



LIGHTWEIGHT, BIODEGRADABLE, DURABLE PARTICLEBOARDS

Grzegorz Kowaluk¹ – Waldemar Jaskółowski² – Izabela Borkowska¹ –
Katarzyna Kowalska¹ – Sylwia Milwicz¹

Abstract

The aim of this paper was to present the selected up-to-date results of investigation on production of the panels with lowered density by apply of non-wood, biodegradable particles, panels produced with use of waste material from exotic wood species, as well as improvement of reaction to fire of the particleboards by adding of calcium carbonate particles. The results show that the panels produced with use of foamed starch particles have constant mechanical properties, when the water absorption and swelling in thickness increases. There are possibilities to produce the particleboards with use of particles from waste veneers in core layer, when the mechanical and physical properties raise. Addition of 50% of calcium carbonate particles to particleboards' surface layers significantly reduces the flammability of the panels. The mechanical and physical parameters of such panels significantly improves with calcium carbonate content increase.

Key words: *particleboard, lightweight, biodegradable, starch, calcium carbonate*

INTRODUCTION

One of the most intensively explored area in the investigation of wood-based materials is application of new and/or unused up-to-now raw materials to produce of these. The reasons of such situation have the different roots. One of them, probably the most common in contemporary R&D sector, is price. This is also strongly connected to availability of resources on the market, which causes raise the costs with availability reduction. In the past, the technology of wood-based materials was a good experimental field to utilization of post-production wastes. Yet, it should be added that the technology of particleboards was developed to produce added-value composites from low quality wood residues from mechanical processing. Nowadays, generally speaking, there is no post-production wastes available on the market, especially in wood technology. Every kind of wood, irrespective of species and quality, could be utilized somehow. The last, but quite common way of wood residues utilization is energy production purpose. Therefore, apart from continuous trials to apply a lower quality and/or useless wood in wood-based materials, a growing tendency can be observed in application of non-wood resources to produce lignocellulosic composites. One of the purpose of application non-wood

¹ Warsaw University of Life Sciences – SGGW, Nowoursynowska Str. 159, 02-776 Warsaw, Poland
e-mail: grzegorz_kowaluk@sggw.pl

² The Main School of Fire Service, Słowackiego Str. 52/54, 01-629 Warsaw, Poland
e-mail: wjaskolowski@sgsp.edu.pl

particles, in this example nanoparticles, is flammability decrease. According to Lowden and Hull (2013) in the near future, it will be possible to apply nano-size particles to decrease wood and wood-based composites ability to burn.

The most typical ways to produce the panels with lowered density are: fast growing trees raw materials production (Kaniewski 1998), alternative raw materials (Güler et al. 2008) or modification of the structure of panel (e.g. sandwich board with honeycomb core). In case of fast growing trees, there is limitation of density reduction, connected to density of raw material. There is no such limit in case of sandwich boards, but the production of them is mostly for special, previously known purposes (with predefined dimensions).

The aim of this paper was to present the selected up-to-date results of investigation on production of the panels with lowered density by apply of non-wood, biodegradable particles, panels produced with use of waste material from exotic wood species, as well as improvement of reaction to fire of the particleboards by adding of calcium carbonate particles.

MATERIAL AND METHODS

Panels with foamed starch

As thick as 28 mm, three layer panels, with the density of 500 kg/m³, from industrial coniferous particles and urea-formaldehyde (UF) resin, with 0 (control panel), 5, 10 and 30% content in core layer (by weight) of foamed starch particles, were produced. The starch particles' biggest size was less than 20 mm. The share of face layers was 32%. The resination of all layers was 12%. As a hardener an aqueous solution of NH₄Cl was used, and the curing time of glue mass in 100°C was about 82 s. The moisture content of wood particles was about 6%. The pressing parameters were as follows: temperature 180°C, time factor 15 s/mm, maximum unit pressure 2.5 MPa.

Panels with particles from exotic wood

The raw material to produce the particleboards, except from industrial particles for core and face layers production, were particles produced from waste veneer from 7 different species of exotic wood (e.g. *Juglans nigra*, *Entandrophragma cylindricum*, *Microberlinia brazzavillensis*). The size of produced particles from exotic wood, designed for addition to core layer, was close to the dimensions of industrial particles for core layer production. The following types of panels were produced: 0 (control), 10, 30, 50 and 100% content of particles from exotic wood in core layer. The nominal thickness of the panels was 12 mm, assumed density 750 kg/m³. Resination: 12% face layers, 10% core layer. Face layers share 32%, particles' moisture content 5%. The characteristics of binder, as well as pressing parameters, were as above mentioned.

Panels with calcium carbonate

A three-layer, 12 mm thick panels with following content of calcium carbonate particles in face layers were produced: 0 (control), 5, 10, 30 and 50%. The industrial particles, typically used for particleboards' face layers production, were used for both, face and core layers production. The face layers share was 32%. The resination was as follows: face 15%, core 10%. Assumed density 750 kg/m³, particles' moisture content 3%. The calcium carbonate particles fraction was bigger than 0.16 and smaller than 1 mm mesh size. The characteristics of binder, as well as pressing parameters, were as above mentioned.

The following parameters of produced panels were investigated: bending strength and modulus of elasticity during bending, internal bond, as well as swelling in thickness and water absorption. In case of panels with calcium carbonate, the proper standards to reaction to fire testing were applied: EN ISO 11925-2:2010 and EN 13501-1+A1:2010P. The appropriate European standard procedures for particleboard testing were applied. All samples were conditioned in 20°C/65% of R.H. to weight stabilization prior to testing.

RESULTS AND DISCUSSION

Panels with foamed starch

On the fig. 1a the results of modulus of rupture and modulus of elasticity of the panels with foamed starch are displayed. There is significant increase of modulus of rupture, as well as modulus of elasticity of the panels with 5 and 10% of foamed starch particles content, compare to the panel without such particles. However, the slight decrease of modulus of rupture in case of panel with 30% content of foamed starch can be observed, compare to panels with 5 and 10% of foamed starch content. Also modulus of elasticity significantly improves in case of the panels with 5% starch particles content. The internal bond of the tested panels insignificantly increases with the foamed starch content increase (Fig. 1b). Taking into account the high spread of the results (displayed by \pm standard deviation bars), it should be pointed that this increase is statistically insignificant. Filling the gaps between the wood particles, which are present in the structure of the panels with lowered density, can be explanation of improvement of panels' mechanical parameters, which occurs in case of 5 and 10% content of starch particles. With this amount of starch particles, this additional material, by filling empty spaces, also mechanically supports adjacent wood particles. With the increase of starch particles content, these particles can be located both, in empty spaces, as well as between wood particles. Since the mechanical strength of foamed starch particles is significantly lower compare to wood, lowering of panels' mechanical strength occurs.

The swelling in thickness, as well as water absorption of the panels produced with use of foamed starch, insignificantly increases when the starch content raises. The intensity of water absorption is higher at the beginning of soaking (in 2h from start), and decreases afterwards. This is due to the ability of starch to absorb the water, which is similar (or even higher) to water absorptivity of wood.

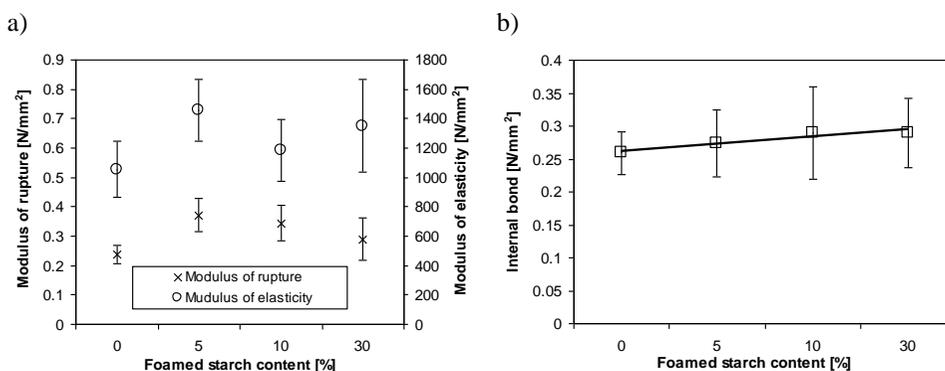


Fig. 1. Modulus of rupture and modulus of elasticity (a), as well as internal bond (b) of the panels with foamed starch

Panels with particles from exotic wood

In case of the panels produced with use of particles from exotic wood, the modulus of rupture is independent from the content of exotic wood particles in core layer (Fig. 2a). However, it should be pointed that bending strength of investigated panels is quite high (over 24 N/mm²). The unchanged, independent from the different core layer content, bending strength, can be explained by rules of mechanic of bended materials. Since the bending strength of bended materials depends mostly on tension/compression strength of face layers, and these layers were the same for all investigated panels, the modulus of rupture stays constant. The modulus of elasticity of the panels with particles from exotic wood species in core layer significantly depends on the content of exotic wood particles (Fig. 2a). From over 5 100 N/mm² for control panel increases to 9 000 N/mm² for panel with 100% exotic wood particles in core layer. This increase can be explained by higher mechanical parameters, especially modulus of elasticity (compare to pine and spruce wood) of exotic wood species used for production of particles to core layer creation. The internal bond of tested panels also insignificantly increases with exotic wood particles content increase (Fig. 2b). The water absorption and swelling in thickness of the tested panels insignificantly decreases with exotic wood particles content increase.

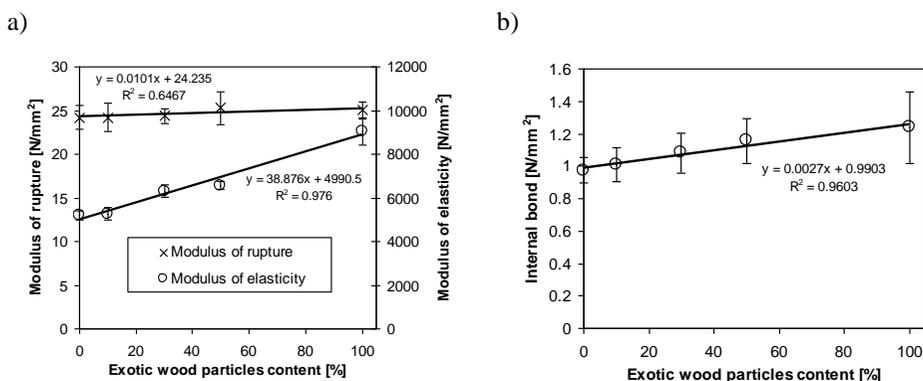


Fig. 2. Modulus of rupture and modulus of elasticity (a), as well as internal bond (b) of the panels with particles from exotic wood species

Panels with calcium carbonate

According to fig. 3a, the most significant increase of modulus of rupture and modulus of elasticity occurs when calcium carbonate content in face layers increases from 0 to 5%. The subsequent increase of calcium carbonate content from 5 to 50% does not influence on the described mechanical properties. Calcium carbonate content significantly improves hydrophilicity of the tested panels. On the fig. 3b the results of investigation of swelling in thickness are displayed. It can be noted that with calcium carbonate content increase, the swelling in thickness values significantly decrease. In case of swelling in thickness after 2h of soaking, the swelling value decreases from 34.5 to 19%, and after 24h of soaking from 42.1 to 24.2%, when the calcium carbonate content in face layers increases from 0 to 50%.

The flammability properties were measured as length of burned-out surface after 30, 60 and 120 s of flame acting on panel's surface. It was found that with increase of flame acting time the length of burned-out surface increases, e.g. for panel with 5% of calcium carbonate content 40 mm after 30 s, 60 mm after 60 s and 90 mm after 120 s. In similar conditions for panel with 50% of calcium carbonate content the length of burned-out surface was as

follows: 20, 30 and 60 mm. The influence of calcium carbonate content on the length of burned-out surface was clearly visible only for 50% content in particleboards' surface layers.

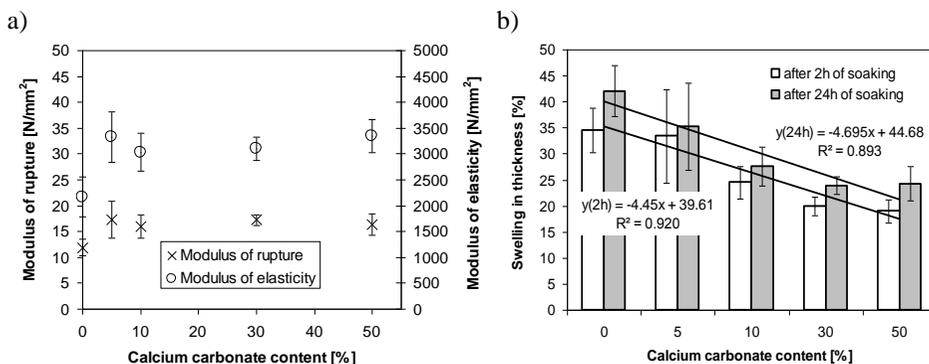


Fig. 3. Modulus of rupture and modulus of elasticity (a), as well as swelling in thickness (b) of the panels with particles of calcium carbonate

CONCLUSION

Due to quite low modulus of elasticity, as well as high water absorption and thickness swelling, the panels with lowered density and foamed starch particles content, could not be applied in structures, where mechanical features play significant role. Also external applications can not be taken into account. However, since tested panels have lower density, can be successfully applied as a filler of indoor structures, e.g. doors.

According to the results achieved for the panels produced with use the particles from waste veneers from selected exotic wood species, there are possibilities to produce particleboards with high mechanical properties and without decrease of physical parameters, where the content of particles from exotic wood species can reach even 100% in core layer.

In case of flammability decrease of particleboards by calcium carbonate particles addition to face layers, the amount of calcium carbonate particles should not be lower than 50% to significantly improve this feature. With this content, the measured mechanical and physical (e.g. swelling in thickness after soaking in water) properties are also improved, compare to the panels without calcium carbonate content.

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