MICROWAVE PROPERTIES OF CARBON FIBER, MODIFIED WITH AMINO GROUPS

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In recent years, carbon materials (CMs) with different microstructures have been reported for which outstanding EMR shielding characteristics have been achieved. Such materials include hollow carbon nanospheres, reduced graphene oxide, and carbon aerogels. Also, CMs have great potential as protective materials due to numerous features including low density, natural origin, low cost, excellent conductivity, and excellent mechanical properties [1]. Despite the widespread use of CMs and their composites as shielding and protective materials in the literature, there are virtually no studies aimed at elucidating the effect of chemical surface modification on their shielding properties [2].

This work aimed to study the effect of chemical surface modification, namely amination of PAN carbon fibers (CFs).

METHODS:

- Scanning electron microscopy (SEM)
- Chemical Analysis (C.A.)
- Thermogravimetric analysis (TGA)
- Thermoprogrammed desorption with IR registration of products (TPD IR)
- Thermoprogrammed desorption mass-spectrometry (TPD MS)
- Vector network analysis method (VNA)

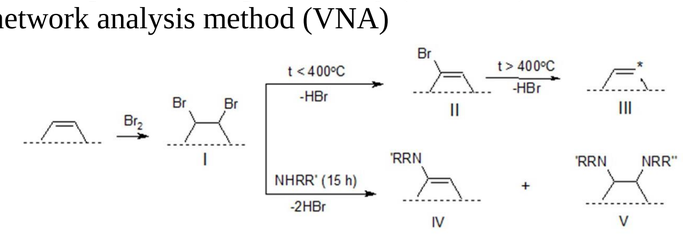

FIGURE 3. Scheme of bromination of PAN CFs with subsequent replacement of bromine with aminogroups.

FIGURE 1. TEM microphotographs of the initial carbon fiber (a, b).

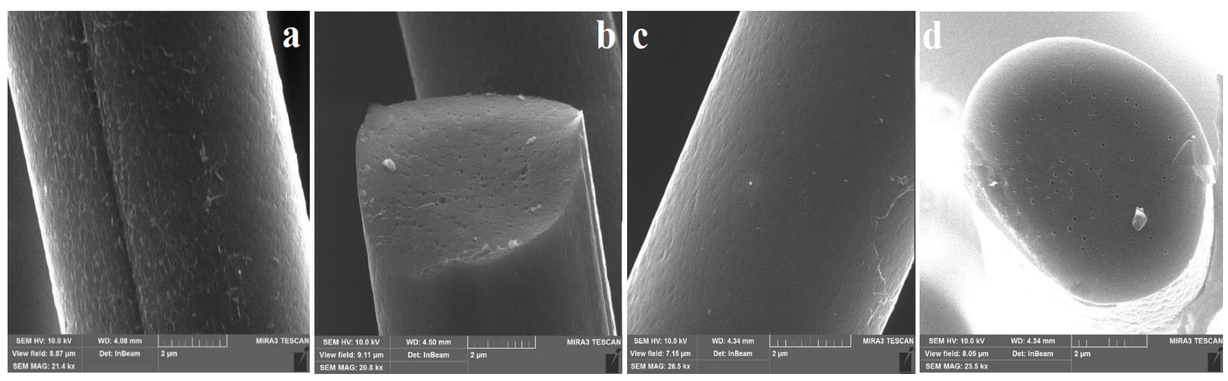

FIGURE 2. SEM microphotographs of the initial (a, b) and aminated carbon fiber (c, d).

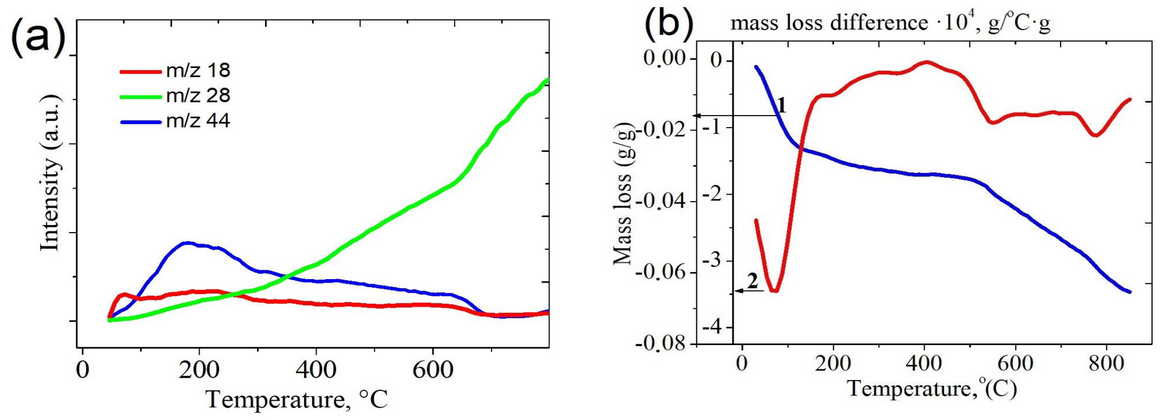

FIGURE 4. TPD MS (a) and TGA (b) profiles of the initial carbon fiber.

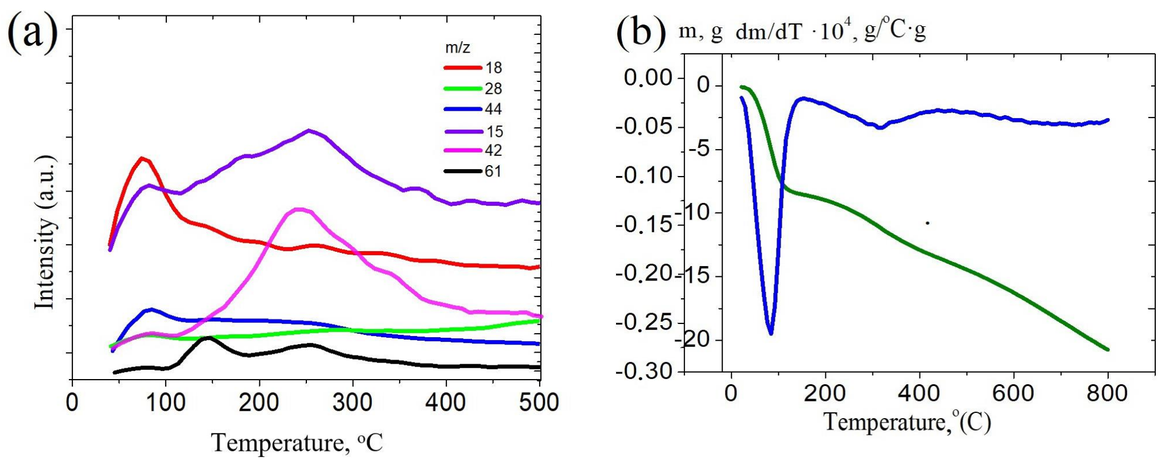

FIGURE 5. TPD MS (a) and TGA (b) profiles of the aminated carbon fiber.

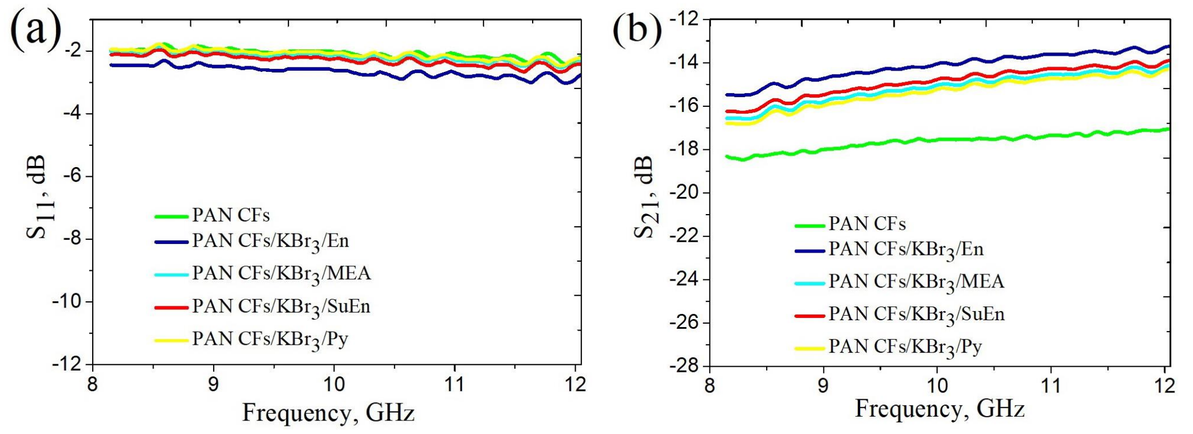

FIGURE 6. (a) S_{11} and (b) S_{21} parameters for the aminated and pristine PAN CFs in X-band.

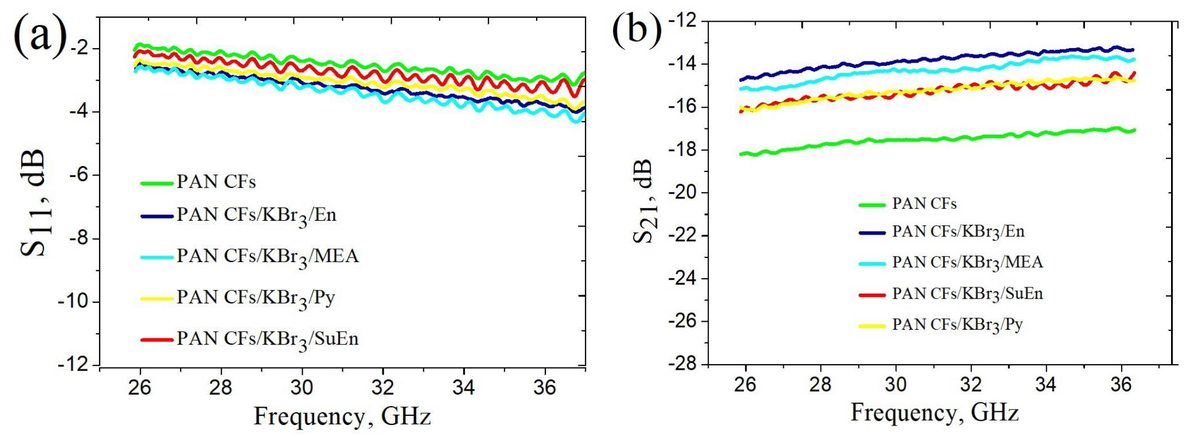

FIGURE 7. (a) S_{11} and (b) S_{21} parameters for the aminated and pristine PAN CFs in Ka-band.

Average value of reflection (S_{11}) and losses on transmission(S_{21}) for aminated samples

Name of the sample	X-band		Ka-band	
	S_{11}	S_{21}	S_{11}	S_{21}
PAN CFs	-2.1	-17.3	-2.5	-17.6
PAN CFs/KBr_3/En	-2.7	-14.2	-3.3	-13.9
PAN CFs/KBr_3/MEA	-2.2	-15.2	-3.4	-14.4
PAN CFs/KBr_3/SuEn	-2.3	-14.9	-2.8	-15.4
PAN CFs/KBr_3/Py	-2.1	-15.3	-3.1	-15.4

Conclusions

1. For the first time, the microwave properties of a carbon fiber based on PAN modified with amino groups in the X- and Ka-bands of microwaves were experimentally investigated.
2. The possibility of adjusting the amount of attenuation of EM waves S_{21} and the amount of reflection S_{11} depending on the mutual orientation, with an increase in the angle between the frame of the PAN CFs and the direction of the electric field, has been demonstrated.
3. It was shown for the first time that the aminated material of PAN CFs is promising for use as a protective material against the harmful effects of electromagnetic radiation on biological tissues in the X- and Ka-bands. In addition, modified PAN CFs are promising in the production of camouflage coatings for military purposes, for example, in the field of radar and radio guidance, they can serve as protective membranes for open transmission lines, for stationary devices.

References

1. P. Yang et al., *ES Mater. Manuf.*, 2020, 7, 34-39.
2. Z.-H. Zhou et al., *ACS Appl. Mater. Interfaces*, 2020, 12 (16), 18840-18849.