NEW FORMALDEHYDE-FREE PARTICLE PANELS MADE FROM AGRICULTURAL WASTES AND CHITOSAN

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EXTENDED ABSTRACT

OVERVIEW

Current environmental problems, deforestation, and tensions over raw materials, are pushing manufacturers to substitute wood in the production of wood-based panels by other alternative lignocellulosic sources. In addition, the replacement of synthetic binders based on non-renewable, petro-sourced, and carcinogenic formaldehyde with other bio based and biodegradable materials is being sought with the aim of pollution reduction and environmentally friendly materials production. Thus, the present work is devoted to the development of new panels using a polysaccharide binder, chitosan, in presence of reinforcements based on miscanthus or spent mushroom substrates combined with olive waste residues.

Keywords: Particleboards; miscanthus; spent mushroom substrate; olive pomace waste; chitosan

METHODS

Miscanthus × giganteus (M) from the summer 2018 harvest comes from the EARL Ar Gorzenn Company (Pont Croix, France). The spent mushroom substrate (SMS) is recovered from the "Gourmet mushroom" farm located in Byblos, Lebanon. These resources underwent grinding followed by automated sieving before use. Olive pomace waste is collected at the "Ghaoui-Ghaoui" olive mill in Darbechtar located in northern Lebanon. This waste has undergone crushing and manual sieving to separate the Olive pomace (OP) from the Olive Stones (OS) waste. Chitosan having a degree of deacetylation greater than 90%, a viscosity of 30 to 100 cps and an average molecular weight of 250,000 g mol^{-1} was purchased from Glentham Life Sciences (Corsham-Wiltshire, United Kingdom).

Four panels were prepared from the different components as shown in Table 1. The binder solution is prepared by dissolving chitosan (4% w/v) in aqueous glacial acetic acid solution (2% v/v) at room temperature using a mechanical stirrer. 24 g of OP or OS are added to the chitosan solution followed by mechanical stirring for 5 minutes. The mixture is then poured onto 36 g of M or SMS particles followed by manual mixing. The mixture is left at room temperature for 30 min to promote reinforcements wetting. Preheating is then applied for 60 min at 105 °C. The partially dried mixture is placed in a Teflon-coated stainless steel mold (180 × 50 × 70 mm^3) and compacted using a backing mold and a hydraulic press to a thickness of 1 cm. Compaction is maintained overnight in an oven at 105 °C. The panels are recovered after cooling and demoulding.

The bulk density, porosity, morphology, water absorption capacity by immersion and mechanical compressive strength before and after immersion are evaluated for the various panels.

RESULTS

Density and Porosity

The average bulk density and the porosity rate are presented in Table 1. Despite the similarity of the total initial weight and the fixed mold dimension, the bulk density of the materials was different depending on the reinforcement type. Thus, the SMS-based panels are much denser than the M-based ones because of significant volume shrinkage of the samples which are probably related to the collapse of the microtubes inside the cells and a reaction of mycelium present in SMS [1].

Table 1. Average bulk density and porosity rate of the panels as a function of the formulations

Sample name	Fibbers (36 g /24 g)	Average $\rho_{apparente}$ (kg/m^3)	Porosity (%)
MOP	Miscanthus / Olive Pomace	665 ±80	16.2
MOS	Miscanthus / Olive Stones	685 ±9	19.4
SMSOP	Spent mushroom substrate / Olive pomace	899 ±47	10.0
SMSOS	Spent mushroom substrate / Olive Stones	806 ±14	15.8

*For all panels: $m_{chitosane}$ = 4.5g; $V_{acetic\ acid\ 2\%}$ = 108 mL; $ratio_{fibres/binder}$ (%/% m/m) = 93/7

The porosity rate decreases with increasing bulk density, and conversely. The most porous panels are MOS and MOP. However, SMSOP has the lowest porosity rate. This phenomenon could be explained by the softening and shrinking of the mycelium [1] after cooking/drying of the panels at 105 °C inducing a decrease in the intrinsic porosity of the SMSs.

Optical Microscopy

Fig. 1 presents the superficial observations of the different panels using a "Ladybird MZ1240 Trinocular" stereomicroscope. The shiny layer on the surface of the fibres corresponds to the presence of the chitosan binder. This can be considered as an indicator of a good wetting of the different particles by the binder. It is visible that the M and SMS are well dispersed and homogeneously oriented parallel to the surface. It appears that OS are dispersed as aggregates. A gap is clearly visible between the particles indicating the presence of pores.

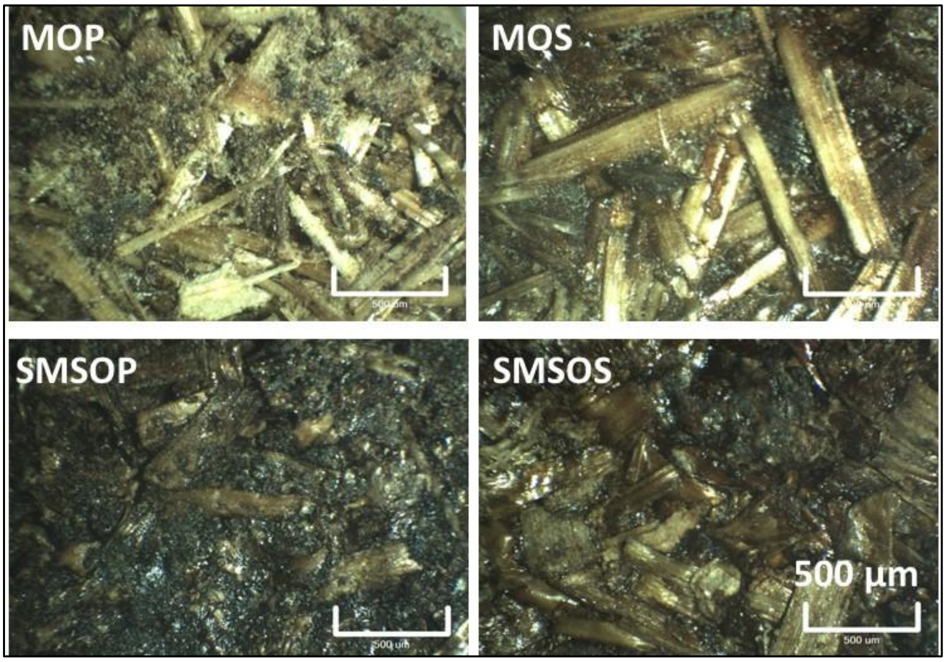

Fig 1. Microscopic observations of the panels surface according to the formulations

Absorption Capacity

The absorption capacity (Δm %) of the panels versus time is presented in Fig. 2. It seems that Δm is independent of the nature of the reinforcements. SMSOS panels have the highest absorption capacity for the first 30 minutes, while for the same duration a low absorption capacity (Δm <10%) is noted for the other panels. After immersion for 5 days, the MOP panels exhibit significant weight gain at saturation, reaching the threshold of 40%. This agrees with the photos of the microscope which show the presence of the large-diameter pores for the MOP panel. The rest of the panels seem to have an intermediate weight gain (32-35%).

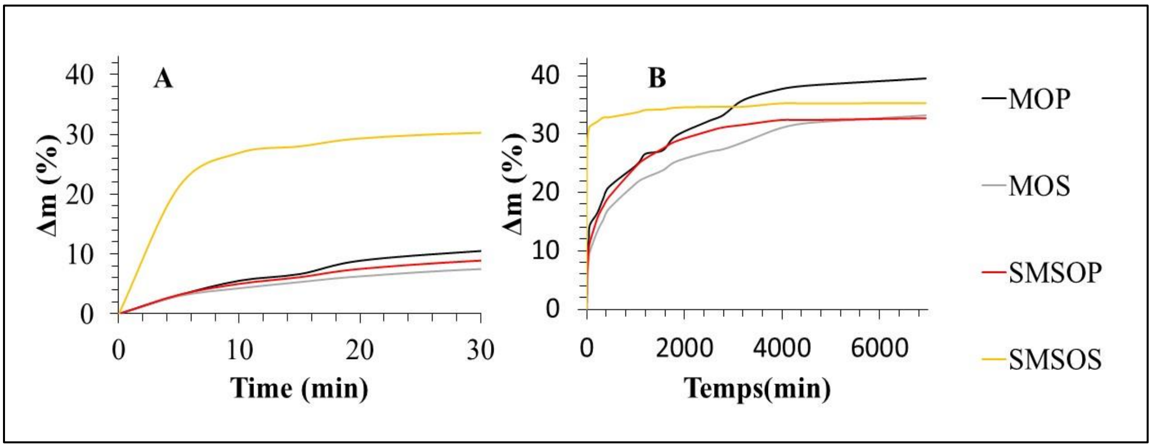

Fig 2. Absorption capacity of the panels versus time (A-for 30 min; B-for 5 days)

Mechanical Behaviour by Compression

Fig. 3 shows the compressive strength (MPa) values of the panels before and after immersion in water. SMSOP panels show the highest strength followed by M panels. This is explained by the presence of minor porosity for SMSOPs and the presence of mycelium. After immersion/drying, the compressive strength appears to be deteriorated for all panels. Only MOP panels seem to have close value to that obtained before immersion.

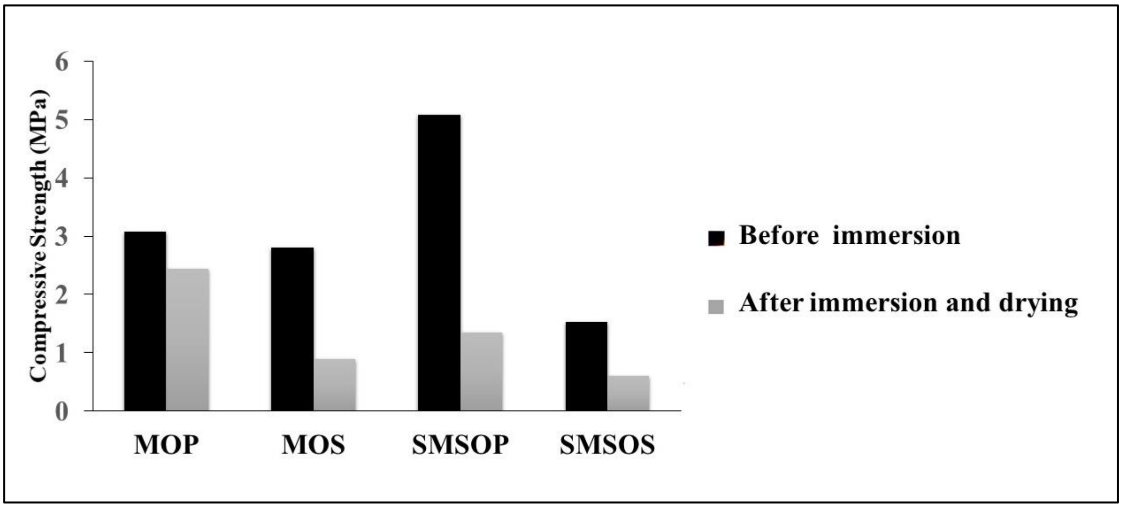

Fig 3. Compressive strength (MPa) of the panels before and after immersion/drying depending on the formulations

CONCLUSIONS

In this study chitosan-based panels using miscanthus and/or spent mushroom substrate with olive pomace waste was produced. Preliminary results show that panels are successfully prepared with an average density between 665 and 899 kg/m^3. The absorption capacity of all panels is less than 40% by weight despite the extended immersion time. To complete this study, additional mechanical bending and internal bonding strength analysis, contact angle analysis and microscopic observations after immersion will be performed. The aim of this study is the production of fully bio-based particleboards using local and/or neglected materials for interior design applications.

REFERENCES

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