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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 o 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)

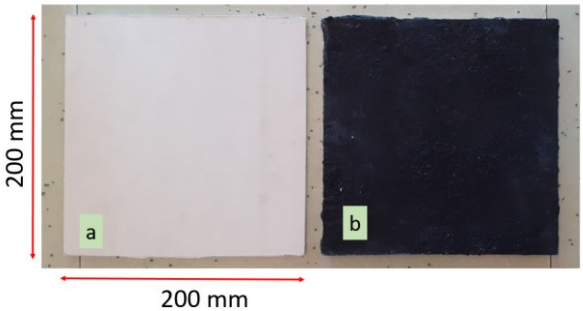

Fig. 1. a) reference sample (drywall) (b) drywall with 2 layer biochar coating.

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”

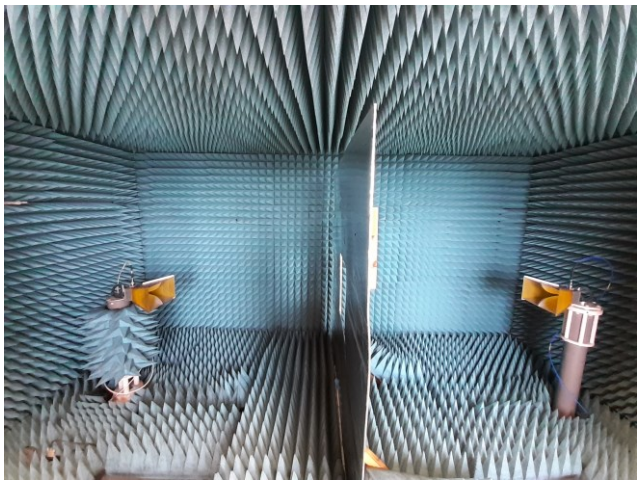

Fig. 2 Measurement setup for transmission measurements of the drywall.

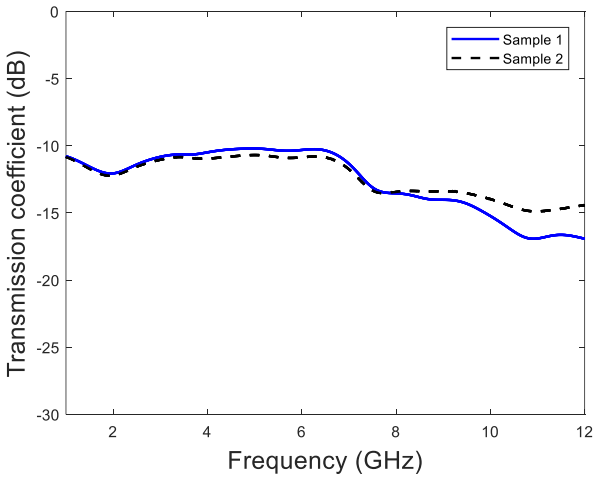

Fig. 3. Plots of the transmission coefficient versus frequency for two samples coated with a 2-layer biochar composites.

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:

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

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.

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