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Sustainable Biochar Coated Drywall with Electromagnetic Shielding Properties

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***Abstract*—The construction sector, traditionally focused on structural integrity and thermal performance, is now exploring the possibility of integrating electromagnetic shielding capabilities into building materials. Biochar, a material derived from biomass with a high carbon content, is a sustainable, renewable, eco-friendly, and cost-effective option in many applications. Recently, biochar has been added to construction materials to obtain electromagnetic shielding properties. In this work, commercial lignin biochar, thermally treated at $750\ ^\circ$C, is applied on drywall panels to develop a building component with increased shielding properties for the construction sector. The transmission of drywall panels coated with several biochar layers is measured in the frequency band 5-12 GHz.**

***Index Terms*—electromagnetic shielding, biochar, drywall**

I. Introduction

Biochar, is a porous, carbon-rich material derived from various types of organic materials such as wood chips, agricultural waste, and other biomass feedstock. It is obtained through a process of thermal breakdown in the absence of oxygen at various temperatures (pyrolysis) [1], [2].

Biochar has been used in various applications including soil amendment [3], carbon sequestration [4] and water decontamination [5]. Biochar is also used in innovative construction materials as a partial cement substitute to reduce overall carbon emissions [6], [7], [8]. Recently, microwave absorption properties of cement-based materials adictivated by biochar have been analyzed to enhance the electromagnetic shielding properties of construction materials [9], [10].

In this work, commercial drywall panels are coated with several layers of biochar and the transmission properties measured and compared with a reference drywall panel without coating.

II. Drywall samples realization

The drywall is a panel made of gypsum plaster pressed between two thick sheets of paper. It is commonly used in the construction of interior walls and ceilings. The gypsum core provides fire resistance and soundproofing and contributes to the overall stability of the panel. Drywall is used to create smooth finished surfaces in buildings. It is a popular material because of its ease of installation, cost-effectiveness, and versatility.

A commercial powder of biochar obtained from wood pyrolisis of Carlo Erba Reagents is used. Thermogravimetric and Differential Thermal analysis (TG-TDA) is performed to investigate the water and carbon content of the biochar powder. TGA curve is shown in Figure 1.

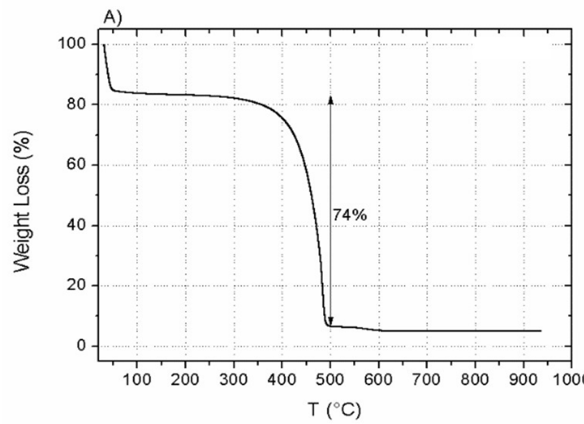

Fig. 1. TGA curve of biochar powder (from [11])

Due to the evaporation of the adsorbed water, the weight loss is about 16% below 100^o C. From 350°C to 500°C the weight loss is about 74% of the total weight of the sample and it is due to the combustion of the graphitic carbon fraction. At 950 °C, a residue of around 5% in weight is observed respect to the initial amount.

The biochar powder is first treated at 750 °C for four hours. Biochar is mixed with water, methyl hydroxyethyl cellulose (MHEC), and ammonia (NH_3) in different proportions (see Table 1). This mixture is manually applied on one side of each drywall panel. The panels are 10 mm thick and have a surface area of 30x30 cm^2. The application of the biochar-based paste is repeated three times. After each application, the panel was kept at ambient conditions (T=25^o C and relative humidity 50%) for 24 hours.

TABLE I
Biochar paste composition

Biochar (gr)	Water (ml)	MHEC (gr)	NH_3 (drops)
27	118	7	31

III. Results

Transmission measurements were made using double-ridged, linearly polarized broadband (1 GHz–18 GHz) horn

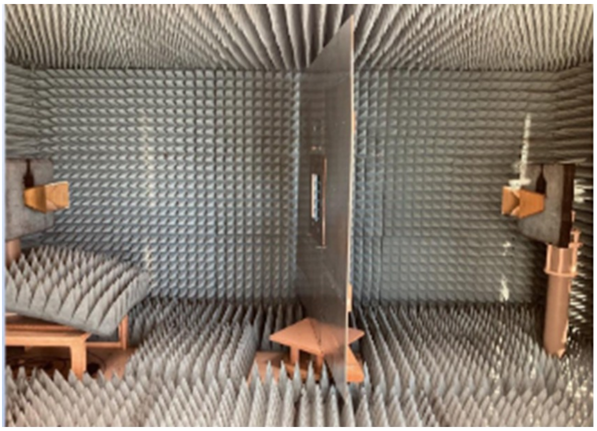

Fig. 2. Measurement setup

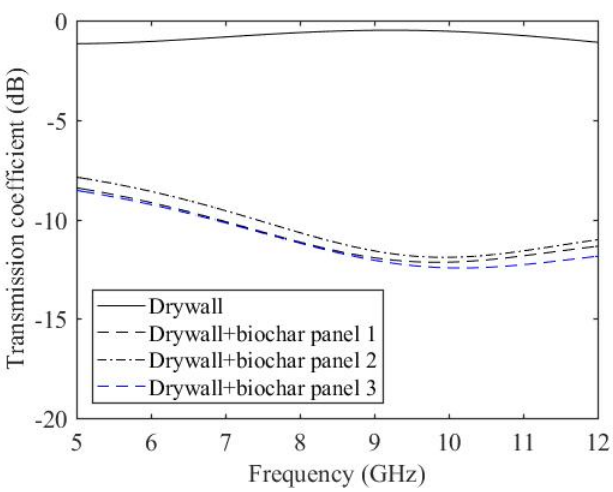

Fig. 3. Transmission coefficient (dB) of three samples of biochar coated drywall compared with drywall without coating.

antennas mounted on a 3-axis positioner and connected to a vector network analyzer (Keysight, N5227A). The transmitting and receiving antennas, as well as the sample under test, are positioned inside an anechoic chamber (dimensions of 2 m × 4 m × 2 m), while the signal generator and receiver are placed outside to eliminate interference. The anechoic chamber has the walls, ceiling, and floor covered with pyramidal microwave absorbers designed from 1200 MHz up to 90 GHz.

The samples are mounted on a wooden holder covered with a metal sheet. The holder has a window of 30 cm x 30 cm where the sample under test can be fixed. The transmission coefficient is measured by comparing the signal levels with and without the sample (see Fig. 2). The transmission coefficient of three samples of drywall (10 mm thick) covered on one side with biochar is measured. Results are shown in Figure 3 and compared with a drywall panel without any coating. The drywall panel alone is almost transparent (transmission around 0.5 dB) while the transmission coefficient is about - 10 dB in almost the whole frequency band.

IV. Conclusions

Commercial biochar has been used as a coating on standard drywall panels and the transmission measured in the frequency band 5-12 GHz. Results show drywall panels without coating exhibits a transmission around 0 dB. By adding three layers of biochar to the drywall, the transmission is -10 dB. These results are significant for several reasons. First, they propose a practical and potentially low-cost solution for reducing indoor EMF exposure, an issue of growing public health concern. Second, they offer a promising way for the sustainable use of biochar, a byproduct of biomass pyrolysis, from a circular economy perspective for the construction sector. Unlike many traditional shielding materials that can be expensive or difficult to install, modified gypsum board panels could easily integrate into existing construction practices.

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