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Evaluation of reaction-to-fire behaviour of wood chipboard: A comparative study of treatments and coatings

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ABSTRACT: Fires in buildings pose significant risks to property and human lives, making material selection crucial for fire safety. This study evaluates the fire reaction of wood agglomerate boards, both treated and untreated, under controlled heat exposure. The tested boards include untreated wood chipboard, chipboard with varnish, intumescent paint, Formica coating, and a fire retardant chipboard (Fimapan IGN E-Z-Finsa). Results indicate notable differences in weight loss and carbonization, with varnished chipboard performing the worst. Intumescent paint proved highly effective, forming a protective char layer that extended ignition time and reduced material degradation. The Electric Radiator test provided valuable insights into the combustion characteristics of these materials. Applying fire retardants, especially intumescent paint, markedly enhances the fire reaction properties of wood agglomerates, bolstering their safety in construction. This study underscores the critical role of material selection in fire safety and provides valuable data for developing more fire-resistant building materials.

KEY WORDS: Wood agglomerate boards; Intumescent paint; Fire retardant treatment; Construction materials; Fire reaction.

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RESUMEN: *Evaluación del comportamiento de reacción al fuego de los tableros aglomerados de madera: Estudio comparativo de tratamientos y revestimientos.* Los incendios en edificios suponen riesgos significativos para propiedades y vidas, haciendo crucial la selección de materiales para la seguridad contra incendios. Este estudio evalúa la reacción al fuego de tableros de aglomerado de madera, tratados y no tratados, bajo exposición controlada al calor. Se probaron tableros sin tratar, barnizados, con pintura intumescente, recubrimiento de Formica y retardante de fuego (Fimapan IGN E-Z-Finsa). Los resultados muestran diferencias en pérdida de peso y carbonización, siendo el barniz el menos eficaz. La pintura intumescente fue muy eficaz, formando una capa protectora que retrasó la ignición y redujo la degradación. La prueba del Radiador Eléctrico aportó datos sobre combustión. Los retardantes, especialmente la pintura intumescente, mejoran notablemente las propiedades de reacción al fuego de los aglomerados, reforzando su seguridad en construcción. Este estudio destaca la importancia de elegir materiales para la seguridad contra incendios y aporta datos para materiales más resistentes.

PALABRAS CLAVE: Tableros de aglomerado de madera; Pintura intumescente; Tratamiento retardante de fuego; Materiales de construcción; Reacción al fuego.

1. INTRODUCTION

The fire reaction of building materials is evaluated based on parameters such as ignition time, weight loss, carbonization index, flame propagation, heat release rate, and smoke generation. Reaction to fire describes how a material contributes to fire development through combustion under specific conditions (1–3). Unlike fire resistance, which refers to the ability of a structural element to maintain its load-bearing capacity (1), reaction to fire focuses on ignition and combustion characteristics.

In this study, wood chipboard samples were exposed to an electric radiator producing a heat flux of approximately 50 kW/m², as prescribed by the UNE 23-725-90 standard for reaction-to-fire testing. This differs significantly from fire resistance tests, where samples are subjected to much higher heat fluxes and additional convective heat transfer within a fire resistance furnace. Thus, this research strictly evaluates fire reaction properties rather than fire resistance.

Wood and engineered wood products offer several advantages as building materials, including thermal and acoustic insulation, seismic resistance, lightweight properties, and cost-effectiveness. However, they are often perceived as less durable compared to traditional materials like masonry and concrete (4–6).

When wood is exposed to heat, its moisture content decreases, leading to contraction and the onset of pyrolysis at approximately 270°C. This process decomposes wood into flammable gases, which ignite at around 400°C in the absence of direct flames. Due to its low thermal conductivity, combustion primarily affects the surface layer, forming a charred exterior that insulates and protects the inner layers, preserving mechanical properties. This natural charring effect explains why wood, despite its combustibility, can exhibit controlled fire behavior under certain conditions (7).

Recent advancements in fire retardant treatments have significantly enhanced the fire reaction properties of wood. For example, phosphorus-based compounds promote char formation, reducing flammability and slowing combustion (8). Similarly, incorporating fire retardants into wood-polymer composites has shown notable improvements in fire reaction (9).

The fire behavior of different hardwood species has been studied extensively, revealing that intrinsic characteristics such as density, moisture content, chemical composition, and cellular structure play a significant role in fire reaction properties. Higher density woods generally burn more slowly, while lower moisture content increases flammability. The composition of lignin and cellulose influences the combustion process, while the cellular arrangement impacts heat transfer and burn rate (10). Additionally, thicker bark and water retention capacity enhance fire reaction, affecting ignition time and fire spread (11).

Research in China and Europe has increasingly focused on fire reaction treatments for wood and engineered wood products, emphasizing sustainable building materials and compliance with fire safety regulations (12, 13). Similarly, Europe has seen significant progress in improving the fire performance of wood through various treatments and regulations (1, 10). The European market places a strong emphasis on sustainable building materials, prompting research into effective fire retardants that do not compromise environmental standards. Studies in Europe have focused on characterizing the fire behavior of wood species commonly used in construction, aiming to enhance safety while maintaining the ecological benefits of wood (13–15).

Studies have highlighted the effects of fire retardant treatments on the mechanical properties of wood, stressing the importance of balancing fire protection with structural integrity (16, 17).The integration of inorganic fire retardants has also demonstrated significant improvements in fire reaction (18), particularly in outdoor applications where both durability and fire resistance are critical (19). Additionally, innovative technologies such as transparent fireproof coatings have led to the development of highly fire-retardant optical wood, which combines aesthetic and safety benefits (20). These advancements demonstrate the potential for new materials and treatments to significantly improve the fire resistance of wood-based products.

While the effects of fire-retardant treatments and coatings on wood-based materials are well-documented (8, 10), this research provides a novel comparative analysis of five treatments—untreated chipboard, varnished chipboard, intumescent-painted chipboard, Formica-coated chipboard, and a commercial fire retardant chipboard (Fimapan IGN E-Z- Finsa)—under identical controlled conditions using the UNE 23-725-90 standard, a less commonly applied test compared to standardized methods like the cone calorimeter (ISO 5660-1). Notably, our study investigates the unexpected high weight loss observed in fire-retardant chipboard, offering new insights into its behavior under prolonged heat exposure, which has not been extensively explored in prior literature (12). These findings contribute to optimizing material selection for fire-safe construction, balancing performance, cost, and environmental considerations.

2. MATERIALS AND METHODS

2.1. Sample preparation and conditioning

All samples were conditioned for one week before testing in a controlled environment at 23°C and 50% relative humidity to ensure consistency. The equilibrium condition was verified through weight stabilization measurements over consecutive days. The moisture content of each specimen was measured using a calibrated moisture meter before testing, ensuring uniform initial conditions of approximately 7–8%. One sample per treatment type was prepared. Samples coated with polyurethane varnish or water-based intumescent paint were applied uniformly with a brush to achieve a film thickness of 27 µm, and then allowed to dry.

2.2. Materials

A series of wood agglomerate boards, cut to 9 cm x 9 cm with a nominal thickness of 16 mm, were used in this study to assess their reaction to fire. The treatments applied included: (A) unprotected wood chipboard, (B) Formica-coated chipboard, (C) varnish-coated chipboard, (D) intumescent paint-coated chipboard, and (E) fire retardant chipboard (Fimapan IGN E-Z - Finsa). The base material for samples A–D consisted of wood particles bonded with urea-formaldehyde resin, while sample E included phosphorus-based fire-retardant additives. Technical specifications for all chipboards are summarized in Table 1, with detailed properties for Fimapan provided in Table 2.

Table 1. Technical data for wood chipboards.

Sample Type	Density (kg/m³)	Thickness (mm)	Composition	Moisture Content (%)
Unprotected Wood Chipboard (A)	650	16	Wood particles, urea-formaldehyde resin	7.5
Wood Chipboard with Formica Coating (B)	680	16	Wood particles, urea-formaldehyde resin, Formica laminate	7.0
Wood Chipboard with Varnish (C)	650	16	Wood particles, urea-formaldehyde resin, polyurethane varnish	7.5
Wood Chipboard with Intumescent Paint (D)	650	16	Wood particles, urea-formaldehyde resin, water-based intumescent paint	7.5
Fire Retardant Chipboard (Fimapan) (E)	710	16	Wood particles, synthetic resins, phosphorus-based fire-retardant additives	7.0

2.2.1. Fire retardant chipboard

The fire-retardant wood chipboard (Fimapan IGN E-Z) is composed of wood particles bonded with synthetic resins and fire-retardant additives, pressed at high temperatures. Phosphorus-based compounds in the board promote char formation, reducing flammability and slowing combustion, achieving a Euroclass B-s2, d0 rating per EN 13501-1. Detailed specifications are provided in Table 2.

2.2.2. Formica-coated wood chipboard

Formica is made of layers of impregnated paper that, when subjected to high temperatures, are fused together to form a durable, hygienic, and high-performance surface. It is highly resistant to wear, heat, impact, and stains, making it a practical and durable product. Typically, Formica is used for coating various types of furniture, walls, floors, sanitary partitions, etc.

2.2.3. Intumescent paint

A water-based intumescent paint was used, which generates a protective foam upon exposure to intense heat. This foam thermally insulates the substrate (in this case, wood chipboard), preventing fire propagation and delaying structural deterioration. The paint is tested and certified by independent laboratories according to European Standard EN 13381-8:2010.

Table 2. Detailed technical data for Fimapan IGN E-Z-Finsa fire retardant.

Property	Value
Composition	Wood particles, synthetic resins, fire retardant additives
Structure	Three-layer formation
Processing	High-temperature pressing

Properties	Test method	Units	Thicknesses mm				
			8/13	>13/20	>20/26	>26/32	>32/40
Density (*)	EN 323	Kg/m³	740	710	695	675	680
Internal bond	EN 319	N/mm²	≥0.25	≥0.24	≥0.20	≥0.17	≥0.14
Bending strength	EN 310	N/mm²	≥10.5	≥10	≥10	≥8.5	≥7
Thickness swelling (2h)	EN 317	%	≤ 8	≤ 8	≤ 8	≤ 8	≤ 8
Surface soundness	EN 311	N/mm²	≥ 0.8	≥ 0.8	≥ 0.8	≥ 0.8	≥ 0.8
Moisture content	EN 322	%	7+/-3	7+/-3	7+/-3	7+/-3	7+/-3
Grit content	ISO 3340	% Weight	≤ 0.05	≤ 0.05	≤ 0.05	≤ 0.05	≤ 0.05
Formaldehyde content	EN ISO 12460-5	mg/100g	≤ 8	≤ 8	≤ 8	≤ 8	≤ 8
Reaction to fire	EN 13501-1	Euroclasses	B-s2-d0	B-s2-d0	B-s2-d0	B-s2-d0	B-s2-d0
Sound absorption coefficient (a) (250 to 500 hz)	EN 13986.2004+A1:2015	A	0.10	0.10	0.10	0.10	0.10
Sound absorption coefficient (a) (1000 to 2000 hz)	EN 13986.2004+A1:2015	A	0.25	0.25	0.25	0.25	0.25
Thermal conductivity	EN 13986.2004+A1:2015	W/(m·K)	0.15	0.14	0.14	0.14	0.13
Airborne sound insulation (surface mass) (n)	EN 13986.2004+A1:2015	Db	24	28	29	31	32
Water vapour permeability Dry cup	EN 13986.2004+A1:2015	µ	50	50	50	50	50
Water vapour permeability Wet cup	EN 13986.2004+A1:2015	µ	19	19	19	19	19
Biological durability use	EN 13986.2004+A1:2015	Class of use	1	1	1	1	1
Content of pentachlorophe-nol (PCP)	EN 13986.2004+A1:2015	%	< 5	< 5	< 5	< 5	< 5
Tolerance on nominal dimensions							
Properties	**Test method**	**Units**	**Thicknesses mm**				
			8/13	**>13/20**	**>20/26**	**>26/32**	**>32/40**
Thickness	EN 324-1	mm	+/-0.3	+/-0.3	+/-0.3	+/-0.3	+/-0.3
Length/width	EN 324-1	mm	+/-5	+/-5	+/-5	+/-5	+/-5
Squareness	EN 324-2	mm/m	+/-2	+/-2	+/-2	+/-2	+/-2
Edge straightness	EN 324-2	mm/m	+/-1.5	+/-1.5	+/-1.5	+/-1.5	+/-1.5
Color resistance to UV light (Xenon Lamp)		UNE EN 14323	Blue wool scale				

2.2.4. Conventional varnish

A solvent-based polyurethane varnish (Brand: Minwax Polyurethane, flash point ~40°C) was used, applied uniformly with a brush to achieve a film thickness of 27 µm. This varnish, commonly used for wood finishing, contains no fire-retardant additives.

2.3. Experimental setup and testing procedure

The experiment utilized an electric radiator (Figure 1) designed for reaction-to-fire testing as per UNE 23-725-90. The equipment includes:

- A radiator with a nominal power of 500W and a radiant surface made of a transparent quartz disc with a diameter of 100 mm ± 5 mm.
- A specimen holder consisting of a fixed, horizontal metal ring with an internal diameter of 122 mm, a horizontal metal ring with a diameter of 118 mm, and a stainless-steel wire mesh with a mesh size of 2.01 mm x 2.10 mm.
- A cylindrical drop receptacle with a diameter of 118 mm and a depth of 12 mm.
- A vertical column supporting the aforementioned elements.
- A wattmeter, a voltage regulator, a stopwatch, and a bell.

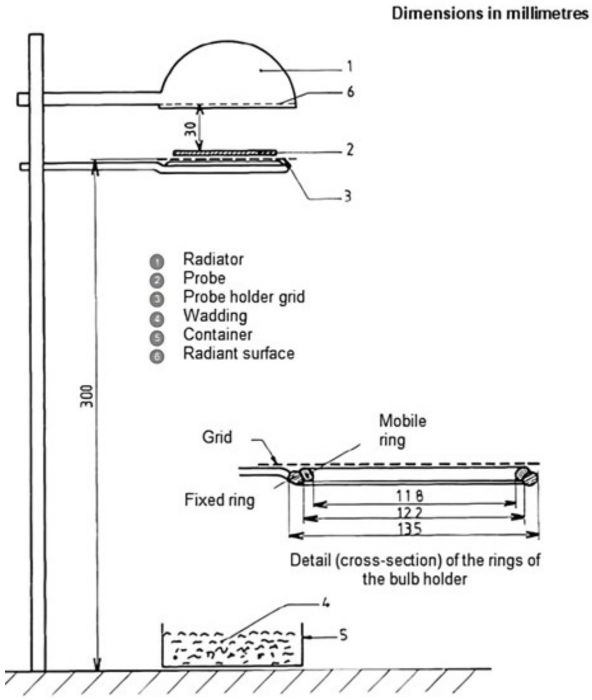

Figure 1. Electric radiator.

Before testing, the radiator was calibrated following UNE 23-729. Each sample was placed on the specimen holder and exposed to the radiant heat source for 5 minutes. The incident heat flux on the surface was estimated at approximately 50 kW/m², significantly lower than that of standard cone calorimeter tests (ISO 5660-1), which typically range from 25 kW/m² to 75 kW/m².

2.4. Weight measurement and loss calculation

To evaluate the fire reaction of each sample, the following parameters were recorded:

- Ignition Time: The moment when sustained flaming was observed.
- Mass Loss: Each specimen was weighed before and after exposure, and weight loss (WL) was calculated as follows Equation [1].

$$WL=IW-FW \quad [1]$$

Where:
WL = Weight loss (g)
IW = Initial weight (g)
FW = Final weight (g)

- Carbonization Pattern: The depth and spread of char formation on the surface were visually assessed.
- Flame Duration: The length of time flames persisted after ignition.

These data provide a comparative analysis of different treatments in terms of their reaction-to-fire performance, not structural fire resistance.

3. RESULTS

One of the critical aspects analysed in research on the reaction of wood to fire is the percentage weight loss of samples exposed to combustion conditions. This parameter provides a quantitative measure of the physical and chemical degradation that wood undergoes during exposure to extreme heat and flame.

Table 3 presents the initial and final weights, weight differences, percentage weight loss, and test duration of the samples after fire exposure, providing an indicator of the fire reaction of each treatment.

Table 3. Weight and fire reaction performance of wood chipboard samples.

Sample type	Weight before (g)	Weight after (g)	Difference (g)	Weight loss (%)	Duration (s)
Unprotected wood chipboard (A)	53.1	45.3	7.8	14.69	300
Wood chipboard with formica coating (B)	116.1	111.0	5.1	4.39	300
Wood chipboard with varnish (C)	55.5	49.0	6.5	11.71	300
Wood chipboard with intumescent paint (D)	57.9	53.8	4.1	7.08	300
Fire retardant chipboard (Fimapan) (E)	62.4	50.2	12.2	19.55	300

The weight loss results show that the unprotected chipboard (A) had a weight loss of 14.69%, Formica-coated chipboard (B) 4.39%, varnish-coated chipboard (C) 11.71%, intumescent paint-coated chipboard (D) 7.08%, and fire-retardant chipboard (E) 19.55% over a 300-second test duration.

3.1. Ignition behavior and combustion analysis

The ignition point of a combustible material is defined as the set of physical conditions (pressure, temperature) necessary for the substance to begin burning and for the flame to sustain itself without external heat. Figure 2 illustrates the behavior of the intumescent paint-treated chipboard (D) in front of the fire, showing a protective mass formed on the fire-exposed face, indicating rapid fire suppression and good fire reaction performance (21). Figures 3–7 graphically represent the ignition patterns of each sample over time, providing a clear view of their fire behavior across different treatments, obtained via the UNE 23-725-90 test.

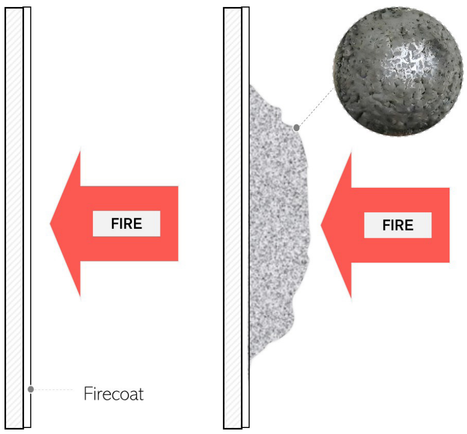

Figure 2. Behavior of the material with intumescent paint in front of the fire.

The unprotected chipboard (A) showed significant ignition activity (Figure 3), with 14 ignitions recorded over a 5-minute period. The horizontal axis (X) represents the number of generations (0 to 10), while the vertical axis (Y) indicates the frequency of ignitions in percentage (0% to 100%). Blue points mark specific ignition frequency values, connected by a green line showing the trend. The frequency started low (~10%), peaked near 80% in generation 3, sharply declined in generation 4, gradually increased to ~70% by generation 7, and settled around 30% by generation 10. The longest ignitions occurred early, indicating high combustibility due to exposed wood particles and urea-formaldehyde resin (Section 2.2).

The Formica-coated chipboard (B) exhibited 12 ignitions characterized by prolonged times and higher flames (Figure 4), with the first ignition at 1 minute 4 seconds, indicating a longer response time compared to other samples. The figure presents time in seconds on the horizontal axis (X) and ignition intensity on the vertical axis (Y), with an orange curve connecting points representing ignition moments. Observations indicate that these 12 ignitions occurred over an extended period, with higher flames compared to other coatings, likely due to gas release during degradation (8).

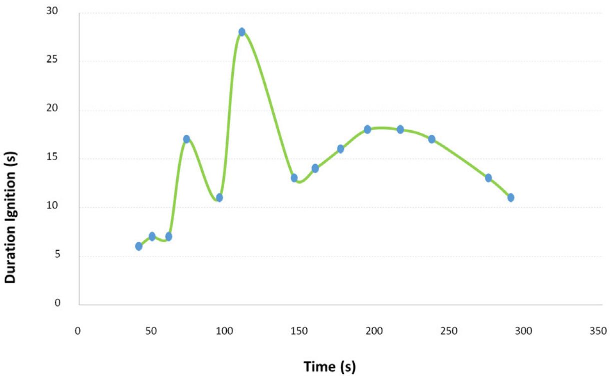

Figure 3. Ignitions of the sample without treatment.

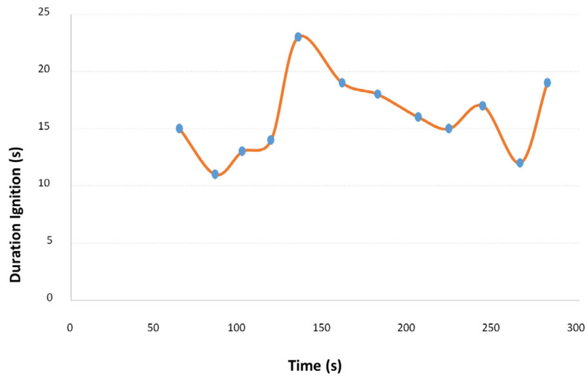

Figure 4. Ignitions of the sample with Formica coating.

The varnish-coated chipboard (C) exhibited 17 ignitions over 5 minutes (Figure 5), with ignition durations remaining relatively consistent but increasing toward the end (last two ignitions at ~23 seconds each). The figure displays the ignition number on the horizontal axis (1 to 17) and duration in seconds on the vertical axis, showing an upward trend in duration toward the end, indicating longer ignitions in the final trials.

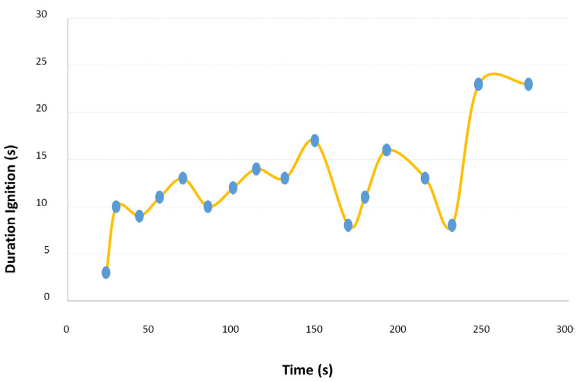

Figure 5. Ignitions of the sample with varnish.

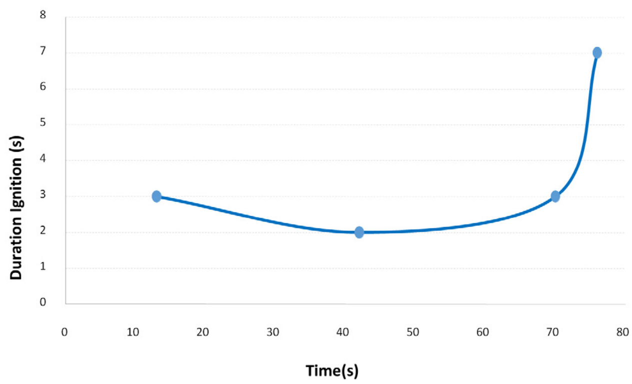

Figure 6. Ignitions of the sample with intumescent paint.

The intumescent paint-treated chipboard (D) exhibited four short-duration ignitions (Figure 6): at 14 seconds (3 seconds), 43 seconds (2 seconds), 70 seconds (3 seconds), and 79 seconds (7 seconds), with no reignition after 1 minute 23 seconds. The figure presents time in seconds on the horizontal axis (X) and ignition intensity on the vertical axis (Y), with points marking ignition moments. Observations indicate that, although four ignitions occurred, they did not persist for a prolonged period and were accompanied by significant smoke emission.

The fire-retardant chipboard (E) exhibited four ignitions (Figure 7): at 230 seconds (24 seconds), 270 seconds (16 seconds), 290 seconds (4 seconds), and 300 seconds (2.5 seconds), with durations decreasing over time. The figure shows time in seconds on the horizontal axis (0 to 250 seconds) and the number of ignitions on the vertical axis (0 to 12). No ignitions occurred from 0 to 200 seconds. The sequential behavior included: (1) bubbling in the first seconds, (2) white smoke emission due to water vapor, and (3) momentary ignitions.

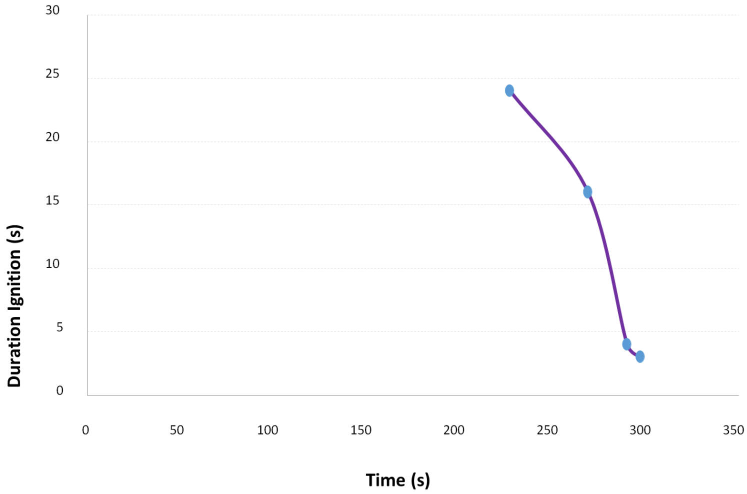

Figure 7. Ignitions of the sample with fire retardant treatment.

4. ANALYSIS AND DISCUSSION

The UNE 23-725-90 test results, complemented by Fimapan's Euroclass B-s2, d0 rating (Table 2), provide insights into the fire reaction performance of wood chipboard treatments for construction applications (22).

4.1. Weight loss analysis

The weight loss data (Table 3) show that the untreated chipboard (A) experienced a weight loss of 14.69%, while the chipboard with varnish showed a slightly lower loss of 11.71%. These results suggest that the varnish offers marginal fire protection compared to the untreated chipboard, which is consistent with previous studies indicating that varnish is not an effective fire retardant (9). In contrast, the chipboard with intumescent paint showed a weight loss of 7.08%, indicating a significant improvement in fire resistance. This finding is supported by literature highlighting the effectiveness of intumescent paints in fire protection (23).

The Formica-coated sample exhibited the lowest weight loss of 4.39%. These results should be evaluated against relevant fire safety standards and building regulations, such as those set by the European Union's EN 13501-1 standard (22), to ensure compliance. Ensuring that construction materials meet these standards is crucial for enhancing building safety and mitigating fire-related risks.

Surprisingly, the fire-retardant treated sample (E), despite its protective treatment, exhibited the highest weight loss of 19.55%. This behavior aligns with its Euroclass B-s2,d0 rating (Table 2), which prioritizes low flammability and smoke production over mass retention (12). The higher density of Fimapan IGN E-Z (710 kg/m³, Table 1) compared to other chipboards (650–680 kg/m³) may contribute to increased material degradation under radiant heat (Section 2.2.1).

The uniform initial moisture content of 7–8% (Section 2.1) ensured consistent testing conditions, minimizing variability in combustion behavior.

4.2. Ignition pattern analysis

The ignition frequency of the unprotected chipboard (A) suggests significant fluctuations, possibly due to external factors or material characteristics, reflecting its high combustibility due to exposed wood particles and urea-formaldehyde resin (Section 2.2). The Formica-coated chipboard (B), despite its low weight loss (4.39%, Table 3), showed prolonged ignition times and higher flames, indicating sustained combustion due to gas release (8, 24). These findings are crucial for material selection in construction projects and for meeting fire safety standards like EN 13501-1 (22).

The varnish-coated chipboard (C) exhibited limited fire resistance, consistent with studies indicating varnish is not an effective fire retardant (9). The intumescent paint-treated chipboard (D) acted quickly to suppress the fire, supported by literature (21). The fire-retardant chipboard (E) aligns with its Euroclass B-s2,d0 rating (Table 2), which prioritizes low flammability and smoke production (12).

4.3. Treatment comparison

The experimental findings indicate significant differences between intumescent paint and fire-retardant treatments in their effectiveness at enhancing fire resistance in wood agglomerates.

The use of intumescent paint on wood samples, as demonstrated in Figure 6, shows that although there were multiple ignitions, each was brief and accompanied by considerable smoke. This indicates that intumescent paint acts quickly to suppress fire. The paint's mechanism of forming an insulating char layer upon exposure to heat effectively slows down heat transfer, delaying the substrate's ignition and structural weakening.

In contrast, the fire retardant-treated samples, shown in Figure 7, delayed ignition significantly, with no ignitions observed in the first 200 seconds of the test. However, once ignited, the fires persisted for longer durations compared to those treated with intumescent paint. This underscores the need for complementary fire management strategies when using fire retardants to ensure comprehensive fire protection (8, 16).

From a practical perspective, the choice between these two treatments should be informed by the specific fire safety requirements of the application. Intumescent paint provides rapid fire suppression by forming a protective char layer, making it ideal for applications requiring high levels of structural integrity. This is particularly suitable for critical infrastructure and high-rise buildings were maintaining structural integrity and allowing safe evacuation are crucial. The quick action of intumescent paint makes it effective in slowing heat transfer and preventing rapid structural weakening, although it generally comes at a higher cost compared to some fire retardant treatments (9).

Fire retardant treatments, on the other hand, are effective in delaying initial ignition and are suitable for a wide range of applications, including residential buildings, furniture, and textiles. These treatments are typically less expensive than intumescent paints and provide long-lasting protection as the chemicals are integrated into the material. However, they may not prevent material degradation once combustion occurs, and some chemical treatments, particularly those containing halogenated compounds, pose environmental and health risks (12).

Environmental and health considerations are also crucial in selecting fire protection treatments. Intumescent paints, generally free from halogenated compounds, are considered more environmentally friendly and safer for indoor air quality. In contrast, some fire retardants, especially those containing halogenated compounds, have been linked to environmental and health risks. For instance, certain fire retardants can release toxic gases during combustion, posing additional hazards to occupants and first responders (10).

The Formica-coated chipboard (B) showed the lowest weight loss (4.39%, Table 3) but had 12 ignitions, indicating less effective ignition performance compared to intumescent paint (D) and fire-retardant treatments (E) (8, 24). The varnish-coated chipboard (C) exhibited 17 ignitions, confirming its limited protective capability, consistent with literature (9).

4.4. Practical implications and future directions

These findings provide practical guidance for material selection in construction projects, emphasizing the need for balancing fire protection, structural integrity, and environmental impact. While intumescent paint and fire-retardant treatments are most effective at preventing ignition and delaying fire spread, Formica coatings minimize weight loss and surface degradation, making them suitable for applications prioritizing material preservation.

Given the limitations of this study, future research should explore standardized fire testing methods, such as the cone calorimeter (ISO 5660-1), to facilitate comparisons with other studies. Additionally, assessing the environmental impact of emissions from treated wood during combustion is recommended to ensure compliance with safety and sustainability regulations.

Overall, this study contributes to the ongoing development of fire-safe construction materials, offering insights into the advantages and limitations of different fire protection strategies for wood agglomerate boards.

The results align with EN 13501-1 standards, which classify materials based on flammability, smoke production, and flaming droplets (22). Fimapan's Euroclass B-s2,d0 rating indicates low flammability, moderate smoke production, and no flaming droplets, but its high weight loss (19.55%, Table 3) suggests mass retention is not prioritized, unlike Formica or intumescent paint. These results guide compliance with building regulations, optimizing safety and performance (22).

5. CONCLUSIONS

This study has yielded several significant conclusions regarding the reaction-to-fire behavior of wood agglomerate boards treated with various protective methods under UNE 23-725-90, providing valuable insights into the efficacy of different fire protection measures for construction materials compliant with EN 13501-1.

Intumescent paint significantly improved the reaction-to-fire performance of wood agglomerate boards with low weight loss (7.08%) and four brief ignitions, forming a protective char layer that insulated the material, reducing thermal degradation. This result is consistent with previous findings (23, 24), which observed similar improvements in fire resistance in construction materials treated with intumescent coatings.

Samples treated with intumescent paint and fire-retardant compounds exhibited high resistance to ignition with four ignitions each, which is crucial in real fire scenarios as it minimises the risk of fire spread and associated hazards, aligning with its Euroclass B-s2, d0 rating. These findings align with earlier research (21), highlighting the effectiveness of fire-retardant treatments in reducing ignition risks in construction materials.

Protective coatings, such as varnish (C) and Formica (B), contributed to delaying the impact of fire on the substrate with moderate to low weight loss (11.71% and 4.39%) despite higher ignition counts (17 and 12, respectively), acting as a barrier against direct exposure. This observation is consistent with prior work (25), which demonstrated that protective coatings enhance the fire resistance and durability of wood products.

The fire-retardant-treated sample (E) exhibited the highest weight loss (19.55%) despite high ignition resistance with four ignitions, consistent with studies on fire-retardant performance (26).

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Authorship contribution statement

Fanny Esther Berigüete Alcántara: Conceptualization; Data cleansing; Formal analysis; Research; Methodology; Resources; Software; Supervision; Validation; Visualization; Write-up - original draft; Write-up - review & editing.

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José Carlos Cárdenas Gómez: Conceptualization; Research; Write-up - review & editing.

Declaration of competing interests

The authors of this article declare that they have no financial, professional or personal conflicts of interest that could have inappropriately influenced this work.

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