Microwave properties of oxidized carbon fiber Busofit in X and Ka-bands

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Nowadays, modern advanced materials that absorb microwave radiation can capture (absorb) waves incident on the surface of equipment, thus creating hiddenness for radars designed to detect a variety of targets in aviation. Such materials, including carbon materials, are also considered the key to stealth technology in the military [1]. Carbon materials are widely used as adsorbents, catalysts, and catalyst carriers. They are carriers for the support and stabilization of metal nanoparticles and are promising alternatives to polymeric materials.

As a rule, carbon fibers (CFs) are excellent absorbers of EM radiation. They are used in manufacturing protective clothing for soldiers and for the masking of military equipment [2]. The widespread of operating radar and missiles frequencies stimulate the creation of new materials for a defense that should absorb EM radiation in the range of 0.1–40 GHz. For this purpose, we proposed to modify the surface of viscose-based carbon fibers (Busofit) by oxidation in order to study the effect of surface modification on the microwave properties of Bus CFs.

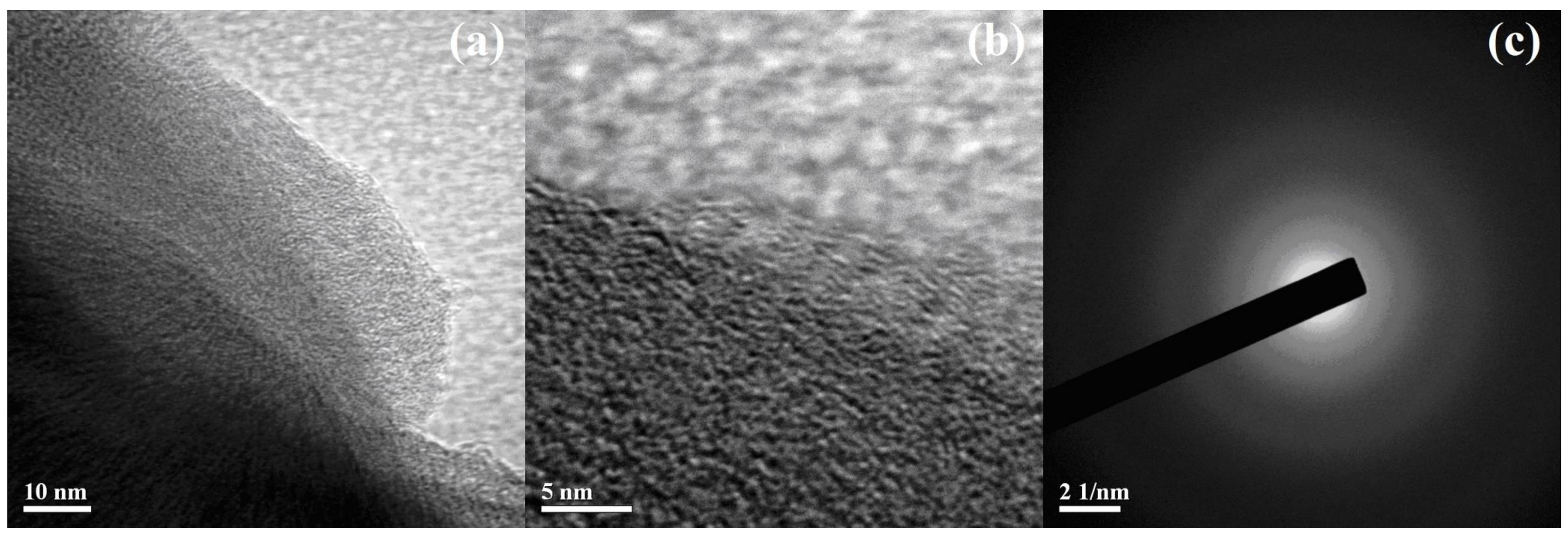

FIGURE 1. TEM microphotographs of the initial carbon fiber.

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)

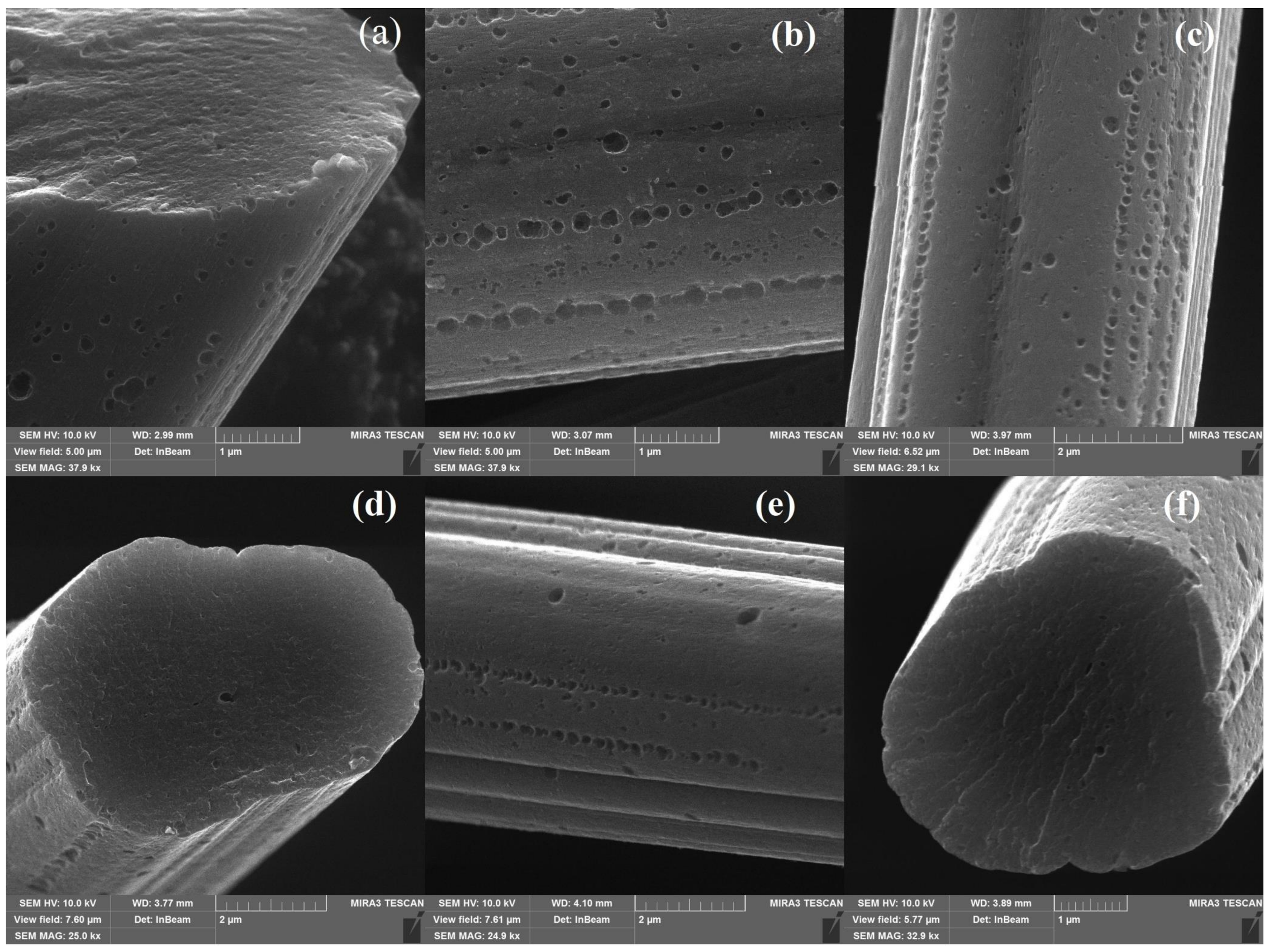

FIGURE 2. SEM microphotographs of initial (a, b) and oxidated (c-f) carbon fiber.

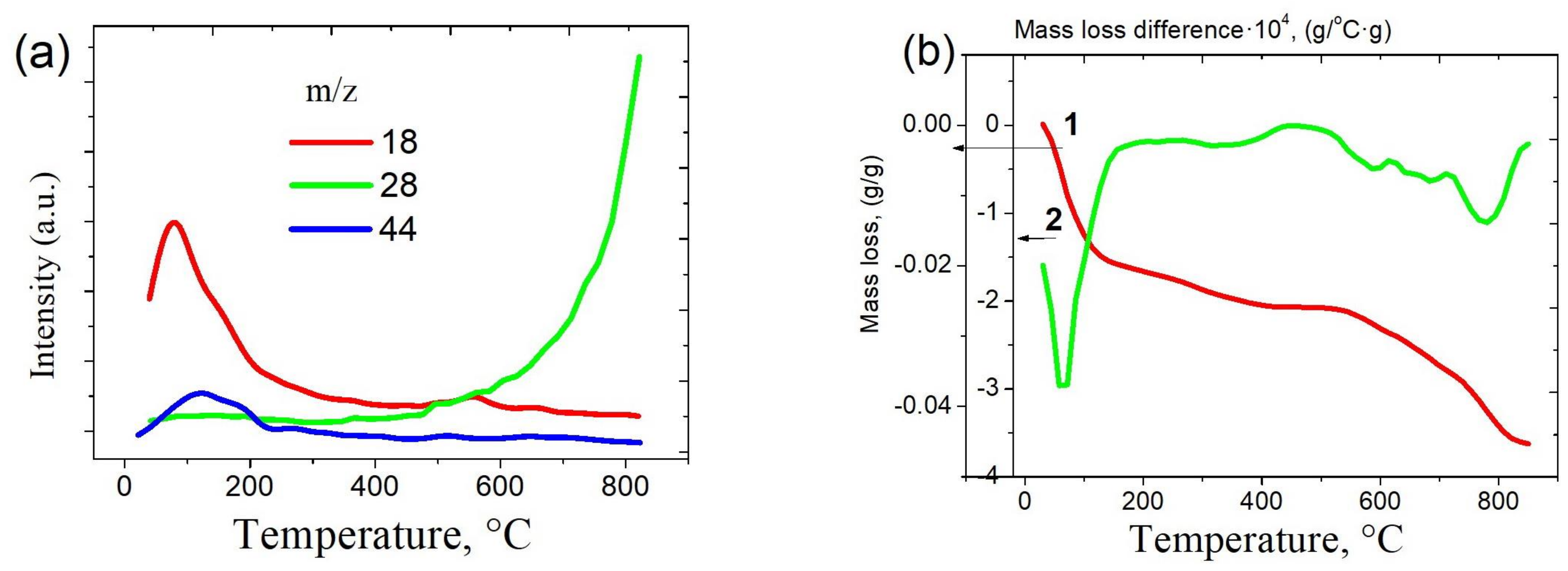

FIGURE 3. TPD MS (a) and TGA (b) profiles of initial carbon fiber.

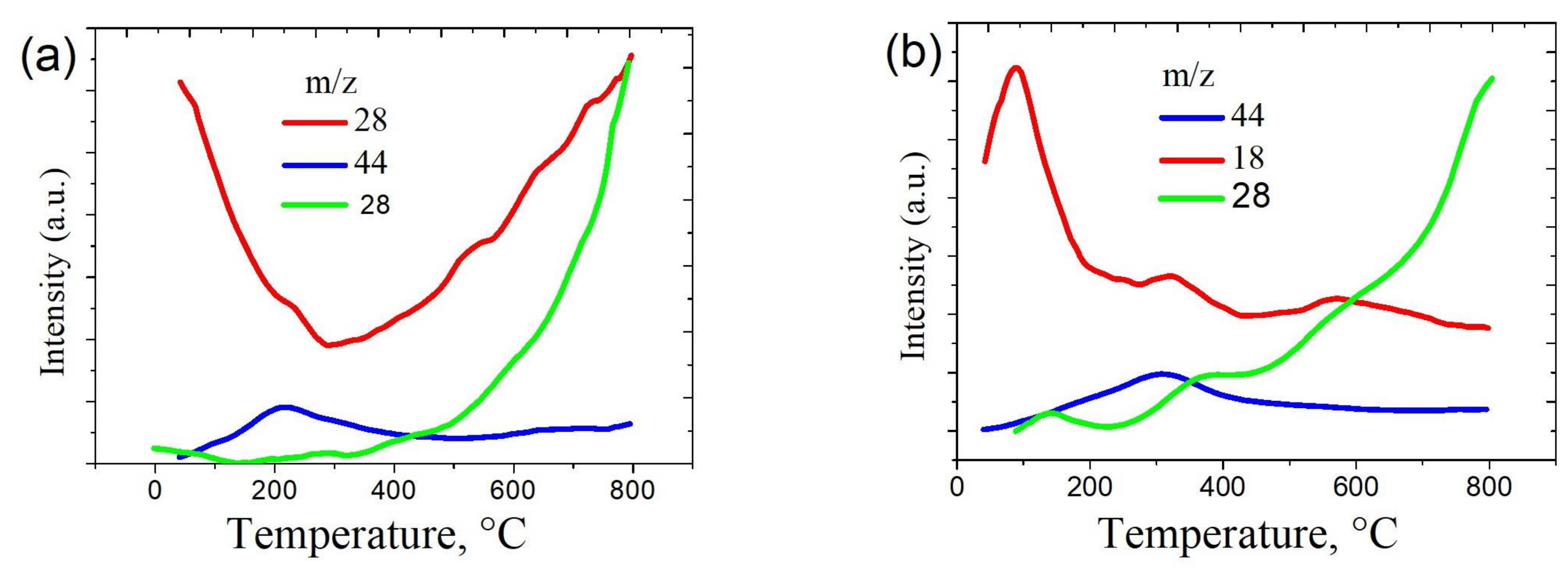

FIGURE 4. TPD MS profiles for oxidiezed carbon fiber: (a) Bus/H_2O_2% and (b) Bus/HNO_3%.

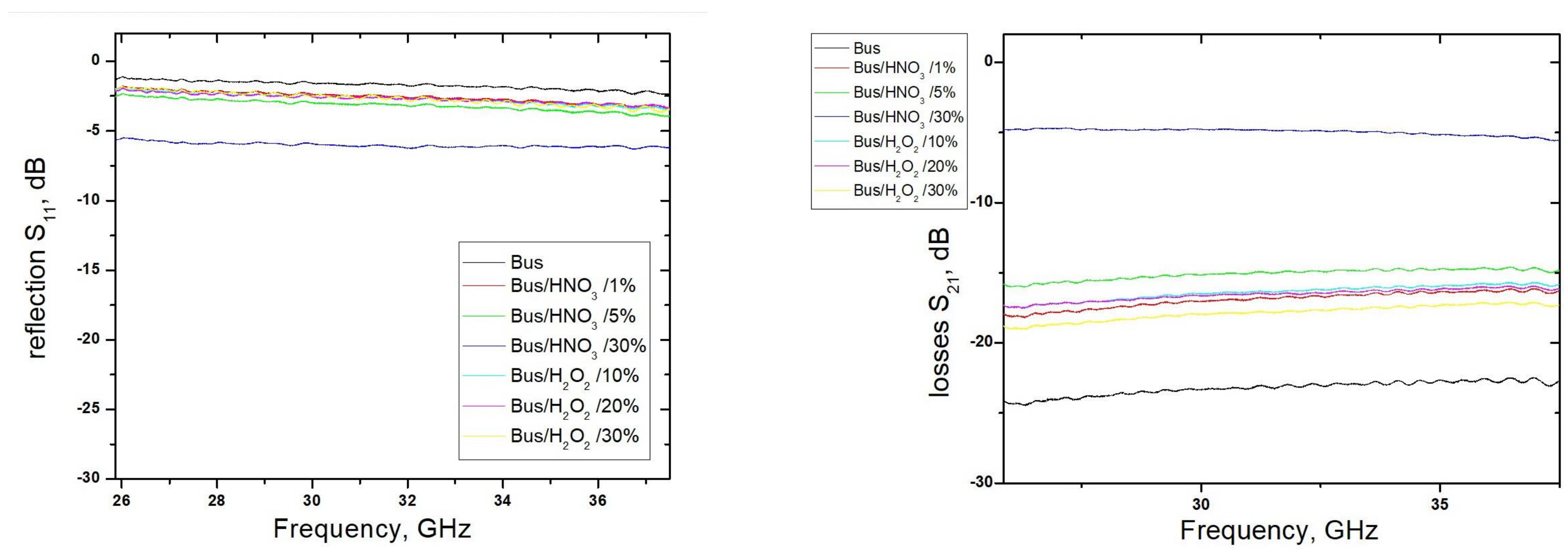

FIGURE 5. Microwave reflection S_{11} and losses S_{21} of initial and oxidated carbon fiber.

Conclusions

1. For the first time, the microwave properties of Busofit carbon fiber modified with O-containing groups in the Ka-band of microwaves were experimentally investigated.
2. Oxidation of carbon fiber HNO_3 and H_2O_2 significantly affects its microwave characteristics and leads to a decrease in EMF reflection and an increase in transmission.
3. Studies show a clear correlation between the concentration of HNO_3 and the values of S_{11} and S_{21}, which allows us to talk about the possibility of programming the corresponding values at the stage of creating carbon materials and composites based on them.
4. The obtained results can be widely used in the improvement of stealth technologies, in the production of radio-absorbing and radio-reflecting materials with specified microwave properties, as well as individual units of ultra-high-frequency equipment.

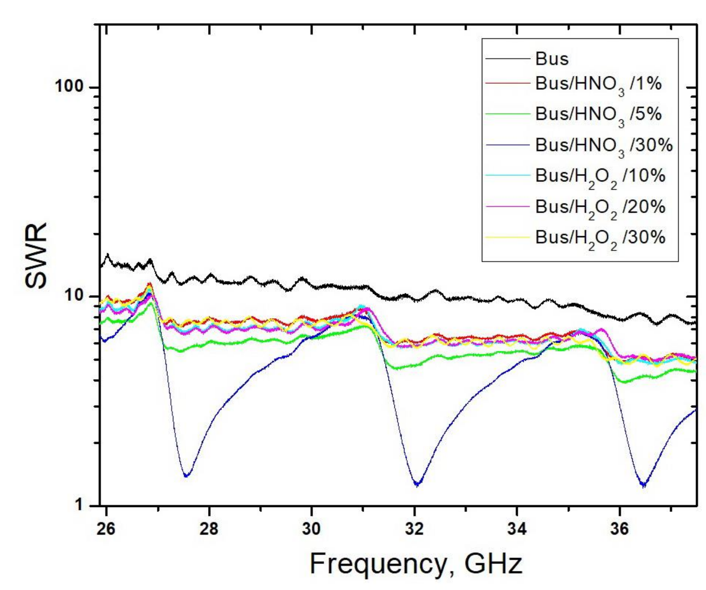

FIGURE 6. VSWR of initial and oxidated carbon fiber.

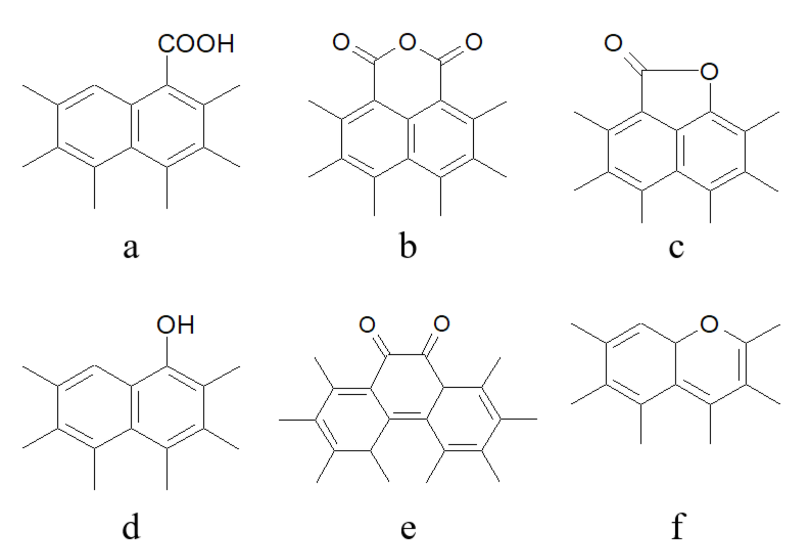

FIGURE 7. Possible structures of surface O-containing groups.

References

1. X. Zhao at al. J. *Mater. Chem. C.*, 2019, **7** (30), 12270 - 12277.
2. L. M. Degenstein at al. *Micromachines*, 2021, **12** (7: 773).

Acknowledgments

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