

Drywall coated with biochar as electromagnetic interference shielding material

Original

Drywall coated with biochar as electromagnetic interference shielding material / Savi, Patrizia; di Summa, Davide; Natali Sora, Isabella; Dassano, Gianluca; Ruscica, Giuseppe; Pelosato, Renato. - ELETTRONICO. - (2021), pp. 403-404. (Intervento presentato al convegno International Conference on Electromagnetics in Advanced Applications (ICEAA) tenutosi a Honolulu, HI, USA nel 9-13 Aug. 2021) [10.1109/ICEAA52647.2021.9539791].

Availability:

This version is available at: 11583/2931074 since: 2021-10-17T12:23:22Z

Publisher:

IEEE

Published

DOI:10.1109/ICEAA52647.2021.9539791

Terms of use:

This article is made available under terms and conditions as specified in the corresponding bibliographic description in the repository

Publisher copyright

IEEE postprint/Author's Accepted Manuscript

©2021 IEEE. Personal use of this material is permitted. Permission from IEEE must be obtained for all other uses, in any current or future media, including reprinting/republishing this material for advertising or promotional purposes, creating new collecting works, for resale or lists, or reuse of any copyrighted component of this work in other works.

(Article begins on next page)

Drywall coated with biochar as electromagnetic interference shielding material

Patrizia Savi
Electronics and Telecom. Dept.
Politecnico di Torino
Torino, Italy
patrizia.savi@polito.it

Gianluca Dassano
Electronics and Telecom. Dept.
Politecnico di Torino
Torino, Italy
gianluca.dassano@polito.it

Davide di Summa
Eng. and Applied Sciences Dept.
University of Bergamo
Dalmine, Italy
davide.disumma@unibg.it

Giuseppe Ruscica
Eng. and Applied Sciences Dept.
University of Bergamo
Dalmine, Italy
giuseppe.ruscica@unibg.it

Isabella Natali Sora
Eng. and Applied Sciences Dept.
University of Bergamo
Dalmine, Italy
isabella.natali-sora@unibg.it

Renato Pelosato
Eng. and Applied Sciences Dept.
University of Bergamo
Dalmine, Italy
renato.pelosato@unibg.it

Abstract— Biochar, a carbon based material derived from biomass, emerges as a sustainable, renewable, environmentally friendly and inexpensive material. Biochar is characterized by high carbon content and it can be used in composites instead of more expensive or less environmentally friendly carbon fillers. Transmission through a common building materials such as drywall coated with a biochar based paste is measured in the frequency band 1-12 GHz for normal incidence in a compact anechoic chamber.

Keywords— commercial biochar, drywall, transmission measurements.

I. INTRODUCTION

In recent years, due to the increasing number of RadioFrequency (RF) sources, great attention has been paid to the development of ElectroMagnetic Interference (EMI) materials to limit and mitigate the effects of this type of exposure [1].

Both in indoor and outdoor environment, problems due to exposure to several RF electromagnetic sources (WiFi, Bluetooth® devices etc.) and the interferences among different devices are increasing [2]. Excessive exposure to such radiations is dangerous to human health, increasing the probability of tumours growth and other diseases.

Low-cost carbons derived from recycled material as biochar produced by pyrolysis of biomass or sewage sludge [3,4], have been gaining attention for applications as removal of pollutants from water [5] or as filler in composites improving their mechanical and electrical properties [6]. Biochar has also been investigated as filler in composites for electromagnetic shielding applications [7,8].

Considering indoor propagation, there are several building materials (plain concrete, lumber, glass and drywall) that can be used as room dividers. Among several methods for measuring the shielding effectiveness (SE), the two most common methods are free-space method based on the measurement of transmitted and reflected signal in an anechoic chamber by the help of broadband antennas, and waveguide method based on the measurement of the scattering parameters in a circular or rectangular waveguide [9,10]. The free-space method required samples of large dimensions (200x200mm or more) and it is particularly convenient in the case of low cost materials.

In this paper, the transmission characteristics of square drywall panels (200x200 mm) of 10mm thickness coated with a composite based on a commercial biochar are measured with two broadband horn antennas in an anechoic chamber in the frequency band 1-12GHz at normal incidence. The scattering parameter S_{21} of a reference sample without coating and the scattering parameter of samples coated with two layers of composite based on biochar are compared.

II. MATERIALS AND SAMPLE PREPARATION

Commercial biochar in form of powder supplied by Carlo Erba, was thermally treated at 750 °C for four hours in a packed and full alumina crucible. The powder was then manually blended with water in the proportion 16:100 g. A 2% methyl hydroxyethyl cellulose solution (8 g.) and 25 drops of 25% NH_3 were added and mixed for 1 minute more until the mixture reached a viscous consistency.

The composite was then applied on one of the faces of a commercial drywall panel (200x200 mm and 10 mm thick) to form a layer with thickness less than 1 mm. Thereafter, the sample was cured in ambient conditions ($T=25$ °C and relative humidity 50%) for 24 hours. This procedure was repeated twice overlapping 2 layers. A reference specimen consisting of a drywall panel itself was also considered for the experimental tests (see Fig. 1)

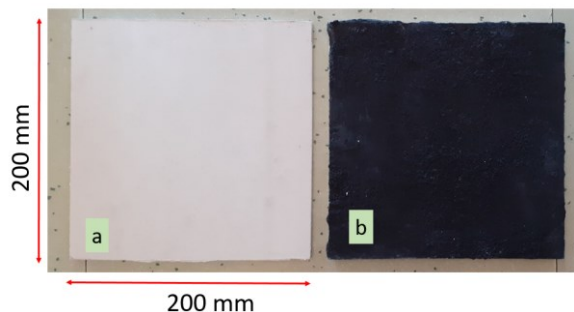


Fig. 1. a) reference sample (drywall) b) drywall with 2 layer biochar coating.

III. RESULTS

Transmission measurements were performed in a full anechoic chamber of dimensions 2x4x2m with a metallic external enclosure. Walls, ceiling, and floor are lined with 8''

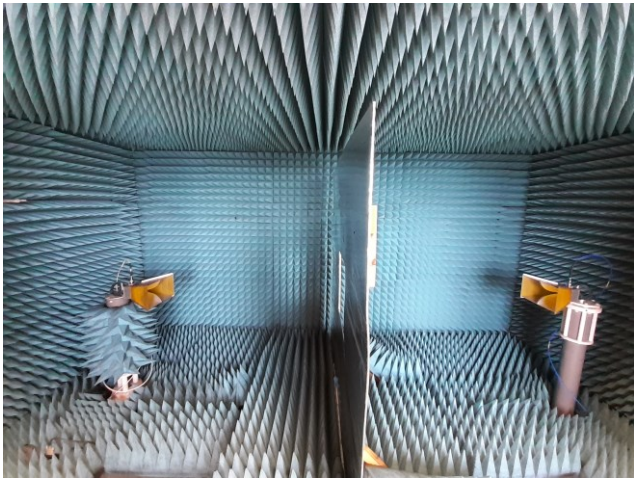


Fig. 2 Measurement setup for transmission measurements of the drywall.

pyramidal microwave absorbers operating above 1200 MHz up to 90 GHz, with 3 axis positioner, for measurement of gain, far field patterns (amplitude and phase) and antenna matching parameters. Double-ridged, vertically polarized broadband horn antennas operating from 1-18 GHz connected to a vector network analyzer (Agilent E8361A) were mounted in the chamber.

Each sample was placed at the center of the chamber fixed on a thin wooden holder of dimensions 1.5x1.5m (see Fig. 2). Distance between the horns was 2.5m and the wooden holder placed in the middle. The scattering parameter S_{21} was measured with the reference sample made of drywall only ($S_{21,ref}$) and with the samples made of drywall coated with biochar paste ($S_{21,sample}$). The transmission coefficient is then computed in dB as:

$$T = 20 \log_{10} \frac{|S_{21,sample}|}{|S_{21,ref}|} \quad (1)$$

Results are shown in Fig. 3 for two samples coated with 2-layer of biochar-based composite. The transmission coefficient is lower than -10dB in the whole frequency band.

IV. CONCLUSIONS

In this work, drywall panels coated with a 2-layer composites based on commercial biochar were made to investigate their shielding properties. Biochar was treated at 750 °C for four hours and mixed with proper solvent to obtain the necessary consistency. Two-layers of composites were then applied on one face of the drywall panels. The scattering parameter S_{21} was measured in an anechoic chamber and compared with the results obtained for a drywall panels without coating. A transmission coefficient lower than -10dB was obtained in the frequency band 1-12GHz. This results can be improved considering a coating with more layers, or using a biochar thermally treated at higher temperature.

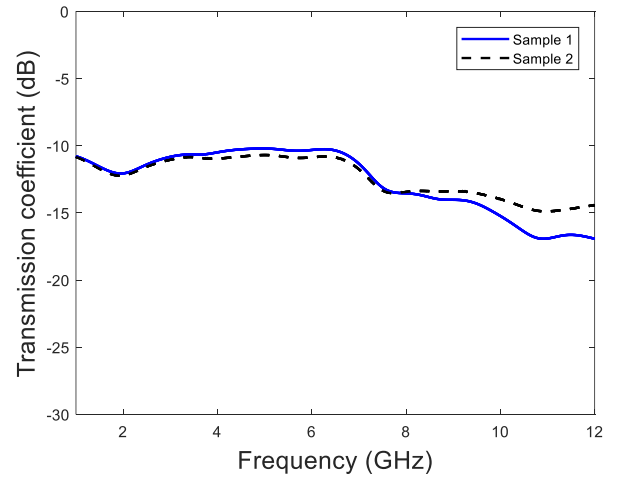


Fig. 3. Plots of the transmission coefficient versus frequency for two samples coated with a 2-layer biochar composites.

REFERENCES

- [1] M. Aqeeli, T. Leng, X. Huang, et al. "Electromagnetic interference shielding based on highly flexible and conductive graphene laminate," *IET Electronics Letters*, vol 51 (17), 2015, pp. 1350–1352, doi: 10.1049/el.2013.3695.
- [2] M. A. Jamshed, F. Hélot and T. W. C. Brown, "A Survey on Electromagnetic Risk Assessment and Evaluation Mechanism for Future Wireless Communication Systems," *IEEE Journal of Electromagnetics, RF and Microwaves in Medicine and Biology*, vol. 4 (1), March 2020, pp. 24-36, doi: 10.1109/JERM.2019.2917766.
- [3] T. Li, D. W. Kirk, C. Q. Jia, "Monolithic wood biochar as functional material for sustainability," *The Canadian Journal of Chemical Engineering*, vol. 99 (3), 2021, pp. 640-656.
- [4] E. Agrafioti, G. Bouras, D. Kalderis, E. Diamadopoulos, "Biochar production by sewage sludge pyrolysis," *Journal Anal. Appl. Pyrolysis*, vol. 101, 2013, pp. 72–78. <https://doi.org/10.1016/j.jaap.2013.02.010>.
- [5] K. Vikrant, Ki-H. Kim, Y. Sik Ok, Daniel C.W. Tsang, Yiu Fai Tsang, B. S. Giri, R. S. Singh, "Engineered/designer biochar for the removal of phosphate in water and wastewater," *Science of the Total Environment*. 616-617, 2018, pp. 1242-1260.
- [6] A.A. Khan, P. Savi, S. Quaranta, M. Rovere, M. Giorcelli, A. Tagliaferro, C. Rosso, C. Jia, "Low-Cost Carbon Fillers to Improve Mechanical Properties and Conductivity of Epoxy Composites," *Polymers*, 9 (12), 2017, pp. 642-654.
- [7] S. Nanda, A.K. Dalai, F. Berruti, J.A. Kozinski "Biochar as an Exceptional Bioresource for Energy Carbon Sequestration, Agronomy Activated Carbon and Speciality Materials," *Waste Biomass Valor*, 2015, pp. 1-35.
- [8] P. Cataldi, J.A. Heredia-Guerrero, S. Guzman-Puyol, L. Ceseracciu, L. La Notte, et al., "Sustainable electronics based on crop plant extracts and graphene: A Bioadvantaged approach," *Advanced Sustainable Systems*, vol. 2(11), 2018, doi:10.1002/adsu.201800069.
- [9] P. Savi, D. Cirielli, D. di Summa, G. Ruscica, I. Natali Sora, "Analysis of shielding effectiveness of cement composites filled with pyrolyzed biochar," *IEEE 5th International Forum on Research and Technology for Society and Industry (RTSI)*, 2019, pp. 376–379, doi.org/10.1109/RTSI.2019.8895522.
- [10] M. Giorcelli, P. Savi, A. Delogu, M. Miscuglio, Y.M.H. Yahya, A. Tagliaferro, "Microwave absorption properties in epoxy resin multi walled carbon nanotubes composites," *International Conference on Electromagnetics in Advance Applications*, 2013, pp.1139-1141.