, which is being studied.

Conclusions

1. The microwave permittivity and dissipation factor of the ACFs is good. ACFs would be used for RAM and EMI shielding materials.
2. The μ” and loss tangent tgδμ of ACFs are due to the irregularity of surface.

References

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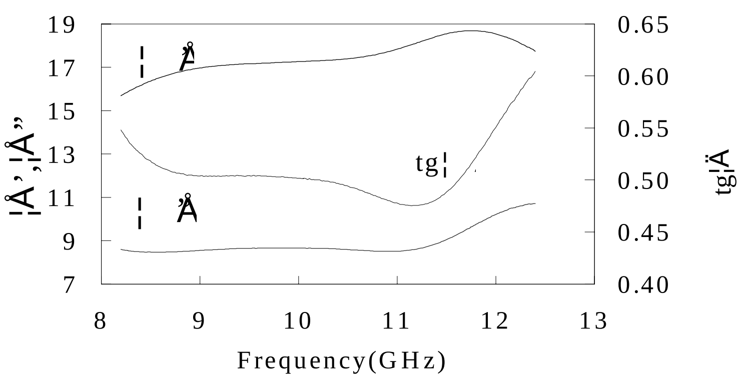

Fig. 1 ε’,ε” and tgδεof ACFs and paraffin wax mixture as function of frequency

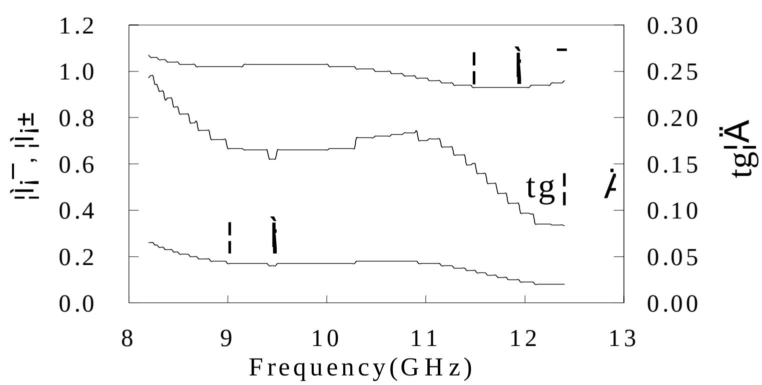

Fig. 2 μ’, μ” and tgδμof ACFs and paraffin wax mixture as function of frequency