REVISTA MATÉRIA V.28 N.4
ISSN 1517-7076 articles e20230273, 2023

# Use of nanotalc as raw material for application in plaster matrix

Luciana Silva Villela[1], Ianca Oliveira Borges[1], Lorran de Sousa Arantes[1], Ana Carolina Corrêa Furtini[1], Larissa Nara Nascimento de Miranda[1], Mário Guimarães Junior[2], Lourival Marin Mendes[1], José Benedito Guimarães Júnior[1]

[1]Universidade Federal de Lavras, Departamento de Ciências Florestais. C.P. 3037, 37200-900, Lavras, MG, Brasil.

[2]Centro Federal de Educação Tecnológica de Minas Gerais, Departamento de Engenharia. Araxá, MG, Brasil.

e-mail: lucianavillela_3@hotmail.com, iancaborges@hotmail.com, lorran.arantes@ufla.br, carol.furtini@gmail.com, larissanara8@gmail.com, mgjunior@cefetmg.br, lourival@ufla.br, jose.guimaraes@ufla.br

## ABSTRACT

Despite the increasing use of plaster as a construction material, due to its numerous advantages when compared to cement, its use is still restricted, because of its low mechanical resistance and high solubility in water. In this context, research has been carried out related to the addition of nanomaterials to improve the mechanical and physical properties of plaster in civil construction. A highly available, low-cost nanomaterial with excellent properties is nanotalc. In this work, nanocomposites with dimensions of 40 × 40 × 160 mm were produced with ultrafine micronized nanotalc replacing plaster in proportions of 0%; 0.5%; 1%; 1.5% and 2%. The physical and mechanical properties of the nanocomposites were evaluated according to standards. The nanocomposites produced with 1% nanotalc showed satisfactory results for physical and mechanical properties, with an increase of 1.8% in apparent density and 24.12% in compressive strength, and a decrease in water absorption of 6.23%, compared to the composite without the incorporation of nanotalc. The production of nanocomposites with the incorporation of 1% nanotalc is viable and shown to be promising, presenting potential for application as linings and internal partitions, since they showed low water absorption due to the hydrophobicity of nanotalc.

**Keywords:** Nanocomposites; Nanomaterial; Construction civil.

## 1. INTRODUCTION

Plaster is a civil construction material, widely used in interior construction and decoration systems [1], being considered an ecologically correct material, as it does not emit carbon dioxide in its production process. It has excellent thermal and acoustic properties, absence of drying shrinkage, fire strength, fast hardening and excellent surface finish when compared to cement [2]. However, plaster has low water strength, since it has reduced mechanical strength, especially under conditions of higher humidity, being widely used indoors [3].

Due to the limitations present in plaster matrices, it is necessary to incorporate reinforcements to improve the physical and mechanical properties, expanding their use and application [3]. To overcome this challenge, researchers are developing, designing and creating so-called nanocomposites, which consist of the use of reinforcements with reduced dimensions on a nanometric scale. These materials present improvements in physical and mechanical properties, being considered promising for construction in terms of compressive strength, density, porosity and new applications [4].

In this context [5], studied the effect of carbon nanomodifier (HFNCM) on the structure and properties of plaster stone, where they obtained improvements in water strength. The research by LI *et al.* [6] evaluated the influence of nanosilica on flue gas desulfurization (FGD) plaster and observed a decrease in the water absorption rate and an increase in compressive strength. GORDINA *et al.* [7], TOKAREV *et al.* [8] and DEREVIANKO *et al.* [9] evaluated plaster modifications using carbon nanotubes. In addition, works using nanocellulose are also growing, such as the study by NINDIYASARI *et al.* [10] who evaluated the mechanical impacts suffered with the addition of 1 and 2% of nanofibrillated cellulose.

Nanotechnology allows the creation of materials with new properties and functionalities. Talc is a mineral with low density, with Mohs hardness on the 1 scale [11] and due to its lamellar geometry (basal faces represent 90% of the total surface) it has a characteristic hydrophobic profile [12]. Adding a hydrophobic material, such as talc, to plaster has several benefits, such as improving water resistance, which is especially useful in

Corresponding Author: Ianca Oliveira Borges Received on 28/09/2023 Accepted on 01/12/2023

DOI: https://doi.org/10.1590/1517-7076-RMAT-2023-0273

applications where the plaster may come into contact with moisture. Reduce water absorption, where the hydrophobic material helps prevent plaster degradation and extend its useful life. Improve the mechanical properties of plaster, making it more resistant and durable. Therefore, adding hydrophobic material to plaster is a way to improve its physical and chemical properties, making it more suitable for certain applications, especially those where water resistance is important.

Among the technical specifications for using talc, particle size is one of the most important to be controlled [13]. This is because particle size has a direct influence on the properties of the material. The plastics industry, for example, uses talc with a particle size of 1 to 20 µm, with a tendency to use it in increasingly smaller particle size ranges [14]. The interest in reducing particle size is due to the fact that this characteristic is inversely proportional to their contact surface, that is, the decrease in particle size causes an increase in the interaction of particles with the matrix in which they are inserted, improving the physical properties mechanics of the material.

To obtain ultrafine particles from materials that have crystalline and brittle characteristics such as talc, micronization is normally used, which is the reduction of particle size by grinding, which can be classified as fine grinding, when the particle size is less than 100 and greater than 10 µm, and ultrafine, less than 10 µm [15]. Micro, or nanometer, scale talc (nanotalc) is widely used in polymers, mainly due to its low cost [11, 16] gains in mechanical properties have been reported [16]. However, no research was found regarding the insertion of nanotalc in plaster matrix.

Nanotalc is considered a highly available, inexpensive nanomaterial with desirable properties for certain applications. Given the context presented, this study incorporated the concentrations of 0.5%, 1%, 1.5% and 2% of nanotalc in the plaster matrix, evaluating the effect on the physical and mechanical properties. The use of nanotalc aims to improve water strength and increase the mechanical strength of plaster, to expand its use as a building material.

## 2. MATERIALS AND METHODS

### 2.1. Obtaining and characterizing

For the production of nanocomposites, fine commercial plaster for casting with an apparent specific mass of 781 kg/m$^3$ and a fineness modulus of 0.85, coming from the Araripe (PE) plaster hub, was used as a matrix. For reinforcement, ultrafine micronized nanotalc was incorporated, with a lamellar structure, white and asbestos-free, supplied by the company Xilolite, located in the city of Brumado (BA). Table 1 shows the chemical and physical information of nanotalc according to the product's technical sheet provided by the company Xilolite.

**Table 1:** Chemical and physical analysis of nanotalc.

| CHEMICAL ANALYSIS | TYPICAL VALUES |
|---|---|
| $SiO_2$ (%) | 57.50 |
| MgO (%) | 34.60 |
| CaO (%) | 0.48 |
| $Al_2O_3$ (%) | 0.50 |
| $Fe_2O_3$ (%) | 0.40 |
| Fire loss (1000ºC) | 6.50 |
| Acid soluble (HCl) | 1.50 |
| pH (solution 10%) | 8,5 |
| **PHYSICAL CHARACTERISTICS** | **TYPICAL VALUES** |
| Moisture (%) | 0.5 |
| Actual density (g/cm$^3$) | 2.7 |
| Hardness (Mohs) | 1 |

To analyze the chemical composition of nanotalc, analytical results were used, where solvents are used for their extraction and determination. Therefore, the amounts found of the chemical elements presented are soluble in the extraction solution and do not represent the total amount.

### 2.2. Production of nanocomposites

The nanocomposites were produced varying the percentage of incorporated reinforcement, totaling five different compositions (Table 2). For the study, six specimens were made for each treatment.

**Table 2:** Different compositions of the produced nanocomposites (m/m).

| TREATMENT | COMPOSITIONS | |
|---|---|---|
| | PLASTER (%) | NANOTALC (%) |
| 0% | 100 | 0.0 |
| 0.5% | 99.50 | 0.5 |
| 1% | 99.00 | 1.0 |
| 1.5% | 98.50 | 1.5 |
| 2% | 98.00 | 2.0 |

The research used concentrations of 0%; 0.5%, 1%, 1.5% and 2% of nanotalc in relation to the plaster mass. The nanocomposite production process followed the scheme shown in Figure 1.

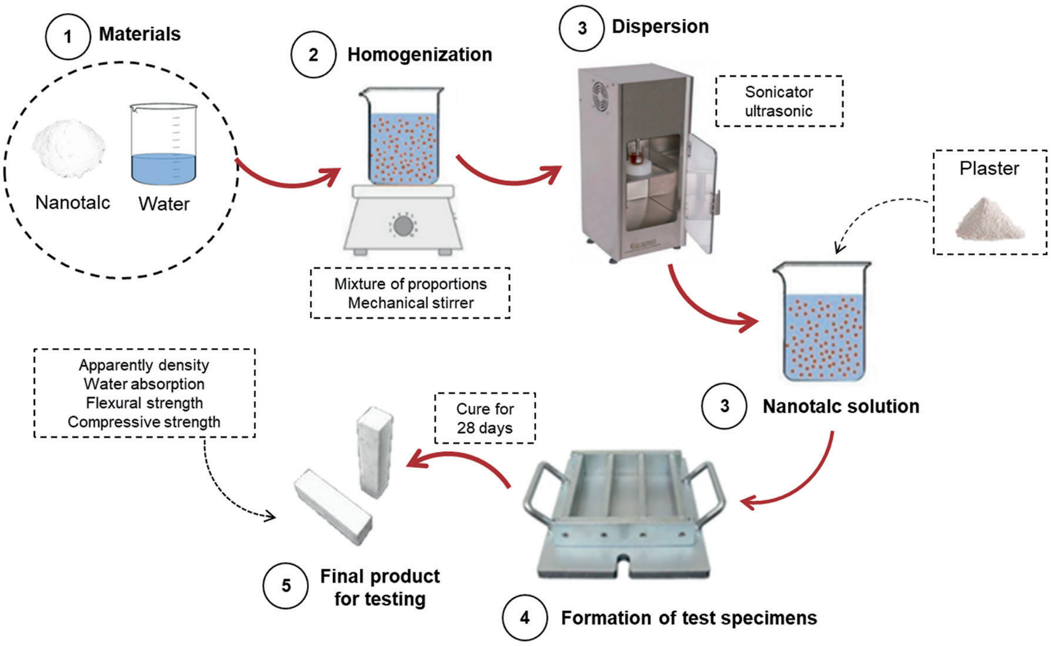


**Figure 1:** Representative scheme of the production of nanocomposite test specimens.

The specimens were produced using metallic molds with internal dimensions of 40 × 40 × 160 mm, according to the specifications of EN 13279-2 [17]. The nanotalc was initially placed in a beaker with water and stirred for a period of 24 h to exfoliate its cleavage layers. The ratio water/plaster used for the production of nanocomposites was 0.6, which is the ratio that guarantees good workability of the plaster paste [7, 18].

After a period of 24 h, the specimens were demoulded and stored in a dry, ventilated and weather-free place. During the seven-day period, they were reoriented daily to ensure uniform healing. At 28 days, the physical-mechanical tests were performed.

### 2.3. Evaluation of physical and mechanical properties

To determine the specific mass, the NM 23 [19] and EN 520 [20] standards were used for water absorption by immersion after 2 h. For the mechanical tests, flexion and compression tests were carried out in a universal testing machine in accordance with the BALTI *et al.* [21]. For the 3-point bending test, the specimens had dimensions of 40 × 40 × 160 mm, the distance between the machine supports was 100 mm. As for the compression test, the dimensions of the specimens were 40 × 40 × 40 mm.

### 2.4. Microstructural evaluation (SEM) with energy dispersive X-ray spectroscopy (EDS)

Scanning electron microscopy (SEM) was performed to characterize the rupture surface of the specimens, after the mechanical flexion test, in the fracture region, with the objective of verifying the interaction between the plaster matrix and the nanoreinforcement, observing whether the voids in the matrix were filled by nanotalcs.

The size of the specimens was adjusted to 1 × 1 × 1 cm (length × width × thickness) for each sample, and dried in an oven at 70°C for a period of 10 hours. Subsequently, they were kept in containers containing silica gel to maintain humidity. Then, the specimens were positioned on aluminum sample holders (stubs) and covered with carbon, using the Bal-tec carbon evaporator equipment. This was used for scanning electron microscope (SEM) FEG-UHR Clara Tescan with X-ray detector X-Flash6-60 Bruker (SEM/EDS) was properly calibrated for the element analysis condition.

Observation in SEM with EDS analysis was performed with magnification of 200,000× for relative quantification of the elements, obtaining the energy spectra of the elements, studying the distribution of elements (function mapping) for each sample, keeping the working distance (WD) close to 9 mm, Kcps value greater than 30 units, voltage at 20 KeV, Bean Current around 1 ηA. Images were taken using a secondary electron detector being emitted at magnifications of 2000, 20,000 and 200,000x.

### 2.5. Analysis of results

The results of the physical and mechanical analyzes were evaluated using a completely randomized design and submitted to analysis of variance and regression at 5% of significance, with the aid of the Sisvar software.

## 3. RESULTS AND DISCUSSIONS

### 3.1. Physical properties of nanocomposites

The average values of the apparent density of the nanocomposites with the addition of nanotalc are shown in Figure 2. It can be seen that the adjustment was significant, and according to the straight line equation, the maximum point of the apparent density was with a percentage of 0.7% of nanotalc, with an increase of 1.8% when compared to the control treatment.

It is possible to observe in Figure 2 a slight trend towards an increase in density with up to 1% of nanotalc insertion, followed by a decrease when adding 1.5 and 2% of nanotalc. The low density, however, provides lightness to the material, due to the increase in empty spaces in the developed formulations [22]. The lightness of the materials is an interesting property for the civil construction segment, as lighter materials reduce effort requests [23] and accelerate construction schedules [24]. In view of the literature, one can see the great interest behind the development of low-density materials with the use of bio-based fibers and the addition of nanomaterials.

The values obtained in this research are close to those reported in the literature [25], when adding $TiO_2$ nanoparticles (0.5; 1; 1.5 and 2%) to plaster, obtained an average density with values between 1051 and 1098 kg/m$^3$ [26] when adding particles of residue from the cocoa agroindustry (2.5; 5; 7.5; 10%) to plaster-based composites, obtained an average density with values between 1138 to 1190 kg/m$^3$.

The average values of water absorption of the nanocomposites with the addition of nanotalc are shown in Figure 3. It can be noted that there was a slight decrease in water absorption, followed by a slight increase.

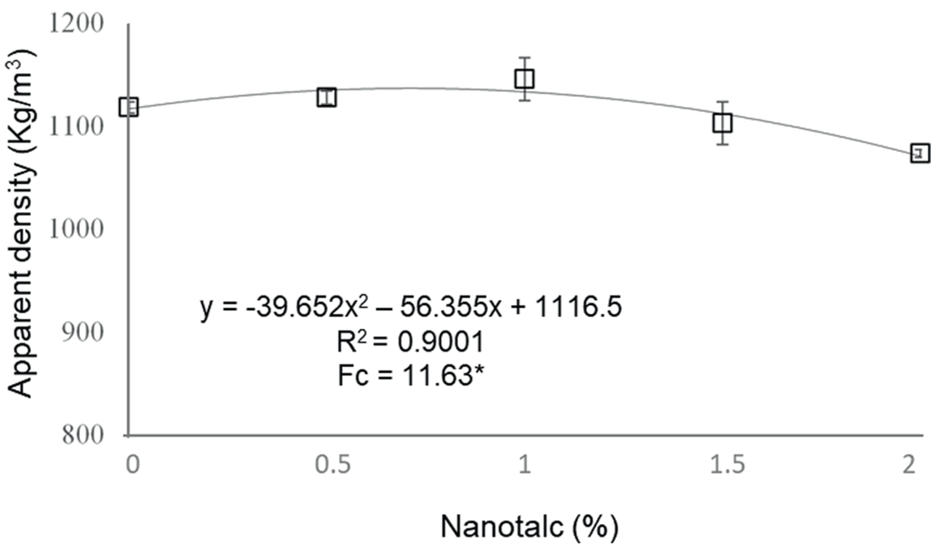


**Figure 2:** Apparent density of the produced nanocomposites.
* Significant regression analysis at the 5% level.

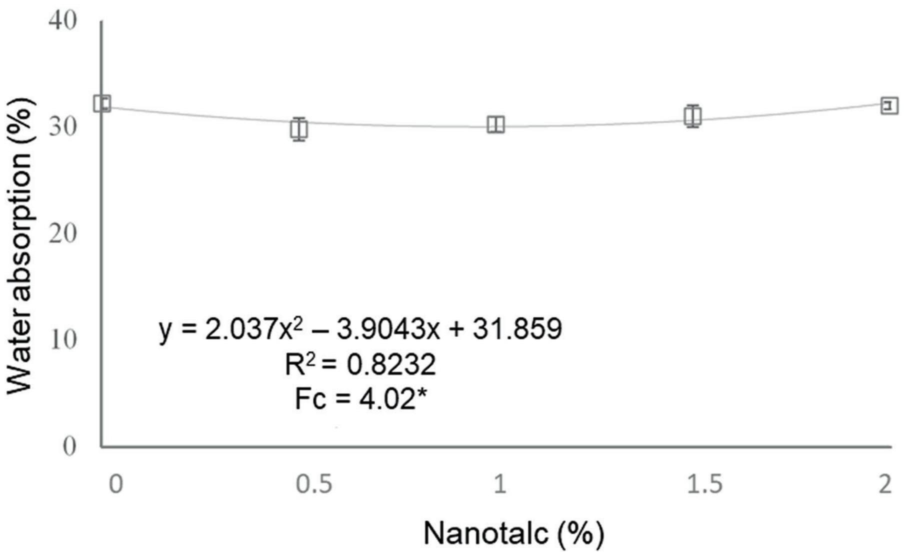


**Figure 3:** Water absorption of the produced nanocomposites.
* Significant regression analysis at the 5% level.

The adjustment was significant, and the minimum point of the characteristic curve was with 1% of nanotalc incorporation, having a decrease of 5.86% in water absorption when compared to the control treatment.

With the insertion of up to 1% of the nanomaterial, there was a decrease in water absorption, this behavior may have occurred due to the filling of empty spaces and consequent increase in apparent density. The increase in porosity is often reported in the literature when it comes to plaster-based composites and nanocomposites, and the main reason given is the formation of voids at the matrix-reinforcement interfaces [27–29].

According to the literature, the values obtained in this research are close to those reported [30] studied the plaster matrix reinforced with cellulosic pulp and jute blanket, finding average values of water absorption between 34.08% and 42.05% [23] when replacing plaster with cotton residues (0, 25, 50, 75 and 100%) obtained average values between 30% and 40%, the authors attributed the increase in water absorption due to the increased porosity of the composites, since the fiber volume was high and the plaster was unable to coat them efficiently and sufficiently, causing fragility of the interfacial connection.

PERVYSHIN *et al.* [18], by incorporating metallurgical powder residue into the plaster matrix, obtained an improvement in water strength, since this material during plaster hydration favored the formation of an amorphous phase of aluminum and calcium hydrosilicates, which protected the plaster crystals from dissolution.

Among the factors that impair the matrix-reinforcement interaction and cause incompatibility between the phases, the chemical properties of the materials used as reinforcement, the hydration and crystallization process of the plaster, the size and shape of the particles or fibers, dispersion, among others, can be mentioned [8–10, 26, 31]. Thus, the fact that nanotalc is hydrophobic, higher percentages may have caused problems with the distribution of particles in the matrix in the production process of the test specimens, making them less homogeneous. In aqueous environment, nanotalc platelets do not readily disperse with a stability element [32].

### 3.2. Mechanical properties of nanocomposites

The result obtained in the static flexion test (Figure 4) shows that, according to the statistical adjustment, there was no significant change in flexural strength as the incorporation of nanotalc increased. The literature demonstrates a variety of responses to mechanical tests in composites and nanocomposites using the plaster matrix, due to the types of reinforcements inserted their dispersion in the matrices, the amount of reinforcement used, among other factors.

Treatment without the addition of nanomaterials (reference) showed mean flexural strength values of 4.45 MPa, close to those found by NINDIYASARI *et al.* [10], JIMÉNEZ RIVERO *et al.* [33] and SERNA *et al.* [34], who found 5.65; 5.11 and 5.45 MPa, respectively. LONG *et al.* [35] studied the incorporation of talc in polyethylene (2,5-furanedicarboxylate) (PEF), talc dramatically reinforced the mechanical properties of the composites at a low load of 1.0% by weight of talc, leading to average increases in flexural strength of 49%, this increase was due to the good interfacial interaction originated from the hydrogen bonds between the filler and the PEF matrix.

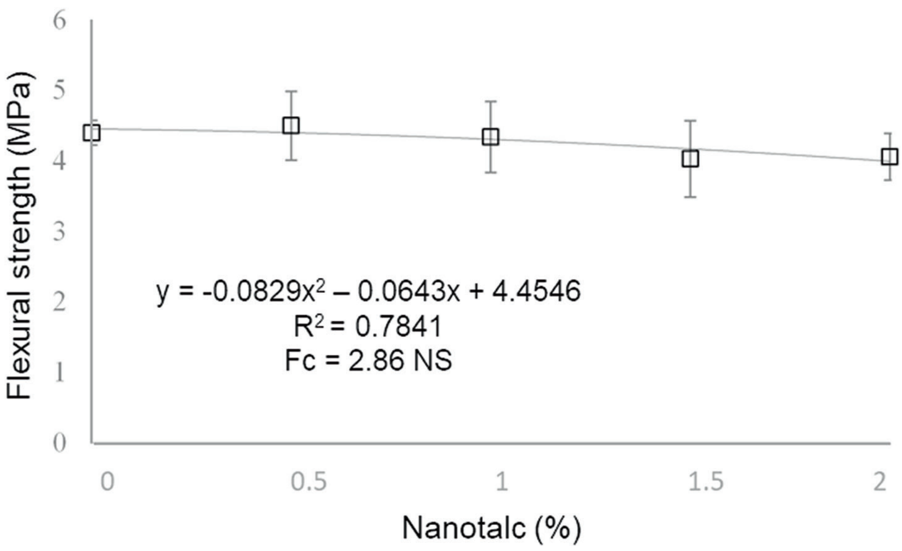


**Figure 4:** Flexural rupture modulus of the produced nanocomposites.
* Significant regression analysis at the 5% level.

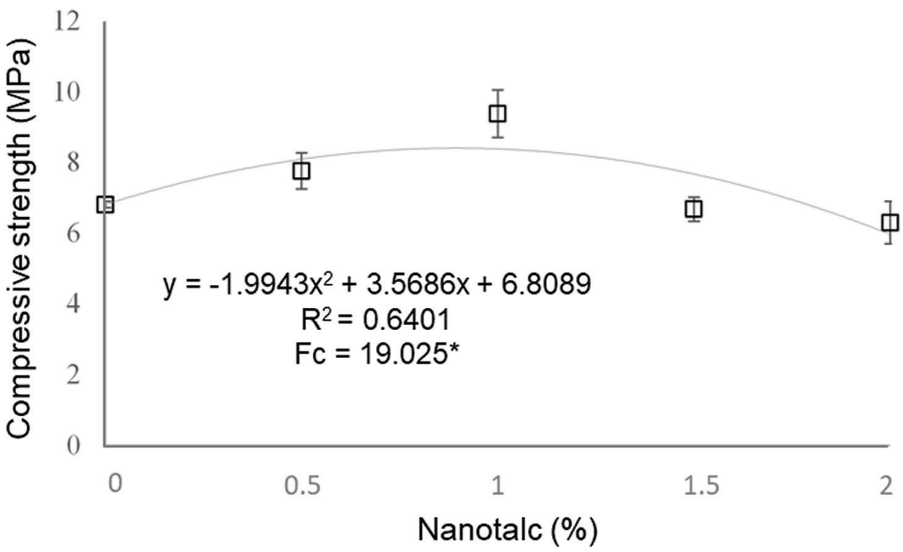


**Figure 5:** Compressive strength of the produced nanocomposites.
* Significant regression analysis at the 5% level.

In the compression test (Figure 5), the results showed improvement in strength up to a certain percentage of insertion of the nanomaterial, followed by a decrease. According to the statistical adjustment, which was significant, with an insertion of 1% nanotalc there was an increase of 24.12% in the compressive strength when compared to the control.

DEREVIANKO *et al.* [9], in their work with carbon nanotubes in the plaster matrix, observed the same trend found in this work for the compression and flexural strength, in which, up to a certain level of insertion of the nanoreinforcement, the strengths gradually increased, and then, increasing the content even more, these were reduced. NINDIYASARI *et al.* [10] observed an increase in the compressive strength of the plaster matrix of 18.37% when 1% of cellulose nanofibrils (CNFs) were added compared to the treatment without incorporation of the nanomaterial, the authors attributed this increase in strength to the fact that the CNFs filled the pores of the nanocomposites.

The porosity, the microcracks present in the composite, the shape and size of the particles, which can cause heterogeneity and segregation in areas of the composite, and the weak reinforcement/matrix interaction are the main influences on the mechanical properties [28, 36–39]. In the case of the present work, with the inclusion of nanotalc, it can be inferred that there was a change in the physical and mechanical properties, mainly in relation to the compressive strength, which increased more expressively.

### 3.3. Microstructural evaluation and energy dispersive X-ray spectroscopy (EDS)

In Figure 6A, it is possible to observe elongated, prismatic, needle-shaped plaster crystals and a more organized arrangement than in the other treatments. In the EDS analysis (Figure 6B) it is possible to confirm the presence of constituent elements of the crystalline phases corresponding to plaster β, with calcium, oxygen and sulfur. In Figure 6C, with the addition of 1% nanotalc, the morphology of the plaster crystals was modified, becoming short and blocky, resulting in a change in the microstructure and presenting a denser structure. Figure 6D shows, in addition to the constituents of plaster, the presence of silicon, aluminum, magnesium, iron and carbon, constituents of nanotalc (see Table 1).

The research by PERVYSHIN *et al.* [18] showed that by incorporating metallurgical powder residue into the plaster matrix, a dense solid plaster structure was formed and, consequently, the water strength properties were improved. This fact is explained by the authors due to the poorly soluble compounds based on hydrosilicates of calcium, aluminum and iron that were formed. Therefore, in the present research, a reduction in water absorption was found, since nanotalc also contains these chemical elements.

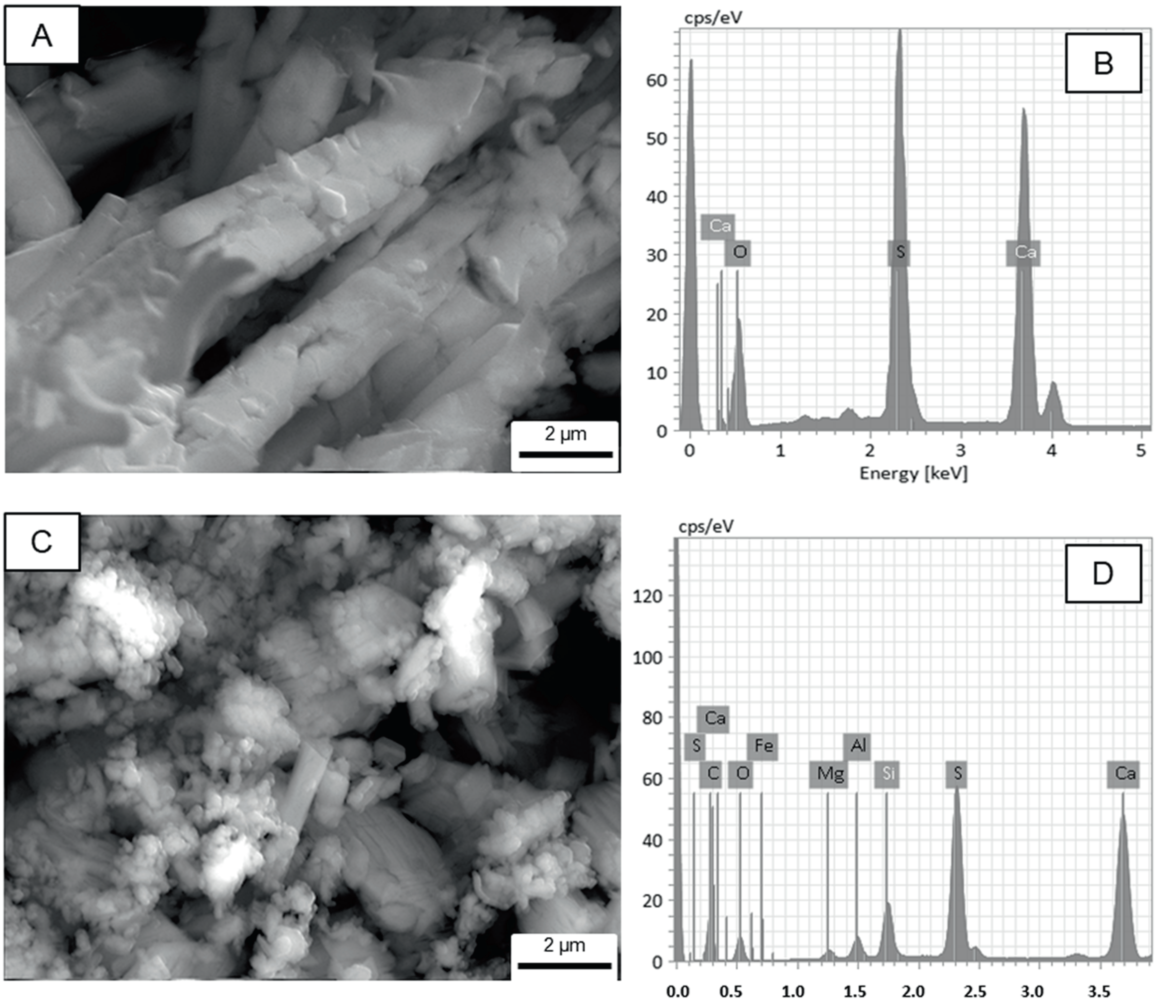


**Figure 6:** Scanning electron micrograph and EDS of the samples, being (a,b) without addition of nanotalc and (b,d) 1% of nanotalc.

## 4. CONCLUSIONS

The insertion of nanotalc showed satisfactory results in terms of physical and mechanical properties, since the insertion of up to 1% of the nanomaterial resulted in an increase of up to 1.8% in apparent density, an increase of up to 24.12% in compressive strength, decreasing water absorption by up to 6.23%, without significantly altering flexural strength.

The inclusion of 1.5 and 2% of nanotalc in the plaster provided a reduction in the apparent density, making the material lighter and more interesting for the civil construction segment, as lighter materials reduce the requests for efforts.

In short, the incorporation of nanotalc up to a concentration of 1% was feasible and showed to be promising, since it filled the empty spaces of the plaster matrix, guaranteeing a greater interaction between the particles and, consequently, improving their properties.

## 5. ACKNOWLEDGMENTS

The authors thank the Research Support Foundation of the State of Minas Gerais (FAPEMIG), Higher Education Personnel Improvement Coordination (CAPES) and National Council for Scientific and Technological Development (CNPq). We also thank the Nucleus of Studies in Forest Nanotechnology (NENF), the Nucleus of Studies in Wood Panels (NEPAM), Graduate Program in Biomaterials Engineering (PPGBIOMAT) and Forest Science Department (DCF) of the Federal University of Lavras, for their support.

## 6. BIBLIOGRAPHY

[1] MUTUK, T., ARPACIOĞLU, K., ALIŞIR, S., *et al*., “Thermal and mechanical evaluation of natural fibers reinforced gypsum plaster composite”, *Materials and Minerals*, v. 33, n. 1, pp. 116–123, 2023. doi: http://dx.doi.org/10.55713/jmmm.v33i1.1669

[2] BUTAKOVA, M.D., GORBUNOV, S.P., “Study of the influence of complex additives on properties of the plaster-cement-puzzolan binder and concretes on its basis”, *Procedia Engineering*, v. 150, pp. 1461–1467, 2016. doi: http://dx.doi.org/10.1016/j.proeng.2016.07.082

[3] YAKOVLEV, G., POLYANSKIKH, I., FEDOROVA, G., *et al*., “Anhydrite and plaster compositions modified with ultrafine man-made admixtures”, *Procedia Engineering*, v. 108, pp. 13–21, 2015. doi: http://dx.doi.org/10.1016/j.proeng.2015.06.195

[4] DAHLAN, A.S., “Impact of nanotechnology on high performance cement and concrete”, *Journal of Molecular Structure*, v. 1223, pp. 128896, 2021. doi: http://dx.doi.org/10.1016/j.molstruc.2020.128896

[5] MATVEEVA, L.Y., LETENKO, D.G., MOKROVA, M.V., “Influence of carbon nanomodifier on the structure and properties of the modified plaster binder”, *Materials Science Forum*, v. 992, pp. 233–237, 2020. doi: http://dx.doi.org/10.4028/www.scientific.net/MSF.992.233

[6] LI, J., CAO, J., REN, Q., *et al*., “Effect of nano-silica and silicone oil paraffin emulsion composite waterproofing agent on the water strength of flue gas desulfurization plaster”, *Construction & Building Materials*, v. 287, pp. 123– 155, 2021. doi: http://dx.doi.org/10.1016/j.conbuildmat.2021.123055

[7] GORDINA, A., TOKAREV, Y., YAKOVLEV, G., *et al*., “Evaluation of the influence of ultradisperse dust and carbon nanostructures on the structure and properties of plaster binders”, *Procedia Engineering Modern Building Material Structures and Techniques*, v. 57, pp. 334–342, 2013. doi: http://dx.doi.org/10.1016/j.proeng.2013.04.045

[8] TOKAREV, Y., GINCHITSKY, E., SYCHUGOV, S., *et al*., “Modification of plaster binders by using carbon nanotubes and mineral additives”, *Procedia Engineering*, v. 172, pp. 1161–1168, 2017. doi: http://dx.doi.org/10.1016/j.proeng.2017.02.135

[9] DEREVIANKO, V., KONDRATIEVA, N., HRYSHKO, H., “Study of impact factors and the mechanism of plaster binder hydration process in the presence of nanomodifiers”, *French-Ukrainian Journal of Chemistry*, v. 6, n. 1, pp. 92–100, 2018. http://dx.doi.org/10.17721/fujcV6I1P92-100

[10] NINDIYASARI, F., GRIESSHABER, E., ZIMMERMANN, T., *et al*., “Characterization and mechanical properties investigation of the cellulose/plaster composite”, *Journal of Composite Materials*, v. 50, n. 5, pp. 657–672, 2016. doi: http://dx.doi.org/10.1177/0021998315580826

[11] YOUSFI, M., LIVI, S., DUMAS, A., *et al*., “Use of new synthetic talc as reinforcing nanofillers for polypropylene and polyamide 6 systems: Thermal and mechanical properties”, *Journal of Colloid and Interface Science*, v. 403, pp. 29–42, 2013. doi: http://dx.doi.org/10.1016/j.jcis.2013.04.019. PubMed PMID: 23683955

[12] SAVINI, G., ORÉFICE, R.L., “Comparative study of HDPE composites reinforced with microtalc and nanotalcs: high performance filler for improving ductility at low concentration levels”, *Journal of Materials Research and Technology*, v. 9, n. 6, pp. 16387–16398, 2020. doi: http://dx.doi.org/10.1016/j.jmrt.2020.11.090

[13] SALVADOR, I.F.P.E., ALMEIDA, L.M. Talco. In: Luz, A.B., Lins, F.A.F. (eds.). *Rochas e minerais industriais: usos e especificações*, 2. ed., Rio de Janeiro, CETEM-MCT, pp. 793–816, 2008.

[14] DA CAMARA, A.L., "*Uso de talco nacional como aditivo adsorvente de piches e materiais pegajosos no processo de fabricação do papel*", M.Sc. Thesis,Universidade Federal de Minas Gerais, Belo Horizonte, 2003.

[15] LONDE, T.M., FINZER, J.R.D., "Micronização em moinho com jato de ar em espiral", In: Poisson, E. (ed.), *Engenharia no Século XXI*, v. 13, Belo Horizonte, Poisson, 2020. Doi: dhttp://dx.doi.org/10.36229/978-85-7042-235-4.CAP.04

[16] HADAL, R.S., MISRA, R.D.K., "The influence of loading rate and concurrent microstructural evolution in micrometric talc and wollastonite-reinforced high isotactic polypropylene composites", *Materials Science and Engineering A*, v. 374, n. 1–2, pp. 374–389, 2004. http://dx.doi.org/10.1016/j.msea.2004.03.035

[17] EUROPEAN COMITTE OF STANDARDIZATION, *EN 13279-2: Plaster binders and plaster plasters. Part 2: Test methods*, Bruxelas, CEN, 2006.

[18] PERVYSHIN, G.N., YAKOVLEV, G.I., GORDINA, A.F., *et al*., "Water-resistant gypsum compositions with man-made modifiers", *Procedia Engineering*, v. 172, pp. 867–874, 2017. http://dx.doi.org/10.1016/j.proeng.2017.02.087

[19] ASSOCIAÇÃO MERCOSUL DE NORMALIZAÇÃO, *NM 23: Cimento portland e outros materiais em pó – Determinação da massa específica*, Rio de Janeiro, AMN, 2000.

[20] EUROPEAN COMITTE OF STANDARDIZATION, *EN 520. Plaster plasterboards. Definitions, requirements and test methods*, Bruxelas, CEN, 2004.

[21] EUROPEAN COMITTE OF STANDARDIZATION, *EN 13279-1: Gesso e produtos à base de gesso para a construção, Parte 1: Definições e requisitos*, Bruxelas, CEN, 2008.

[22] BALTI, S., BOUDENNE, A., DAMMAK, L., *et al*., "Mechanical and thermophysical characterization of plaster composites reinforced by different wastes for green building applications", *Construction & Building Materials*, v. 372, pp. 130840, 2023. doi: http://dx.doi.org/10.1016/j.conbuildmat.2023.130840

[23] LOPES, T.A., FERREIRA, R.L., GARCIA, H.V.S., *et al*., "Nanocompósitos minerais produzidos com matriz de gesso e reforçados com resíduos de algodão (Gossypium herbaceum L.) Mineral composites produced with plaster matrix and reinforced with cotton waste (Gossypium herbaceum L.)", *Brazilian Journal of Development*, v. 8, n. 3, pp. 19205–19225, 2022. doi: http://dx.doi.org/10.34117/bjdv8n3-252

[24] CHARAI, M., SGHIOURI, H., MEZRHAB, A., *et al*., "Thermal insulation potential of non-industrial hemp (Moroccan cannabis sativa L.) fibers for green plaster-based building materials", *Journal of Cleaner Production*, v. 292, pp. 126064, 2021. doi: http://dx.doi.org/10.1016/j.jclepro.2021.126064

[25] PAWEŁKOWICZ, S.S., SVORA, P., PROŠEK, Z., *et al*., "Laboratory assessment of a photoactive Gypsum-based repair plaster", *Construction & Building Materials*, v. 346, pp. 128426, 2022. doi: http://dx.doi.org/10.1016/j.conbuildmat.2022.128426

[26] VELOSO, M.C.R., VILLELA, L.S., MESQUITA JÚNIOR, L., *et al*., "Produção e caracterização de nanocompósitos à base de gesso reforçado com partículas de resíduo da agroindústria do cacau", *Matéria (Rio de Janeiro)*, v. 26, n. 1, pp. e12945, 2021. doi: http://dx.doi.org/10.1590/s1517-707620210001.1245

[27] RIBEIRO, S., ALSERRA, J.C.V., "Composites obtained from waste paper and reinforced sawdust and plaster", *Engineering and Science*, v. 2, n. 1, pp. 1–9, 2014.

[28] SHIROMA, L., CAMARINI, G., BERALDO, A.L., "Effect of wood particle treatment on the properties of plaster plaster pastes and composites", *Revista Materia*, v. 21, n. 4, pp. 1032–1044, 2016. doi: http://dx.doi.org/10.1590/s1517-707620160004.0095

[29] THUMBS, J., KOHLER, H.-H., "Capillaries in alginate gel as an example of dissipative structure formation", *Chemical Physics*, v. 208, n. 1, pp. 9–24, 1996. doi: http://dx.doi.org/10.1016/0301-0104(96)00031-6

[30] FURTINI, A.C.C., DOS SANTOS, C.A., RODRIGUES, H.M.A.C., *et al*., "Compósitos laminados de gesso com reforço de polpa celulósica e manta de juta", *Conjecturas*, v. 22, n. 9, pp. 257–270, 2022. doi: http://dx.doi.org/10.53660/CONJ-1388-AG02

[31] HINCAPIE, A.M., CINCOTTO, M.A., "Efeito de retardadores de pega no mecanismo de hidratação e na microestrutura do gesso de construção", *Ambiente Construído*, v. 1, n. 2, pp. 7–16, 1997.

[32] CALABRIA-HOLLEY, J., PAPATZANI, S., NADEN, B., *et al*., "Tailored montmorillonite nanoparticles and their behaviour in the alkaline cement environment", *Applied Clay Science*, v. 143, pp. 67–75, 2017. doi: http://dx.doi.org/10.1016/j.clay.2017.03.005

[33] JIMÉNEZ RIVERO, A., DE GUZMÁN BÁEZ, A., GARCÍA NAVARRO, J., "New composite plaster plaster – ground waste rubber coming from pipe foam insulation", *Construction & Building Materials*, v. 55, pp. 146–152, 2014. doi: http://dx.doi.org/10.1016/j.conbuildmat.2014.01.027

[34] SERNA, A., RÍO, M., PALOMO, J.G., *et al*., "Improvement of plaster plaster strain capacity by the addition of rubber particles from recycled tyres", *Construction & Building Materials*, v. 35, pp. 633–641, 2012. doi: http://dx.doi.org/10.1016/j.conbuildmat.2012.04.093

[35] LONG, L., YE, B., WEI, J., *et al*., "Structure and enhanced mechanical properties of biobased poly(ethylene 2,5-furandicarboxylate) by incorporating with low loadings of talc platelets", *Polymer*, v. 237, pp. 124351, 2021. doi: http://dx.doi.org/10.1016/j.polymer.2021.124351

[36] DAI, D., FAN, M., "Preparation of bio-composite from wood sawdust and plaster", Industrial Crops and Products, v. 74, pp. 417–424, 2015. doi: http://dx.doi.org/10.1016/j.indcrop.2015.05.036

[37] KHALIL, A.A., TAWFIK, A., HEGAZY, A.A., *et al*., "Effect of some waste additives on the physical and mechanical properties of plaster plaster composites", *Construction & Building Materials*, v. 68, pp. 580–586, 2014. doi: http://dx.doi.org/10.1016/j.conbuildmat.2014.06.081

[38] KHALIL, A.A., TAWFIK, A., HEGAZY, A.A., "Plaster composites modified morphology with enhanced compressive strength and water strength characteristics", *Construction & Building Materials*, v. 167, pp. 55–64, 2018. doi: http://dx.doi.org/10.1016/j.conbuildmat.2018.01.165

[39] ROCHA, T.M.S., MIRANDA, L.F.R., PARCHEN, C.F.A., "Influência da composição granulométrica das partículas de resíduos de madeira nas propriedades de nanocompósitos minerais: parte 2: gesso-madeira", *Ambiente Construído*, v. 19, n. 4, pp. 195–206, 2019. doi: http://dx.doi.org/10.1590/s1678-86212019000400351