A study on the use of and alternatives for borates, propiconazole and tebuconazole in wood preservatives (PT8)

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Summary

- *Report and summary*

This report describes the results of a study that looked into:

- The current use, hazards, and risks of wood preservatives (PT8) based on borates, propiconazole, tebuconazole, or a combination of those as active substances;
- The current use, hazards, and risks of wood and wood products that have been preserved with these preservatives (treated articles);
- The replacement prospects for these products respectively these treated articles.

This research was conducted on behalf of the Dutch Ministry of Infrastructure and Water Management (IandW), which wants to use the results as an input into EU decision-making on the reassessment of the approval of these active substances, which are all candidates for substitution, and two of which (borates and propiconazole) are exclusion substances.
This summary briefly outlines the results of the research.

- *Research method*

The research was carried out by means of desk research (study of the databases on the ECHA and Ctgb websites[1] and document study) and interviews with those involved in and around the chain of production and use of the wood preservatives and of the treated wood in question. In total, exchanges took place with 15 producers and authorization holders, 5 (representatives of) users and 12 experts. In addition, 4 Dutch government institutions were consulted about the sources and search directions involved.
The research has led to conclusions on the key questions, which are summarized below.

- *Authorisation*

The first main question is: which wood preservatives for PT8 based on borates, propiconazole and/or tebuconazole as active substances are currently permitted and for which applications?

Conclusions are:

- Wood preservatives with borates are authorized for:
  - Preventive and curative treatment of wood (use class 2 and adjacent brickwork) (1 product)
  - Preventive treatment of wood (use class 1 and 2) (1 product)
  - Preventive and curative treatment of wood (use class(es) not specified) (1 product)
- Wood preservatives with propiconazole and/or tebuconazole are authorized for:
  - Preventive treatment of wood ((soft) wood, use classes 1, 2, 3 and 4)
    - Based on propiconazole: 4 products
    - Based on tebuconazole: 2 products
    - Based on propiconazole and tebuconazole: 5 products
  - Curative and preventive treatment of wood (wood, use classes 1, 2 and 3)
    - Based on propiconazole: 3 products
- Application of these products may only be done by professional applicators and/or in industrial settings. (Authorizations for private use of two propiconazole based preservatives expires February 2025 at the latest).

- *Use of wood preservatives*

The second main question is: what is known about the current use of wood preservatives based on one or more of these active substances, both qualitatively and quantitatively?

[1] ECHA: European Chemicals agency; Ctgb: Dutch Board for the Authorisation of Plant Protection Products and Biocides.

Conclusions in qualitative terms are:
- It is assumed that a large part of the preserved primary wood products used in the Netherlands are treated with wood preservatives abroad, as the largest part of wood that is used (> 80%) is imported.
- Borates-based wood preservatives are hardly used anymore in the Netherlands (and in the EU), except for some anti-sapstain treatment of pallet wood and for preventive and curative treatment against dry rot fungus on wood and brickwork.
- Propiconazole and tebuconazole based products are widely used for the preservation of (European) soft wood. Application is done, among others, by specialised companies, pallet producers and manufacturers of joinery and construction wood.

Conclusions in quantitative terms are:
- There are no accurate data on amounts of traded wood preservatives in the Netherlands, since they are not publicly recorded and are considered confidential by (most) companies.
- Some information was obtained about the amount of traded borates, propiconazole and tebuconazole as active substances on the Belgian market (order of magnitude 5 to 20 tons/year) (reportedly fairly comparable to the Dutch market) and on the French (20 to 55 tons/year) and Croatian markets (less than 1 ton/year) (both markets not comparable to the Dutch market).

- *Risks of using these wood preservatives*

The next main question is: what is known about the dangers and risks of using these products?

Conclusions are:
- The hazard properties of the different active substances are:
  - Borates are reprotoxic (1b). Disodium tetraborates irritate the eye.
  - Propiconazole is reprotoxic (1b), is suspected to have endocrine disrupting properties, is (moderately) acute toxic when swallowed and may cause allergic skin reactions. It is hazardous to the aquatic environment, with both acute and long-term effects. Use of propiconazole can lead to resistance in fungi against azoles, leading to treatment failure in human healthcare.
  - Tebuconazole is suspected of being reprotoxic (reprotoxic 2). It is hazardous to the aquatic environment, with both acute and long-term effects. Similar to propiconazole, the use of tebuconazole can lead to resistance in fungi.
- Industrial wood preservation takes place in controlled and sometimes closed systems (for vacuum preservation) (following KOMO guidelines). Operators work with personal protection equipment and are sometimes trained by their wood preservative suppliers. Under these circumstances risks for humans and the environment are deemed to be properly controlled.

- *Alternatives in wood preservation*

From a preventative (IPM) perspective, the main questions are: what is the risk awareness of the parties involved, what are the current possibilities for prevention of wood decay and for substituting borates, propiconazole and/or tebuconazole, and what drives and hinders substitution?

Conclusions are:
- Reportedly, risk awareness in wood preservation companies and among professionals is high.
- Several non-chemical alternatives are available to prevent the decay of wood:
  - Conducting adequate monitoring and repair operations with unpreserved wood is sometimes feasible in lower use classes but may bring along high costs and is often not possible.

- Improved wood management, both in logistics and in the wood application, can help reduce the use of biocides. However, this requires expertise and more time, and therefore also entails higher costs.
- Hardwoods are used as an alternative. However, there is a mismatch between supply of (slow growing) hardwood and demand. Moreover, tropical hardwood can be unsustainable.
- Drying wood to less than 21% moisture content prevents rot and can be a (bio) energy-intensive alternative for anti-sapstain treatment with biocides. However, it has limited residual efficacy (the wood must stay dry).
- Both chemical and thermal modification deliver wood of higher durability (longer service life), but with limitations to its use (only for certain use classes, not for in-ground use), and with protection that does not cover the full range of moulds and insects. Thermally modified wood cannot be used for structural elements.
- Other non-chemical technologies are relatively new and do not yet offer real alternatives.

– Low-risk chemical alternatives
  - A low-risk chemical alternative that is mentioned, is Xyhlo-biofinish. Its mode of action results from a combination of linseed oil (which repels moisture) and a protecting fungus. The product still must prove its market potential. Xyhlo-treated wood is usually black.

– Acceptable risk chemical alternatives
  - There are some – but not many – alternatives to borate-based wood preservatives that have acceptable risks and that cover the same use. However, for some specific applications the availability of borate-based preservatives is deemed crucial. They are:
    - Use in internal building structures and control of the dry rot fungus
    - Control of sapstain in freshly cut timber
    - Curative and (subsequent) preservative treatment of piles and grillages.
  - There are some – but not many – alternatives to propiconazole and/or tebuconazole-based wood preservatives with acceptable risks. For some specific applications the availability of propiconazole-based preservatives is deemed crucial. They are:
    - Control of sapstain in freshly cut timber
    - Treatment of structural wood, particularly for use classes 3 and 4
    - Treatment of joinery
    - In situ brush, spraying or injection applications for use classes 2 and 3
  - Alternatives that include the active substance penflufen will probably take another 6 – 11 years before they can fully replace preservatives based on propiconazole and/or tebuconazole. Meanwhile, uncertainties concerning hazard properties of alternatives call for maintaining substances with known performance on the market, according to interviewees.

- *Use of, and alternatives for preserved wood*

The next main questions are: for what purposes is the treated wood used, what are alternatives to realise these purposes, to what extent can they substitute the treated wood, and what drives and hinders substitution?

Conclusions are:

– The preserved wood is mostly used for construction purposes, for garden wood and for pallets. It is not clear which part of these applications is treated with preservatives based on borates, propiconazole and/or tebuconazole.
– Deeper into the value chain (contractors, retailers, consumers) there is little awareness (and little information) about the preservatives used to treat the wood. Most parties rely on the KOMO quality mark. Information about treated articles (cf. art. 58 BPR) is hardly or not communicated to consumers.

- About the use of alternatives for these applications:
  - In the Netherlands, indoor constructions are often made with non-preserved wood. Preserved wood is mostly used in construction of outdoor applications and for elements that become moist. Interviewees argue that use of (preserved) wood is preferable to the use of plastic, concrete, steel, and aluminium for economic and sustainability reasons (CO_2 footprint, sustainable forestry, transport, and supply). However, in the LCA calculation of environmental impact of building products, wood that is preserved with borates, propiconazole and/or tebuconazole has a bad score, due to their human toxicity. Still, technical and economic considerations may lead to these types of preserved wood as the preferred option.
    There are examples of (biobased) houses that are built without using preserved wood (possibly illustrating that a targeted design of wooden structures can prevent attack by fungi – although the Dutch climate and moist soils are complicating factors).
  - Plastic pallets can be – and sometimes are - used instead of preserved wooden pallets. For reasons of costs, sustainability (life cycle impact, non-biodegradability) and availability, they are however not considered suitable alternatives that can fully replace wooden pallets.

- *What if approval is granted or withheld?*

The final question is: what will be the impact of renewed approval or of a decision by the EC to withhold approval of these three active substances?

Conclusions are:

- Withholding approval will be disruptive for a large part of wood preservation activities and particularly for the use of applications that rely on wood that is preserved with preservatives based on one or more of these active substances and for which no alternatives are readily available. This will specifically be the case for:
  - Wood for construction purposes (joinery (specifically for use class 2 and 3) and structural wood (specifically for use class 3 and 4)
  - Curative and (subsequent) preservative treatment of piles and grillages
  - (Preventive and curative) control of the dry rot fungus
  - Control of sapstain in freshly cut timber (including wood used for pallets)
- This disruption may lead to use of alternatives that have poorer performances in terms of sustainability (less sustainable materials with a higher CO_2 footprint) and/or in terms of strengths and durability of constructions, with negative economic consequences.
- To some extent, this disruption may lead to increased use of imported preserved wood. It is not always transparent what substances are used for preserved wood that is imported.
- For wood that is traded using the quality mark of KOMO, auditors will exert control on the use of authorized wood preservatives. Thus, for KOMO certified wood there is no way around the restriction of these active substances.
- Little innovation has taken place in recent years for safer alternative wood preservatives. There is a lack of viable business cases for such innovations, partly because of current legal and policy conditions.

- With unconditional renewed approval, the current use of wood preservatives based on borates, propiconazole and/or tebuconazole will remain as it is now. The research shows that the following conditions may be worth considering:
  - Consider a restrictive reapproval of borates, propiconazole and tebuconazole for only (some of) the applications mentioned above (also considering the question whether this leaves producers with a viable business case for keeping on producing these products for applications that are deemed crucial).
  - Pay specific attention to the control of imported wood that is treated with these substances.

- Stimulate R&D for safer alternatives by other means, like designing and tendering new buildings with the use of indicators that favour the use of less toxic preservatives. Promote design and maintenance principles that foster the prevention of decay of wood and protection from humidity and encourage knowledge transfer and international embedding of knowledge about this, including in education and training. Take measures at EU level that help overcome the barriers to innovation that are (at least partly) caused by present legal and policy conditions.
- Stimulate or enforce communication through the value chain, to improve awareness of the risks of certain wood preservatives.

Samenvatting

- *Rapport en samenvatting*

Dit rapport beschrijft de resultaten van onderzoek naar:

- Het huidige gebruik, de gevaren en risico's van houtverduurzamingsmiddelen (PT8) op basis van boraten, propiconazool, tebuconazool of een combinatie van deze actieve stoffen;
- Het huidige gebruik, de gevaren en risico's van hout en houtproducten die met deze conserveermiddelen zijn geconserveerd (behandelde voorwerpen);
- De vervangingsmogelijkheden voor deze producten respectievelijk deze behandelde artikelen.

Dit onderzoek is uitgevoerd in opdracht van het Ministerie van Infrastructuur en Waterstaat (IenW), dat de resultaten wil gebruiken als input voor de EU-besluitvorming over de herbeoordeling van de goedkeuring van deze werkzame stoffen, die alle drie in aanmerking komen voor vervanging en waarvan er twee (boraten en propiconazool) exclusiestoffen zijn.
In deze samenvatting worden de resultaten van het onderzoek op hoofdlijnen weergegeven.

- *Onderzoeksmethode*

Het onderzoek is uitgevoerd door middel van deskresearch (bestudering van databases op de websites van ECHA en Ctgb[2] en documentstudie) en interviews met betrokkenen in en rond de ketens van productie en gebruik van houtverduurzamingsmiddelen en van behandeld hout. In totaal heeft uitwisseling plaatsgevonden met 15 producenten en toelatinghouders, 5 (vertegenwoordigers van) gebruikers en 12 deskundigen. Daarnaast zijn vier Nederlandse overheidspartijen geraadpleegd over de betrokken bronnen en zoekrichtingen.
Het onderzoek leidde tot conclusies over de belangrijkste vragen, die hieronder zijn samengevat.

- *Toelatingen*

De eerste hoofdvraag is: welke houtverduurzamingsmiddelen (PT8) op basis van boraten, propiconazool, tebuconazool of een combinatie van deze actieve stoffen zijn momenteel toegelaten en voor welke toepassingen?

Conclusies zijn:

- Houtverduurzamingsmiddelen met boraten zijn toegelaten voor:
  - Preventieve en curatieve behandeling van hout (gebruiksklasse 2 en aangrenzend metselwerk) (1 product)
  - Preventieve behandeling van hout (gebruiksklasse 1 en 2) (1 product)
  - Preventieve en curatieve behandeling van hout (gebruiksklasse(n) niet gespecificeerd) (1 product)
- Houtverduurzamingsmiddelen met propiconazool en/of tebuconazool zijn toegelaten voor:
  - Preventieve behandeling van (zacht) hout (gebruiksklasse 1, 2, 3 en 4)
    - Op basis van propiconazool: 4 producten
    - Op basis van tebuconazool: 2 producten
    - Op basis van propiconazool en tebuconazool: 5 producten
  - Curatieve en preventieve behandeling van hout (gebruiksklasse 1, 2 en 3)
    - Op basis van propiconazool: 3 producten
- Het aanbrengen van deze producten mag alleen worden gedaan door professionele toepassers en/of in industriële omgevingen. (De toelatingen voor niet-professioneel gebruik van twee conserveermiddelen op basis van propiconazool lopen uiterlijk februari 2025 af).

[2] ECHA: Europees chemicaliën agentschap; Ctgb: College voor de toelating van gewasbeschermingsmiddelen en biociden.

- *Gebruik van houtverduurzamingsmiddelen*

De tweede hoofdvraag luidt: wat is er kwalitatief en kwantitatief bekend over het huidige gebruik van houtverduurzamingsmiddelen op basis van één of meer van deze werkzame stoffen?

Conclusies in kwalitatieve termen zijn:
- Aangenomen wordt dat een groot deel van de houtverduurzaming buiten Nederland plaatsvindt, aangezien het grootste deel van het in Nederland gebruikte hout (> 80%) geïmporteerd wordt.
- Houtverduurzamingsmiddelen op basis van boraten worden in Nederland (en in de EU) nauwelijks meer gebruikt, behalve in een enkel geval voor anti-sapvlekbehandeling van pallethout en voor preventieve en curatieve behandeling tegen houtrotschimmel op hout en metselwerk.
- Producten op basis van propiconazool en tebuconazool worden veel gebruikt voor de conservering van (Europees) zachthout. Toepassing wordt onder meer gedaan door gespecialiseerde bedrijven, palletproducenten en producenten van schrijnwerk en constructiehout.

Conclusies in kwantitatieve termen zijn:
- Er zijn geen gegevens over de hoeveelheden verhandelde houtverduurzamingsmiddelen in Nederland, omdat deze niet openbaar worden geregistreerd en door (de meeste) bedrijven als vertrouwelijk worden beschouwd.
- Er is enige informatie over de hoeveelheid verhandelde boraten, propiconazool en tebuconazool als werkzame stoffen op de Belgische markt (ordegrootte 5 tot 20 ton/jaar) (naar verluidt redelijk vergelijkbaar met de Nederlandse markt) en op de Franse (20 tot 55 ton/jaar) en Kroatische markten (minder dan 1 ton/jaar) (beide markten niet vergelijkbaar met de Nederlandse markt).

- *Risico's bij het gebruik van deze houtverduurzamingsmiddelen*

De volgende hoofdvraag is: wat is bekend over gevaren en risico's van gebruik van deze producten?

Conclusies zijn:
- De gevaarseigenschappen van de verschillende werkzame stoffen zijn:
  - Boraten zijn reprotoxisch (1b). Dinatrium-tetraboraten irriteren het oog.
  - Propiconazool is reprotoxisch (1b), wordt verdacht van hormoon-ontregelende eigenschappen, is (matig) acuut giftig bij inslikken en kan allergische huidreacties veroorzaken. Het is gevaarlijk voor het aquatisch milieu, met zowel acute als langetermijneffecten. Het gebruik van propiconazool kan bij schimmels leiden tot resistentie tegen azolen, wat kan leiden tot falende behandelingen in de menselijke gezondheidszorg.
  - Tebuconazool wordt verdacht van reprotoxische eigenschappen (reprotoxisch 2). Het is gevaarlijk voor het aquatisch milieu, met zowel acute als langetermijneffecten. Net als bij propiconazool kan het gebruik van tebuconazool leiden tot resistentie bij schimmels.
- Industriële houtverduurzaming vindt plaats in gecontroleerde en soms gesloten systemen (vacuümconservering) (volgens KOMO-richtlijnen). Professionals werken met persoonlijke beschermingsmiddelen en zijn soms getraind door leveranciers van houtverduurzamingsmiddelen. Onder deze omstandigheden worden de risico's voor mens en milieu geacht afdoende beheerst te zijn.

- *Alternatieven in houtverduurzaming*

Vanuit preventief (IPM) perspectief zijn de belangrijkste vragen: wat is het risicobewustzijn van betrokken partijen, wat zijn huidige (alternatieve) mogelijkheden voor het voorkomen van houtrot resp. voor het vervangen van boraten, propiconazool en/of tebuconazool, en wat drijft en belemmert vervanging?

Conclusies zijn:

- Naar verluidt is het risicobewustzijn bij houtverduurzamingsbedrijven en onder professionals hoog.
- Er zijn verschillende niet-chemische alternatieven beschikbaar om houtaantasting te voorkomen:
  - Het uitvoeren van adequate monitoring- en reparatiewerkzaamheden met ongeconserveerd hout is soms haalbaar in lagere gebruiksklassen, maar kan hoge kosten met zich meebrengen en is vaak niet mogelijk.
  - Verbeterd houtbeheer, zowel in de logistiek (timing van het kappen van bomen, sneller verwijderen, zagen en drogen van hout) als in de houttoepassing (vochtreductie, gebruiksklassen, korte nattijd en vermindering van het risico op bederf), kan helpen om het gebruik van biociden te verminderen. Dit vergt echter expertise en meer tijd en brengt dus ook hogere kosten met zich mee.
  - Als alternatief wordt hardhout gebruikt. Er is echter een mismatch tussen het aanbod van (traag groeiend) hardhout en de vraag. Bovendien is tropisch hardhout vaak niet duurzaam.
  - Het drogen van hout tot een vochtgehalte van minder dan 21% voorkomt rot en kan een (bio) energie-intensief alternatief zijn voor behandeling tegen sapvlekken met biociden. Het heeft echter slechts beperkte restwerking (het hout moet droog blijven).
  - Zowel chemische als thermische modificatie leveren hout op met een hogere houdbaarheid, maar met beperkingen in het gebruik ervan (alleen voor bepaalde gebruiksklassen, niet voor gebruik in de grond), en met bescherming die niet het volledige scala aan schimmels en insecten dekt. Thermisch gemodificeerd hout kan niet worden gebruikt voor structurele elementen.
  - Andere niet-chemische technologieën zijn relatief nieuw en bieden nog geen alternatief.
- Chemische alternatieven met een laag risico
  - Een laag risico chemisch alternatief dat wordt genoemd is Xyhlo-biofinish. Het werkingsmechanisme is gelegen in een combinatie van lijnzaadolie (dat vocht verdrijft) en een beschermende schimmel. Het product moet zijn marktpotentie nog bewijzen. Met Xyhlo behandeld hout is vaak zwart.
- Aanvaardbare risicovolle chemische alternatieven
  - Er zijn enkele – maar niet veel – alternatieven voor houtverduurzamingsmiddelen op basis van boraten die aanvaardbare risico's met zich meebrengen en die hetzelfde gebruik dekken. Voor sommige specifieke toepassingen wordt de beschikbaarheid van houtverduurzamingsmiddelen op basis van boraten echter van cruciaal belang geacht. Dat zijn:
    - Gebruik in interne bouwconstructies en voor bestrijding van houtrotschimmel
    - Tegengaan van sapvlekken in vers gekapt hout
    - Curatieve en (vervolg)conserverende behandeling van palen en roosters.
  - Er zijn enkele – maar niet veel – alternatieven voor houtverduurzamingsmiddelen op basis van propiconazool en/of tebuconazool met aanvaardbare risico's. Voor sommige specifieke toepassingen wordt de beschikbaarheid van conserveermiddelen op basis van propiconazool van cruciaal belang geacht. Dat zijn:
    - Tegengaan van sapvlekken in vers gekapt hout
    - Behandeling van constructiehout, met name voor gebruiksklassen 3 en 4
    - Behandeling van schrijnwerk
    - In situ kwast-, spuit- of injectietoepassingen voor gebruiksklassen 2 en 3
  - Alternatieven met de werkzame stof penflufen zullen waarschijnlijk nog 6 tot 11 jaar nodig hebben voordat ze conserveermiddelen op basis van propiconazool en/of tebuconazool volledig kunnen vervangen. In de tussentijd is het vanwege onzekerheden over gevaarseigenschappen van alternatieven volgens geïnterviewden zaak dat stoffen met bekende prestaties op de markt blijven.

- *Gebruik van en alternatieven voor verduurzaamd hout*

De volgende hoofdvragen zijn: voor welke doeleinden wordt het behandelde hout gebruikt, wat zijn alternatieven om deze doeleinden te verwezenlijken, in hoeverre kunnen deze behandeld hout vervangen, en wat drijft en belemmert vervanging?

Conclusies zijn:

- Het verduurzaamde hout wordt vooral gebruikt voor bouwdoeleinden, voor tuinhout en voor pallets. Het is niet duidelijk welk deel van deze aanvragen wordt behandeld met conserveermiddelen op basis van boraten, propiconazool en/of tebuconazool.
- Dieper in de waardeketen (aannemers, detailhandelaren, consumenten) is er weinig bewustzijn (en weinig informatie) over de conserveermiddelen die worden gebruikt om hout te behandelen. De meeste partijen gaan af op het KOMO-keurmerk. Informatie over behandelde voorwerpen (cf. art. 58 BPR) wordt niet naar consumenten gecommuniceerd.
- Over het gebruik van alternatieven voor deze toepassingen:
  - In Nederland worden binnenconstructies vaak vervaardigd met niet-verduurzaamd hout. Verduurzaamd hout wordt vooral gebruikt voor buitentoepassingen en voor elementen die vochtig worden. Geïnterviewden stellen dat het gebruik van (verduurzaamd) hout de voorkeur verdient boven het gebruik van plastic, beton, staal en aluminium om economische en duurzaamheidsredenen (CO_2-voetafdruk, duurzame bosbouw, transport en aanbod). Bij de LCA-berekening van de milieu-impact van bouwproducten scoort hout dat verduurzaamd is met boraten, propiconazool en/of tebuconazool echter slecht vanwege hun humane toxiciteit. Toch kunnen technische en economische overwegingen ertoe leiden dat dit soort verduurzaamd hout de voorkeur krijgt.
    Er zijn voorbeelden van (biobased) huizen die gebouwd zijn zonder gebruik van verduurzaamd hout (wat mogelijk illustreert dat een gericht ontwerp van houten constructies aantasting door schimmels kan voorkomen - hoewel het Nederlandse klimaat en de vochtige bodems complicerende factoren zijn).
  - Kunststof pallets kunnen worden gebruikt in plaats van verduurzaamde houten pallets. Om redenen van kosten, duurzaamheid (impact op de levenscyclus, niet-biologische afbreekbaarheid) en beschikbaarheid worden ze echter niet als geschikte alternatieven beschouwd.

- *Wat als goedkeuring wordt verleend of geweigerd?*

De laatste vraag is: wat zal de impact zijn van een hernieuwde goedkeuring of van een besluit van de EC om de goedkeuring van deze drie werkzame stoffen te onthouden?

Conclusies zijn:

- Het onthouden van goedkeuring zal een groot deel van de houtverduurzamingsactiviteiten ontregelen, alsook een groot deel van de toepassingen die afhankelijk zijn van hout dat is verduurzaamd met middelen op basis van één of meer van deze werkzame stoffen en waarvoor niet direct alternatieven voorhanden zijn. Dit zal specifiek het geval zijn voor:
  - Bouwhout/schrijnwerk (specifiek voor gebruiksklassen 2 en 3) en constructiehout (specifiek voor gebruiksklassen 3 en 4)
  - Curatieve en (vervolg) conservering van palen en roosters
  - (Preventieve en curatieve) bestrijding van houtrotschimmel
  - Tegengaan van sapvlekken in vers gekapt hout (waaronder hout voor pallets)
- Deze ontregeling kan leiden tot toenemend gebruik van alternatieven die slechter presteren qua duurzaamheid (minder duurzame materialen met een hogere CO_2-voetafdruk) en/of op het gebied van sterkte en duurzaamheid van constructies, met negatieve economische gevolgen.
- Tot op zekere hoogte kan dit leiden tot toename in het gebruik van geïmporteerd verduurzaamd hout. Het is niet altijd duidelijk welke stoffen daarvoor zijn gebruikt.

- Voor hout dat wordt verhandeld onder het KOMO keurmerk zullen auditors toezicht uitoefenen op het gebruik van toegestane houtverduurzamingsmiddelen. Voor KOMO-gecertificeerd hout zullen beperkingen in het gebruik van deze werkzame stoffen dus direct doorwerken.
- Er heeft de afgelopen jaren weinig innovatie plaatsgevonden op het gebied van veiliger alternatieve houtverduurzamingsmiddelen. Het ontbreekt aan reële verdienmodellen voor dergelijke innovaties, mede vanwege de huidige wettelijke en beleidsmatige omstandigheden.

- Bij onvoorwaardelijke hernieuwde goedkeuring zal het gebruik van houtverduurzamingsmiddelen op basis van boraten, propiconazool en/of tebuconazool blijven zoals die nu is. Uit het onderzoek blijkt dat de volgende voorwaarden het overwegen waard zijn:
  - Overweeg een restrictieve hergoedkeuring van boraten, propiconazool en tebuconazool voor (een deel van) de hierboven genoemde toepassingen (en hou daarbij rekening met de vraag of dit producenten voldoende verdienmodel overlaat om deze producten te blijven produceren voor toepassingen die cruciaal worden geacht).
  - Besteed specifieke aandacht aan de controle op geïmporteerd hout dat met deze stoffen is behandeld.
  - Stimuleer R&D voor veiligere alternatieven op andere manieren, zoals door het ontwerpen en aanbesteden van nieuwe gebouwen met behulp van indicatoren die het gebruik van minder gevaarlijke conserveermiddelen bevorderen. Promoot ontwerp- en onderhoudsprincipes die het voorkomen van houtrot en bescherming tegen vocht bevorderen, en stimuleer kennistransfer en internationale inbedding van kennis hierover, onder meer in onderwijs en opleidingen. Neem maatregelen op EU-niveau die helpen de belemmeringen voor innovatie te overwinnen die mede worden veroorzaakt door de huidige wettelijke en beleidsmatige omstandigheden.
  - Stimuleer communicatie via de waardeketen (en/of dwing deze af), om het bewustzijn van de risico's van bepaalde houtverduurzamingsmiddelen te vergroten.

1. Introduction

1.1. Background to the study

The Biocidal Products Regulation (BPR; EU/528/2012) prohibits the use in biocidal products of active substances with carcinogenic, mutagenic or reprotoxic (CMR), endocrine disrupting, PBT or vPvB[3] properties (Article 5(1)). Exceptions to that ban are only possible if the risk of use is demonstrably negligible, if the active substance is essential to prevent or control a serious danger to human or animal health or to the environment, or if non-approval of the active substance would have disproportionate negative impact on society when compared with the risk to human and animal health or the environment arising from the use of the substance (Article 5(2)).

The approval of active substances is reassessed at regular intervals, in addition to the fact that the European Commission can reconsider an approval at any time based on new information. This also applies to active substances that have been approved based on Article 5(2) of the BPR.

Boric acid and disodium tetraborate (further referred to as: borates), propiconazole and tebuconazole have been approved as active substances for wood preservation (PT8)[4] in 2009,[5] 2023[6] and 2008[7] respectively. In the recent approval procedure for propiconazole, it was concluded that the exclusion criteria of article 5(1) are met. Borates and tebuconazole were approved in procedures that started before the BPR came into effect, based on conclusions that the risks arising from use of these substances can effectively be mitigated. All three substances are marked as candidates for substitution.[8]

The approval of borates and tebuconazole for PT8 are scheduled for reassessment soon (expected in the following years). The recently renewed approval of propiconazole will be reassessed in 2030. The decision-making regarding reapproval or phasing out takes place in the Standing Committee on Biocidal Products (SCBP), which includes the Ministry of Infrastructure and Water Management (IandW) for the Netherlands. For its input into reassessments in the SCBP, IandW needs up-to-date insight into the use and replacement perspective of borates, propiconazole and tebuconazole for PT8. The present report has been prepared to function as such a knowledge document, describing the impact of reapproval or phasing out of these substances.

1.2. Purpose of the study

The objective of the research project described here is as follows.

The aim of the project is:

- to map:
  - ✓ (what is known of) the current use and the hazards and risks of wood preservatives (PT8) based on one or more of the active substances borates, propiconazole and tebuconazole,

[3] PBT: persistent, bioaccumulative, toxic; vPvB: very persistent, very bioaccumulative

[4] PT8: Product type 8. The BPR distinguishes 22 product types into 4 main groups. Product type 8 concerns products (both preventive and curative) used for the preservation of wood, from and including the saw-mill stage, or wood products by the control of wood-destroying or wood-disfiguring organisms, including insects. PT8 is part of main group 2: preservatives.

[5] Commission Directive 2009/94/EC

[6] Commission Implementing Regulation (EU) 2023/2596

[7] Commission Directive 2008/86/EC

[8] Active substances are marked as 'candidate for substitution' following article 10 of the BPR. Article 10 makes mention of several grounds for considering an active substance a candidate for substitution, amongst which: 'it meets at least one of the exclusion criteria listed in Article 5(1) but may be approved in accordance with Article 5(2)' (article 10.1(a)).

- ✓ As well as (what is known of) the current use and the hazards and risks of wood and wood products that have been preserved with these preservatives (treated articles),[9]
- ✓ and what the replacement perspective is for these products, respectively for these treated articles,

➢ and to make this knowledge available in a report to support considerations in the SCBP.

This research builds on - and will also refer to - previous inventories that have been made regarding the use and replacement of active substance in wood preservation. In particular, this concerns the Arcadis study on innovative methods for wood protection,[10] and the INERIS study on the potential for substitution of substances used in wood preservatives.[11]
In addition, in the context of the approval of propiconazole and tebuconazole, and in particular of borates for PT8,[12] ECHA has held public consultation rounds on possible replacement or alternative substances or techniques. This research also builds on that.

1.3. Research questions

As the purpose of the study already indicates, the main question is: what is known about the current use, the hazards and risks and the replacement perspective of wood preservatives based on one or more of the active substances borates, propiconazole and tebuconazole, and of wood and wood products that have been preserved with these preservatives? This main question has been elaborated in this project in the following sub-questions.

The question about the use and dangers and risks of these substances can be divided into several sub-questions:

- Which wood preservatives based on these active substances are currently authorised and for which specific applications?
- What is known about the current use of wood preservatives based on these active substances (and, if possible, also its historical development),
  - ✓ both qualitative (nature of application, field of application, function)
  - ✓ and quantitative (volumes)?
- What is known about the dangers and risks of using these products?

Questions about the use and dangers and risks of articles treated with wood preservatives based on these substances are:

- What is known about the nature and current use of these treated articles (and, if possible, also their historical development), both qualitative and quantitative?
- What is known about the dangers and risks of using these products?

The questions about the replacement perspective are informed by the Integrated Pest Management (IPM) principle. According to this principle, prevention, and monitoring form the basis and the first step to prevent or control harmful organisms. If preventive measures prove insufficient, non-chemical measures are used as a second step. If these are also not sufficient, low-risk biocides are used.

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9 'Treated articles' are articles that have been treated with biocides and that carry a biocidal claim. They are regulated in art. 58 of the BPR.

10 Arcadis (2022): *Innovative methods for wood protection.* Final report for the Ministry of Infrastructure and Water Management. By J. Nuijten, D. Paardekoper et al.

11 INERIS (2022): *Potential for substitution of substances used in wood preservatives; issues related to future approval decisions.* P. Boucard and C. Denize. Ineris-207016-2757679-v1.0.

12 BPC (2020): *The evaluation of the availability of alternatives to boric acid and disodium tetraborate pentahydrate.* ECHA/BPC/271/2020.

If this is not sufficient, biocides with an acceptable risk are used, and as a final step, a biocide that poses a risk and/or contains an undesirable substance.[13]

Answers to the following questions concerning use of wood preservatives are important from a replacement perspective:

- To what extent are prevention and monitoring (or can they be) applied and effective to prevent or control harmful organisms?
- To what extent are low- and/or acceptable risk (or can they be) applied and effective to prevent or control harmful organisms?
- Can the use of wood preservatives based on borates, propiconazole and tebuconazole be reduced?
- What drives and what prevents substitution?
  - ✓ What is the risk awareness of the various actors dealing with wood preservatives based on borates, propiconazole and tebuconazole?
  - ✓ What are drivers and motives for adapting alternatives and for preventing avoidable use? What are bottlenecks and barriers to adapting alternatives?

Next, the following questions concern the use of wood that is treated with preservatives based on borates, propiconazole and tebuconazole (treated articles) from a replacement perspective:

- For what purposes are these treated articles used?
- What are alternative ways to realise these purposes, and to what extent can they substitute the articles that are treated with borates, propiconazole or tebuconazole?
- What are benefits, disadvantages, and risks of using these alternatives as compared to the use of the treated articles?
- What drives and what prevents substitution of the treated articles?
  - ✓ What is the risk awareness of the various actors dealing with these treated articles?
  - ✓ What are drivers and motives for adapting alternatives? What are bottlenecks and barriers to adapting alternatives?

And the final question:

- What will be the impact of renewed approval or of a decision to withhold approval of borates, propiconazole and tebuconazole as active substances for wood preservatives?

1.4. The approach of this study

• *The approach in general terms*

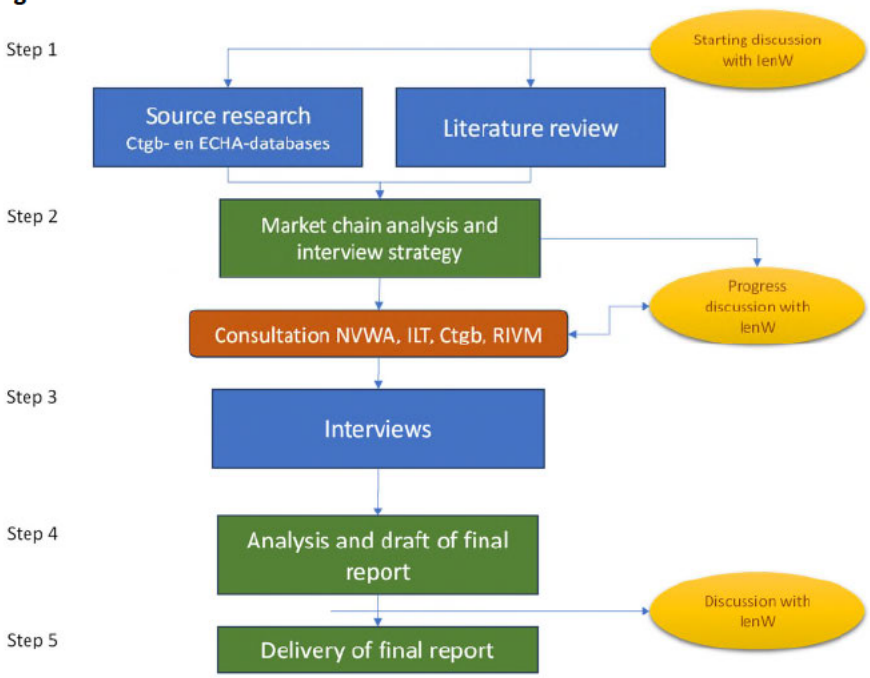
To answer the questions described above, a study was carried out in 5 steps. Two steps were aimed at data collection, namely the desk research in step 1 and the interviews in step 3. In intermediate step 2, a market chain analysis was carried out based on the insights obtained (which parties play a role where?) and an interview strategy was set up (which of those parties do we want to talk about?). Several relevant government parties were also consulted during this step to determine whether all relevant themes, data and parties were adequately covered. After the interviews in step 3, the data obtained were analysed and reported in draft form (step 4). The final report was delivered in step 5.

Consultations took place with the commissioning body (IandW) at essential moments in the process: at the start of the project (start of step 1), at the end of step 2 and for a discussion of the draft final report (between steps 4 and 5).

[13] Ministerie van Infrastructuur en Waterstaat (2023): *Strategisch kader voor de inzet van biociden bij het voorkomen en beheersen van ongewenste organismen*

Figure 1 below shows the broad outline of the approach used. The individual steps are explained in more detail in the following subsections.

Figure 1: Broad outline of the research



- *Step 1: Desk research*

The desk research was carried out along two lines:

– The databases on the Ctgb and ECHA websites were searched for the approval of borates, propiconazole and tebuconazole for PT8 and for the authorizations of PT8 biocides based on these active substances. In particular, it has been mapped out:
  - ✓ who the producers/applicants are;
  - ✓ what the specific applications, intended uses are (including any special forms of wood preservation, treated articles) and specific legal instructions for use; and
  - ✓ any additional comments and opinions.

– A literature search was carried out for relevant publications on, among other things, borates, propiconazole and tebuconazole, wood preservatives based on these active substances, innovations in word preservation.

- *Step 2: Market chain analysis and interview strategy*

A chain analysis was carried out based on this information. It was mapped out who the upstream and downstream producers of (wood preservatives based on) borates, propiconazole and tebuconazole are, to which markets (and companies) they supply for which use, and which other (sector) organizations play a relevant role in this area and/or have relevant expertise. In a similar way the value chain of the applications of wood preserved with borates, propiconazole and tebuconazole was mapped.
It was also examined to what extent answers to the various research questions could already be distilled from the data obtained (for example about volumes and about hazard and risk properties). Any gaps in these answers were taken into account when determining the interview strategy.

Based on the chain analyses, it was determined who are the relevant parties to be interviewed. A distinction was made between players with a unique information position and more generic players from whom exploratory information (and possible referrals) can be obtained.

Based on all this and the further research questions as stated above, an interview strategy was drawn up, including the question items to be addressed by the various players.

The overview described above of available or unavailable information and of parties to be interviewed has been submitted to several government parties (NVWA, ILT, Ctgb, RIVM and commissioning body landW); This was to check completeness and with a view to possible additional search directions.

- *Step 3: Interviews*

The interview strategy was then implemented. Parties in all links of the production and application chain have been approached (in some cases, umbrella organizations were approached to represent the users). The first approach took place by email, followed by either a written exchange of information or by a telephone, online or (in several cases) face-to-face interview.

In total, information was exchanged with the following types and numbers of parties involved. Appendix 1 to this report provides a further description of this.

Table 1: Numbers and types of consulted parties

	Number of interviewed persons	Number consulted in writing
Producers / authorization holders (Including producers of alternatives)	7	8
Applicants / umbrella organizations of applying sectors	1	4
Experts	7	7

Global (not verbatim) reports were made of the interviews. If so required, respondents were sent the interview reports for approval.

- *Step 4 en 5: Final reporting*

Based on all this, an overall analysis was carried out and a draft version of the present report was drawn up. This was submitted to the ministry of landW. After questions and comments were processed, the present final report was sent to the client for approval.

1.5. Reading Guide

The remainder of this report is structured as follows:

- The next chapter (2) describes the most important results of the desk research. It describes what is known about the functional and hazardous properties of borates, propiconazole and tebuconazole, for which applications in PT8 wood preservatives with these active substances are authorised and what is otherwise known about the nature and size of the current market.
- Chapter 3 and 4 mainly describe the results of the interviews. In chapter 3, it is described whether and how wood preservation takes place in the various areas of application of wood preservatives based on these active substances (including the possible use of alternatives). Chapter 4 deals with (developments in) the use and possible risks of the treated articles; the preserved wood and wood products.
- Chapter 5 discusses other matters that fall outside the scope of the previous chapters (i.e. about the present lack of innovation and about the general availability of alternatives).
- Chapter 6 draws conclusions from all this, and in particular about the question of what the impact will be of re-approval or of a decision to withhold approval for borates, propiconazole and tebuconazole as active substances in PT8.

The appendices contain an overview of sources consulted (appendix 1) and an overview of the authorizations for wood preservatives based on borates, propiconazole and tebuconazole (appendix 2).

2. Properties, application, and market data

2.1. Introduction

This chapter describes, mainly based on desk research:

- What is known about the functional and hazard properties of borates, propiconazole and tebuconazole (section 2.2). This mainly concerns data of a natural scientific nature that have largely been known and established for a longer time. The description in this chapter is therefore largely based on the assessments of the evaluating competent authority and opinions of the Biocidal Product Committee (BPC);
- For which applications in PT8 wood preservation products are authorised (section 2.3). Current data on this are taken from the websites of ECHA and Ctgb (reference date November 1, 2023); and
- What else is known about the nature and size of the current market (section 2.4).

2.2. Properties

2.2.1. Functional properties

The substances studied are as follows:

- Borates, which are:
  - Disodium tetraborate, existing in either of its three manifestations:
    - Disodium tetraborate anhydrous (CAS 1330-43-4)
    - Disodium tetraborate pentahydrate (CAS 12267-73-1 and 12179-04-3[14])
    - Disodium tetraborate decahydrate (CAS 1303-96-4)
  - Boric acid (CAS 10043-35-3)
- Propiconazole (CAS 60207-90-1)
- Tebuconazole (CAS 107534-96-3)

The three manifestations of disodium tetraborate are different forms of the same compound. They differ only in their amount of water in crystallisation. The active substance and their behaviour in the environment and dissolution in water is the same.[15]

- *Borates*

The intended use of boric acid and disodium tetraborate is both as fungicide and insecticide. Their exact mode of action is not completely elucidated though it is known that it is less specific than that of the conazoles. From previous research it is known that:

- Borates are in-activators of several enzymatic processes, by reacting with functional groups in proteins, inhibiting metabolic activity and inhibiting growth processes in fungi.[16]

[14] Two CAS numbers exist for the same compound disodium tetraborate pentahydrate (12045-88-4) or borax pentahydrate (12179-04-3). Also, two EC numbers exist for the same compound: disodium tetraborate pentahydrate (borax pentahydrate): EC 215-540-04 and EC 235-541-3.

[15] ECHA (2009). *Assessment Report Disodium tetraborate Product-type 8 (Wood preservative);* February 2009, eCA: the Netherlands

[16] Reinprecht (2010). Fungicides for wood protection-World viewpoint and evaluation/testing in Slovakia (pp. 95-122). InTech, Rijeka, Croatia.

- Boric acid inhibits biofilm formation and hyphal transformation, which lowers the chances of the fungus to replicate and survive within a host.[17] In addition, boric acid appears to arrest fungal growth and prevents the production of reproductive spores.[18]
- In insects, the effects of borates are miscellaneous and non-specific. Borates appear to inhibit several processes, including metabolism and exoskeleton.[12,18]

Because of these modes of action boric acid is labelled as both insecticide and fungicide and is also effective against spores.

Borates possess several other advantageous properties such as a low vapour pressure, high diffusion capability flame retardant properties, corrosion inhibiting properties and a high diffusion capability.[7, 11] Authorization holders inform us that these properties contribute to the preference for the use of borates especially for indoor applications.

- *Propiconazole and tebuconazole*

Both tebuconazole and propiconazole are intended to be used as fungicide, specifically against wood discolouring and wood rotting fungi and moulds.[19,20]

The mode of action of the azole-group is through the ergosterol biosynthesis: it inhibits the enzyme lanosterol 14-alpha-demethylase, thus halting the production of ergosterol. Ergosterol is the main sterol in the fungal cell membrane. Depletion of ergosterol thus damages the cell membrane, leading to fluidity of the membrane, halting growth and eventually resulting in cell death.[16]

2.2.2. Hazardous properties for human health

As indicated in the introduction, propiconazole qualifies as an exclusion substance under the BPR. Borates and tebuconazole were approved in procedures that started before the BPR came into effect. All three substances are marked as candidates for substitution. This is mainly the result of the conclusion that these substances either can cause adverse effects on sexual function and fertility or on development of the unborn child (reproductive toxicant, 1b) or that it is suspected of doing so.

Table 2: Summary of hazardous properties for human health

Active substances	Classification of reprotoxicity	Other classifications
Borates[21]	1B	Can cause serious eye irritation (disodium tetraborate)
Propiconazole[22]	1B	Suspected to have endocrine disrupting properties Acute toxic when swallowed May cause allergic skin reaction (sensitizer)
Tebuconazole[23]	2 (suspected)	Acute toxic when swallowed

17 *Boric acid: Uses, Interactions, Mechanism of Action | DrugBank Online.* (n.d.). DrugBank. https://go.drugbank.com/drugs/DB11326
18 *Boric Acid Technical Fact Sheet.* (n.d.). http://npic.orst.edu/factsheets/archive/borictech.html
19 ECHA (2023). *Renewal Assessment Report Propiconazole Product type 8 (Wood preservatives);* March 2023, eCA: Finland
20 ECHA (2007). *Assessment Report Tebuconazole Product-type 8 Wood preservative;* November 2007, eCA: Denmark
21 *Brief Profile - ECHA.* (n.d.). https://echa.europa.eu/nl/brief-profile/-/briefprofile/100.030.114 and *Brief Profile - ECHA.* (n.d.-b). https://echa.europa.eu/de/brief-profile/-/briefprofile/100.014.129
22 *Brief Profile - ECHA. (n.d.-c).* https://echa.europa.eu/nl/brief-profile/-/briefprofile/100.056.441
23 *Brief Profile - ECHA. (n.d.-d).* https://echa.europa.eu/nl/brief-profile/-/briefprofile/100.100.535

- *Borates*

Borates are classified reprotoxic 1B. Its reproductive toxicity has been observed in animals where it has embryotoxic and teratogenic effects. Fertility is also impaired as a result of exposure to borates. Metabolism and distribution of borates in the body is very rapid. As a result, boron has a low potential for accumulation. Borates harbour a low acute toxicity and are not skin irritating.[24] However, disodium tetraborate is an eye irritant, while boric acid is not. Borates are neither genotoxic nor carcinogenic.[15,25]

An additional note to the risks following from the hazardous properties of borates, concerns their concentration in biocidal products. In order to reach the desirable efficacy, boron compounds have to be applied in relatively high amounts, leading to concentrations in the biocidal product of 5%, which is substantially higher than the average concentrations of propiconazole and tebuconazole (0,05% – 1,45%).

- *Propiconazole and tebuconazole*

Propiconazole is classified reprotoxic 1B as well. Other hazardous properties of propiconazole are its moderate toxicity when swallowed (mainly through damaging the liver), it is a skin sensitizer (category 1a) and it is suspected to have endocrine disrupting properties, since, as an inhibitor of aromatase, it has activity on steroidogenesis. Propiconazole is not genotoxic or carcinogenic.[19,26]

Tebuconazole is reported to present mostly the same hazardous properties as propiconazole, although to a lesser extent. It is suspected to harbour embryotoxic effects (reprotoxic 2). The acute toxicity through the oral route is low. Tebuconazole is not irritating or sensitizing to the skin. Tebuconazole is also neither genotoxic nor carcinogenic.[20,23]

2.2.3. Hazardous properties for the environment

Borates, propiconazole and tebuconazole can be released into the environment during production, processing, from treated timber in storage after industrial treatment, during the use of the treated articles and during and after in-situ treatment of wood. Releases would mainly enter the aquatic compartment (incl. sediment) and the soil (incl. groundwater).

Table 3: Summary of hazardous properties for the environment

Active substances	Classifications
Borates[21]	-
Propiconazole[22]	Hazardous to aquatic environment, acute and long-term effects
Tebuconazole[23]	Hazardous to aquatic environment, acute and long-term effects

[24] The toxicity of borates can be compared to other active substances by comparing the DNEL (Derived No Effect Level) and/or NOAEL values (No Observed Adverse Effect Level) of other substances. The effect levels of borates are a factor 3 to 7 higher (and thus less toxic) than those of tebuconazole and propiconazole. However, in order to reach the desirable efficacy, boron compounds have to be applied in relatively high amounts, leading to concentrations substance in the biocidal product of 5%, which is substantially higher than the average concentrations of propiconazole and tebuconazole (0,05% – 1,45%).

[25] ECHA (2009). *Assessment Report Boric acid Product-type 8 (Wood preservative);* February 2009, eCA: the Netherlands

[26] Biocidal Products Committee (2022). *Opinion on the application for approval of the active substance: Propiconazole Product type: 8;* ECHA/BPC/324/2022

- *Borates*

Disodium tetraborate will, once released in the environment and dissolved in (surface)water, dissociate to boric acid. Boric acid is not bioconcentrated or bioaccumulated along the food chain in both aquatic and terrestrial ecosystems. It is considered very persistent since it is an inorganic compound and does not biodegrade in sediments.[27]

While their high diffusion capability on the one hand leads to deeper penetration of borates into the wood, borates can – on the other hand – leach easily from treated wood.[12,16] Therefore, boron-containing biocides that are used in outdoor environments must be modified with fixatives or other protective additives to reduce their leachability.

- *Propiconazole and tebuconazole*

The behaviour and fate of propiconazole and tebuconazole are similar. When released into the environment, propiconazole and tebuconazole remain stable and do not dissociate or biodegrade. They adhere to soil particles, are not expected to have long-range transport and thus accumulate in the environment.[19,20] Because of this, the compounds are considered persistent.[28] On the other hand, propiconazole and tebuconazole have a low bioaccumulation potential, since they will be metabolized in organisms. Both propiconazole and tebuconazole are very toxic to aquatic organisms such as fish, invertebrates and algae.[20,29]

2.2.4. Resistance development

- *Propiconazole and tebuconazole*

A specific risk involved in the use of propiconazole and tebuconazole is the development of resistance in fungicides against these compounds. Metabolites of propiconazole and tebuconazole (triazoles) are used in human healthcare. There are signs of the potential involvement of the use of propiconazole and tebuconazole with resistance of a human pathogen, leading to treatment failure. Triazole-resistant fungi have been found on several locations in the Netherlands (including flower bulb waste, green waste, and wood chip waste).[26]

This risk of developing resistance is not specifically stated for tebuconazole, but as stated in the BPC opinion of propiconazole (2023): *[it] is a normal phenomenon embodied in the natural process of the evolution of biological systems and all DMIs (demethylation inhibitors), including propiconazole, have a similar risk for resistance development, although resistance factors may differ.* Since tebuconazole utilizes the same mode of action as propiconazole (inhibition of C14-demethylation), development of resistance is expected.[26]

Both ECHA and RIVM/Ctgb report the observation of triazole-resistant fungi (*A. fumigatus*) in wood waste and in soil in The Netherlands and Great-Britain respectively.[26,30] It is currently not immediately deducible what the source of this resistance is. Emissions of medicines (or medicine residues) and crop protection products to the environment may be a source as well.

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27 One interviewee claims that Boric acid has a long-term AEL value (Acceptable Exposure Level) of 0,572 mg/kg bw/day, whereas other approved active substances have AEL's ranging from 0,000007 – 0,2 mg/kg bw/day, which suggests that boric acid represents an active substance with the lowest long-term toxicity despite its reprotoxic effects.

28 ECHA (2013). *Assessment Report Tebuconazole Product-type 10 (Construction material preservatives);* September 2013, eCA: Denmark

29 ECHA (2007). *Assessment Report Propiconazole Product-type 8 (Wood preservatives);* November 2007, eCA: Finland

30 Wezenbeek, J., & Komen, C. (2023). Verkenning risicofactoren biocidegebruik. Aanbevelingen voor toezicht, onderzoek en beleid. rivm.openrepository.com. https://doi.org/10.21945/RIVM-2023-0376

An interviewed producer stated that the quantities of biocides containing triazoles are insignificant as compared to the amounts of crop protection products with triazoles that are or were emitted to the environment; thereby bringing into question the contribution of wood preservatives in this development of resistance.

A general practice for counteracting development of resistance is by mixing multiple active substances with different modes of action.[12] It can indeed be observed that several of the wood preservatives authorized for use in the Netherlands combine propiconazole and/or tebuconazole with other fungicides, particularly IBPC (Iodopropynyl Butyl Carbamate) or Basic Copper Carbonate.

Because of the possible consequences of infections with resistant fungi including the risks for human health, a European research project into azole resistance is underway.[30]

- *Borates*

The occurrence of resistance due to the use of boron-compounds is not considered a critical factor, due to their broad modes of action. Besides, the formulations of biocidal products containing borates are usually mixes of multiple active substances (see above).[12]

2.3. Authorized applications

2.3.1. Use classes and the application of biocides

The legal instructions of use state for which applications the biocides are authorized. For application onto wood, this is determined in relation to the intended use of the wood. The use of wood is defined in classes according to the European Standard NEN-EN 335. A use class is not a performance class but represents different use and (mainly moisture related) exposure situations of wood and wood-based products.[31]

Use class 1	Internal use, not exposed to weather and wetting.
Use class 2	Internal use, occasionally moist conditions (e.g. from condensation).
Use class 3	External use, no ground contact, generally moist conditions.
Subclass 3.1	In this situation the wood and wood-based products will not remain wet for long periods. Water will not accumulate.
Subclass 3.2	In this situation the wood and wood-based products will remain wet for long periods. Water may accumulate.
Use class 4	External use, with ground contact, permanently moist conditions, direct contact with water is possible.[32]
Use class 5	The wood is permanently or regularly submerged in salt water.

Depending on the use class, the NEN generally describes which type of degradation by fungi, insects and other organisms can potentially be expected. Attack by wood-boring insects such as termites is possible in all use classes (depending on geographical region), while attack by disfiguring and wood destroying fungi is more common from use class 2 on. Attack by invertebrate marine organisms applies only to UC 5.

31 NEN (2013). Durability of wood and wood-based products - Use classes: definitions, application to solid wood and wood-based products. https://www.nen.nl/nen-en-335-2013-en-181850#; User classes were previously known as Hazard Classes

32 In previous versions of the NEN-EN 335 there was also a division in user class 4 into 4a: no direct contact with water; and 4b: in direct contact with water (ground or fresh water). Some of the legal instructions for use refer to these classes.

2.3.2. Authorized application of borates

According to the Ctgb and ECHA databases, wood preservation products with boric acid or tetraborate as the active substance for PT8 are authorized for use in the Netherlands for the applications shown in table 4 below.

Table 4: Authorized applications of wood preservation products with borates and/or tetraborate as active substance for PT8

(Source: Ctgb and ECHA databases; reference date March 1, 2024)

Authorized application	Active substance	For application in	Number and type of authorizations
For the preventive and curative treatment of wood	Boric acid	Wood, use class 2 and adjacent brickwork	1 fungicide and insecticide
	Disodium tetraborate	Wood. Use class(es) not specified	1 fungicide and insecticide
For the preventive treatment of wood	Boric acid	Wood, use class 1 and 2	1 fungicide and insecticide

According to the BPC opinion on borates, borate-based wood preservation products are currently authorized in PT8 for the preservation and curative treatment of both soft- and hardwood in use classes 1, 2, 3 and 4.[12,33] For all these authorisations for PT8, application may only be done by professional applicators, as stated in the legal instructions for use. The biocides are applied using a brush or by dipping.

2.3.3. Authorized application of propiconazole and tebuconazole

According to the Ctgb and ECHA databases, wood preservation products with propiconazole and/or tebuconazole as the active substance(s) for PT8 are authorized for use in the Netherlands for the applications shown in table 5 below.

As can be seen in Table 5, propiconazole and/or tebuconazole based wood preservation products are currently authorized in PT8 for the preservation treatment of both soft- and hardwood in use classes 1, 2, 3 and 4.[34,35]

[33] For two wood preservatives (one with tetraborate, one with propiconazole) the legal instructions for use states that the biocide may also be applied on wood that comes into contact with foodstuffs. At first glance, this appears to contradict the ECHA exposure assessment of tetraborate that states that *"finished wood products containing borates and manufactured for structural and building material are not appropriate to be used and would not be used to make products that would come in to contact with food or feeding stuff".* The scenario of contact with food or feed is therefore not accounted for in the exposure scenario and therefore in the risk assessment by ECHA. However, the BPC opinion on Propiconazole of 2023 states: *"For products that may lead to residues in food or feed a dietary risk assessment has to be performed at product authorisation level."* Therefore, there is no contradiction after all.

[34] See also footnote 33.

[35] Most biocides with propiconazole and/or tebuconazole are only authorized for application in use classes 2 and 3. Some are however also authorized for application in use class 4. Both authorizations for use classes 3 and 4 are in contrast with specific requirements in some of the legal instructions for use that the treated wood may not be regularly exposed to moist and/or may not come in direct contact with soil and/or (surface) water.

Table 5: Authorized applications of wood preservation products with propiconazole and/or tebuconazole as active substance for PT8
(Source: Ctgb and ECHA databases; reference date March 1, 2024)

Authorized application	Active substance	For application in:	Number and type of authorizations
For the preventive treatment of wood	Propiconazole	(Soft)wood, generally use class 2 and 3	3 fungicides 1 fungicide and insecticide (due to addition of permethrin)
	Tebuconazole	Softwood, use class 1, 2, 3 and 4	2 fungicides and insecticides (due to addition of basic copper carbonate)
	Propiconazole and tebuconazole	(Soft)wood, use class 1, 2, 3 and 4	2 fungicides 3 fungicides and insecticides (due to addition of basic copper carbonate or permethrin)
For the preventive and curative treatment of wood	Propiconazole	Wood, use class 1, 2 and 3	2 fungicides 1 fungicides and insecticides (due to addition of permethrin)

In general, for all these authorisations for PT8, application may only be done by professional applicators, mostly only in an industrial setting, as stated in the legal instructions for use. For two products the legal instructions for use allow application by non-professionals. The authorized non-professional method of application is brushing or spraying.

The fact that propiconazole is classified as Reprotoxic 1B implies – according to the BPR – that it cannot be applied by non-professionals. This has been confirmed Implementing Regulation 2023/2596 in which propiconazole as an active substance for PT8 is reapproved. All authorizations of wood preservatives based on propiconazole will have to be renewed before February 10, 2025. With that renewal the authorization for private use will expire.

For professionals, the methods of application are applying with brush/roller, casting (flow coating), manual dipping, automatic spraying in closed systems by industrial users, vacuum pressure treatment by industrial users and automatic dipping by industrial users. Curative treatment is done by either applying with a brush/roller or by borehole injection.

Authorized biocides are used for their fungicidal properties, or for their combined fungicidal and insecticidal properties. The active components propiconazole and tebuconazole are specifically responsible for the fungicidal effect. Propiconazole and/or tebuconazole are regularly combined with other active substances that are also fungicides or that add insecticidal properties to the product. Propiconazole and tebuconazole are regularly combined with IPBC (Iodopropynyl Butyl Carbamate) (fungicide), basic copper carbonate (fungicide and insecticide) and permethrin (insecticide).

2.4. Market data

- *Products, authorisations, and suppliers*

On the reference date (March 1, 2024), a total of 14 biocidal products with either propiconazole, tebuconazole or borates or a combination of these as an active substance were authorised for the Dutch market for PT8. The authorizations for these products are in the names of a total of 10 authorization holders. A total of 6 suppliers of propiconazole, tebuconazole or borates as an active substance for PT8 are registered with ECHA for the Dutch market.

Table 6 shows these figures further broken down.

Table 6: Numbers of products, authorization holders and suppliers of active substances, and biocidal claims

	Total	Only fungicidal effect	Fungicidal and insecticidal effect
Number of authorised products	14	7	7
... of which contain propiconazole	12	7	5
... of which contain tebuconazole	7	2	5
... of which contain both propiconazole and tebuconazole	5	2	3
... of which contain borates	3	0	3
Number of authorisation holders	12		
... for biocides containing propiconazole	10		
... for biocides containing tebuconazole	5		
... for biocides containing borates	3		
Number of suppliers of active substance	6		
... propiconazole	3		
... tebuconazole	2		
... borates	2		

Besides above presented figures, the database of ECHA also provides information on cancelled and expired authorizations: for propiconazole the authorizations of 10 biocides were expired between 2019 and November 2023 and 5 were cancelled. For biocides containing tebuconazole 1 authorization was expired and 2 were cancelled in this period. Two biocidal products containing borates were expired.

- *Market volumes*

An attempt was made to gain insight into the amounts of the borates, propiconazole and tebuconazole as the active substances and the quantities in PT8 on the Dutch market. This proved to be hardly or not possible when looking for public sources in the Netherlands, as there is no registration of this. Interviewed companies generally indicate that this is confidential company information that they do not wish to share in the context of this research. Besides, when figures are available, it is usually of the with-biocide-protected articles (treated articles) and not the volumes of the biocide itself.[36]

General indications of the amounts of borates, propiconazole and tebuconazole on the European market can be obtained from Member States where the volumes of traded active substances and biocides are registered. These volumes that are reported are presented in table 7 below.

[36] E.g. authorization holder Wolman GmbH estimates that more than one billion pallets have been protected using their product so far in Europe

Table 7: Market quantities of propiconazole, tebuconazole and borates in a few EU countries

Active compound	Country	Tonnage of the active compound on the market for PT8							
		2010	2013	2016	2018	2019	2020	2021	2022
Propiconazole	Belgium				10,9	10,5			
	France							54	
	Croatia	0,03	0,34	0,1	0,11	0,08	0,17	0,15	0,09
Tebuconazole	Belgium				4,8	4,8			
	France							22	
	Croatia	5*	0,03	0,15	0,09			0,17	0,03
Borates	Belgium				20,5	19,8			
	France							20	
	Croatia								

* Due to the large deviation from the average, this number is considered an outlier.

In Belgium the market data that suppliers are obliged to provide – numbers and tonnages of active substances and products per year – are published on a website,[37] albeit only at the level of Product Groups and PTs. Further inquiries revealed that data for 2018 and 2019 are currently publicly available on biocides in PT8.[38]
Some Dutch interviewees indicate that the Belgian market for PT8 is largely comparable to the Dutch market. It is estimated that the Dutch market will be bigger but in the same order of magnitude.

Another Member State where volumes of traded active substances and biocides are registered is Croatia. Upon inquiry, only figures for propiconazole and tebuconazole placed on the market in 2010 – 2022 proved to be available. The quantities are calculated from quantities of the biocidal products placed on the market and the concentration of active substance present in the final products. According to the Croatian ministry of Health, the market in Croatia is small and will not resemble to that of the Netherlands.

In France, a study has been published that includes market data over 2021[11]. The volume traded for each active substance in PT8 has been determined based on the number of biocides sold and their composition. In France, propiconazole is one of the active substances in 20 of the 36 biocides in PT8. Tebuconazole is in 15 out of 36 biocides in PT8. There are only few products with borates on the French market (same as in the Netherlands): in France only one. Still, borates are used in large absolute quantities (20 tonnes). This is due to the market share of this one product and to the concentration in which borates are to be applied (see paragraph 2.2.2).

37 See: apps.health.belgium.be/files-dwh-ext/files/gau/index.html
38 In Belgium, registration started in 2018; After 3 years, figures at substance level become passively public.

3. Current use and alternatives

3.1. Introduction

The following paragraphs describe for the application areas for which borates, propiconazole and tebuconazole are authorised, how wood preservation takes place, what the use of biocides with these active substances is, under what circumstances this takes place and why. From a preventative (integrated pest management) perspective, the risk awareness of the parties involved is described, as well as the current options for other ways and means for wood preservation and for the substitution of the focal exclusion substances.

The description in this chapter is based on reports, and on interviews with and written answers from those involved. Where these sources and parties gave different or even opposite information, this is stated in the text. This is the case several times. Nevertheless, a reasonably consistent picture emerges from the information provided by different parties.

3.2. Use in professional and industrial wood preservation

3.2.1 Professional and industrial wood preservation

Preventive wood treatment with wood preservatives mainly takes place in an industrial setting, either by impregnating (dipping or vacuum pressure methods) or brushing of wood.[39] Curative treatment is carried out by professionals, mainly through brushing and injection.

Wood preservation mostly happens outside of the Netherlands, as the largest part of the preserved wood used in the Netherlands is imported from other (EU and non-EU) countries (see chapter 4).

As was described in the previous chapter, most of the wood preservation products based on borates, propiconazole and tebuconazole as active substances, are authorized for professional and industrial use. Only two products based on propiconazole are still also authorized for non-professional use. This will stop by February 10, 2025, at the latest, after renewal of these authorizations, following the decision of Regulation 2023/2596 that private use is no longer allowed since propiconazole is classified as reprotoxic 1B.

Branch association 'Verduurzaamd Hout Nederland' (VHN; Preserved Wood Netherlands) has 7 company members that are active in (industrial) wood preservation in the Netherlands (next to 3 suppliers of wood preservation products and 1 distributor of preserved wood).

The KOMO quality mark (KOMO keur) is a certification scheme designed for the Dutch building sector, which aims to guarantee the quality of different (mostly building) products. KOMO has specific certificates for wood preservation (including dipping and vacuum pressure preservation).[40] In total 21 wood preservation companies have such certificates; 10 of them are Dutch, including VHN members. Next to requirements that pertain to production processes and product quality, the KOMO schemes also contain requirements for environmental protection (e.g. to prevent leakage), working conditions (e.g. to prevent persons from exposure to impregnating agents in mist form), user safety (e.g. information about risks and safe use) and user instructions for safe waste disposal.

[39] See: https://www.vhn.org/verduurzaming-hout/techniek/
[40] See: https://beheer.komo.nl/brl/getfile/2724

According to interviewees, risk awareness in wood preservation companies and among professionals is high. Industrial wood preservation takes place in controlled production systems. Vacuum pressure preservation happens in closed systems. Operators work with personal protection equipment and are sometimes trained by their suppliers. Under these circumstances the risks for humans and the environment are deemed to be properly controlled.[41]

3.2.2 Borates in professional and industrial wood preservation

Reportedly, borates-based biocides are hardly used anymore in the Netherlands for preventive wood preservation. Interviewees state that users have mostly shifted towards copper and azoles. The few last applications that are mentioned, are the use against dry rot fungus on wood and brickwork, and the use for the preservation of wood – particularly wood for pallets – against sapstain.[42] ECHA states that the use against sapstain is one of the key uses of borates.[12] One interviewee estimates the EU market share of its borate containing product for anti-sapstain to be more than 60% (having protected more than one billion pallets over the last 25 years).

About sapstain: although it does not decay the wood (no rot), it does make the wood unsuitable for certain applications. According to several experts, laymen (including customs officers) often assume that pallets from wood with sapstain are infected, which causes problems with acceptance and export.

For curative purposes, borates-based biocides appear to be more and more replaced by biocides based on propiconazole and quaternary ammoniums. However, reportedly, borates are still used for some applications, particularly against dry rot fungus.

3.2.3 Propiconazole and tebuconazole in professional and industrial wood preservation

As was described in the previous chapter, propiconazole and tebuconazole are both frequently used active substances in wood preservatives, often in combination with each other and/or other actives. They are both, and increasingly, used for preventative and for curative purposes, also because of the disappearance from the market of wood preservation products with other, no-longer approved active substances.

Propiconazole and tebuconazole based wood preservatives are widely used for the preservation of soft wood. Application takes place, amongst other things, by specialised companies, pallet producers and manufacturers of joinery (frames, windows, and doors), facade cladding and construction wood.

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41 The Netherlands Labour Authority (Nederlandse Arbeidsinspectie) is currently carrying out an inspection project in the wood, carpentry and furniture industries, which include wood preservation companies. Results are not yet made public. The previous inspection project in these industries took place in 2012-2013. Violations of the Working Conditions Act were most of all found in the field of machine safety, next to violations in the field of exposure to wood dust and safe design of the workplace (Inspectie SZW, 2013). These findings concerned the industry as a whole, of which companies that conduct wood preservation are but a small and different part. To set priorities in that project, the Labour Inspectorate used a study into work-related health effects of exposure to hazardous substances carried out by TNO (TNO, 2011). Particularly regarding wood preservation, the report concludes: "Exposures to chromium, arsenic and PAHs are found in other countries, but in the Netherlands no products containing these substances were found in the Pesticide Database and therefore they are not permitted in the Netherlands" (TNO, 2011, annex 7, p. 79).

42 According to one interviewee, the concentration of borates in the product that is used for this purpose has been reduced to 6%, only to serve as a fixative for the quaternary ammoniums that are the real active substances. The exact opposite can be read in the ECHA opinion on alternatives to borates, where it is stated that borates leach easily from treated wood, which is why they are often co-formulated with fixing wood preservatives such as quaternary ammoniums (ECHA/BPC/271/2020, p. 11 (footnote 12)).

3.3. Alternatives in wood preservation

This paragraph discusses ways to preserve wood with alternative means than preservatives based on borates, propiconazole and tebuconazole.[43] Ways to realise societal functions (e.g. building, fencing) with other means than by using (preserved) wood, are discussed in the next chapter.

Most of the alternative means serve preventative purposes. Some, however, are also used for curative treatments.

3.3.1. Non-biocidal alternatives in wood preservation

- *Monitor and repair*

There are several alternative ways for preventing wood from being affected by fungi and insects. The first one is to refrain from wood preservation and to conduct adequate monitoring and, if necessary, repair operations. This option may be feasible in the lower use classes (possibly in combination with other forms of protection (varnish, paint, drought). For many applications, however, monitoring and repairing may bring along high costs, and are in some case not possible.

- *Improved wood management*

Improved wood management, both in logistics (timing of felling trees, faster removal, sawing and drying of wood) and in the wood application (moisture reduction, use classes, short time of wetness and reduction of the risk of deterioration), can help to reduce the use of biocides. However, this requires expertise and more time, and therefore also entails higher costs.

- *Durable woods*

Using natural durable woods (hardwood) is another option for avoiding the use of biocides. Some species are exotic and have an uncertain sustainability record. Others are regionally/locally available and are suitable for use classes 1 to 4. However, the most obvious limitation of this option is the clear mismatch between supply (also because trees for durable wood grow slower) and potential demand. Therefore, most of the wood that is used is softwood from regional sources, which mostly requires preservation to become durable.

- *Drying*

Drying wood to less than 21% moisture content prevents rot. Drying is an alternative for anti-sapstain treatment with biocides. The method of kiln-drying is predominantly used in the Nordic countries. It is an energy-intensive process, although usually the residual wood that remains after the tree has been sawn into planks is used as fuel (conversion rates are 50 to 60%), which means that bioenergy is used. Drying only has limited residual efficacy (the wood must stay dry).

- *Wood modification*

There are several techniques for wood modification, some of which already on the market for several years, that have a preservative effect: chemical, thermal and oleothermal modification of wood and wood-polymer composites.

– Chemical modification is done by different processes including furfurylation (Kebont process), acetylation (Accoya process) and treatment with DMDHEU.[44] Chemical modification of wood

[43] This paragraph is largely based on Ineris, 2022; ECHA/BPC/271/2020 (see footnote 11); and Arcadis, 2022 (see footnote 10).

[44] DMDHEU = 1.3-dimethylol-4.5-dihydroxyethyleneurea. DMDHEU penetrates and reacts with the wood cell, forming cross-links. This provides moisture control, resulting in resistance to decay and the enhancement of some other wood properties.

results in a distinct chemical change in the macromolecules of the cell walls and is therefore referred to as a non-biocidal treatment for preservation of wood.[45] Wood is injected with chemicals to make it partially hydrophobic and less susceptible to biological pathogens. Chemically modified wood can be used for class 2 and 3 (not for in-ground use),[46] with a lifespan expectation around 20-50 years. Disadvantages are possible reactions of the injected substances with finishes and hardware, sensitivity to fire, discoloration of the wood (some remaining sensitivity to moulds when used outside) and higher costs. Besides, only a few wood species are suitable (although research is ongoing).[47]

- Thermal modification by high temperature treatment sterilises and dries the wood (thus depriving moulds of moisture), makes tars appear and reduces insect-attracting terpene emissions (expected lifespan: 15-25 years when not in ground contact). However, the treatment makes the wood more brittle, which excludes it for use as a structural element. It is more expensive than chemical preservation (but less expensive than chemical modification), generates oils and tars (toxic residue) and is not guaranteed against termite attack. It is rather well available on the market.
- Oleothermy (also known as Oil heat treatment (OHT)) is a process that (partly) replaces the water in the wood with oil to a depth of about 2 to 3 mm. This makes the wood less susceptible by fungi and less attractive to insects. However, the technique does not fully protect against insects, does not allow any finishing to the wood, and the appearance of thermo-oiled wood can be altered by dirt clinging to the excess oil.
- Wood-polymer composites may be used as alternatives. However, they are expensive, not cost-effective and are considered synthetic materials (and not a genuine alternative to wood).[12]

According to an interviewee, the market share of modified wood in the Netherlands is slowly growing, but only for special purposes.

- *Chemical non-biocidal alternative*

A low-risk chemical non-biocidal alternative that is specifically mentioned by the interviewees, is Xyhlo-biofinish. This technology is a combination of a fungus and water repellent effects of natural oils that utilizes the advantage of the competitiveness of species on natural oils and the functional properties of the resulting biofilm.[48] The pigmented fungus (that reduces infection by xylophage organisms) grows densely on wood surfaces that are treated with natural oils, which prevents degradation. A similar technology was previously and effectively used in fruit cultivation.[49] Currently, only the colour black is commercially available due to the fungal pigmentation.

The authorization and application of this fungal strain *Aureobasidium pullulans* does not fall under the BPR as it is not an active compound but is viewed as an auxiliary agent because of its colour-giving pigmentation. Xyhlo-biofinish is therefore not considered a biocide, but it is a wood protecting principle.

According to the producer, Xyhlo Biofinish concept can make the use of biocides for preservation of wood without ground contact unnecessary. Moreover, research into treatment of wood in direct contact with the ground has led to first positive results.

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45 Gérardin, 2016; Mantanis, 2017.

46 Accoya claims durability class 1, which implies a lifespan of 25 years and suitability for outdoor carpentry, terraces and decking, garden furniture, bridges and scaffolding. However, for exterior load-bearing constructions Accoya can only be used in use classes 1 to 3 (which means: not for in-ground use). Outdoor use is allowed up to use class 3.2 under specific conditions. See: https://www.accoya.com/app/uploads/2020/05/Accoya-Collateral_PerformanceTesting_EN.pdf

47 E.g.: Marfo et al., 2018.

48 Sailer, M., Van Nieuwenhuijzen, E. J., & Knol, W. (2010). Forming of a functional biofilm on wood surfaces. Ecological Engineering, 36(2), 163–167. https://doi.org/10.1016/j.ecoleng.2009.02.004

49 From: https://www.ctgb.nl/actueel/nieuws/2022/11/25/groene-middelen-uitbreiden-met-kleine-toepassingen-draagt-bij-aan-verduurzaming

Wood treated with Xyhlo-biofinish is currently applied in several smaller projects in the Netherlands. One interviewee states that the first industrial project is now starting. He expects the market for alternatives such as Xyhlo will grow rapidly in the coming years.

- *Other technologies*

BPC mentions microwave treatment as a technology that is used against wood-attacking insects.[12] It is added that this this method is mostly used as a curative method and that is does not provide residual efficacy.

Arcadis mentions nanotechnology, genetic selection and genetic modification as relatively new techniques for wood preservation.[10]
There is an existing market for nano-based wood preservation products, some of which do not work on the principle of toxicity. According to Arcadis, prices are high and harmful side-effects because of the nanoscale are possible but not yet known.
Both genetic selection and genetic modification aim at producing new or adapted wood types that are inherently durable, without a need for preservation or use of toxics. Genetic selection is a quite traditional, well-known technique in seed breeding. It is, however, barely applied in the wood industry because of the long time needed to grow trees. For genetic modification, a lot of research still needs to be done before it is feasible and before all features are known.

3.3.2. Alternative biocidal techniques to wood preservation

- *Alternative non-authorized (active) substances*

There are also other (active) substances that are presented as alternatives. Broda (2020) points at fungicidal properties of essential oils, tannins, wood extractives, alkaloids, propolis or chitosan and their 'enormous potential in wood protection'. However, according to Broda, these substances also have inherent limitations that need to be solved, and often their modes of action do not match with current testing and legislative requirements. Vanneste et al. (2002) describe experimental use of (1) essential oils and (2) micro-organisms for anti-sapstain treatment, resulting in development of a pine oil derivative being developed for commercial use. In the BPC opinion on alternatives for borates and also in the report from Arcadis (2022), mention is made as well of essential oils, pheromones, fluorines and extracts of thermally treated wood.[10,12] The BPC concludes that for most of these substances research is in an early stage. Also, as none of these substances is authorized at present, they cannot be considered alternatives.

- *Fumigation*

Fumigation is a technique that can be used to exterminate wood-destroying insects in wooden structures. The technique consists of hermetically sealing a wooden structure and to fill it with a (highly toxic) gas (sulfuryl fluoride) in concentrations and for timespans that are sufficient to eradicate target pest infestations. It can be used as a curative treatment for existing wooden structures that can be sealed off (buildings, laboratories, ships, factories). The product may only be applied by experts with professional competence requirements and a valid certificate for the application of sulfuryl fluoride ('gassingsleider'). Before a gassing takes place, the Human Environment and Transport Inspectorate (ILT) must be notified.

3.3.3. Authorised alternatives for borates in wood preservation

In its opinion on 'the availability and suitability of alternatives to boric acid and disodium tetraborate pentahydrate', the BPC makes a comprehensive overview and assessment of possible alternative active substances to borates.[12] The following findings and considerations are reported:

- 17 currently authorized substances are found (excluding substances that meet exclusion criteria or that are candidates for substitution) as alternatives to borates. For fungicidal activity at least 5 different modes of actions remain, and for insecticidal activity at least 4. These numbers are considered sufficient.[50]
- Borates are presented as active substances against which no resistance occurs in target organisms (this was also put forward by one of the interviewees). However, this is not considered as a critical factor, as the formulation of products based on multiple active substances (with different modes of action) has proven to be sufficient in dealing with issues such as tolerance of target organisms or limited fungicidal activity.
- Borates have additional properties that are deemed helpful. Of these, low vapour pressure appears not be unique for borates; several alternatives also have low vapour pressure. However, borates are indeed unique in their flame-retardant properties, corrosion inhibiting properties and high diffusion capability.[51]
- Generally speaking, for each authorized use of borate-based products, products based on alternative active substances are available that cover the same use.[52] However, some specific applications require further scrutiny and are assessed by the BPC, also considering technical feasibility, financial aspects, hazards and risks of alternatives, and availability. Based on this, it is concluded:
  - For anti-sapstain (particularly in pallets): alternative active substances are not in all cases suitable, considering the specificity of anti-sapstain products, the limitations of non-borate actives and their increased costs.
    Kiln drying, and the use of plastic pallets are not considered suitable alternatives, for reasons that include higher costs and limited availability.
  - For internal building structures: 53 alternative active substances may not be suitable in all cases, considering the need for a long service life and several beneficial properties of borate-based products (particularly so in EU member states where termites are endemic).
    The use of steel is not considered a suitable alternative because of higher costs and technical disadvantages.
  - For the dry rot fungus (Serpula lacrymans) in buildings: authorized products are either based on borates or on propiconazole (in combination with other actives). As both active substances meet the exclusion criteria, the number of active substances and modes of action available will be very limited in case the authorization for borates is not renewed.
  - For piles and grillages (in foundations under buildings): Only borate-based products are currently available for this application. Non-chemical alternatives are hydrological manipulation and underpinning; both come at high costs and are disruptive and/or conflict with other interests.
- Based on all this, the BPC concludes that for some uses of borates no suitable alternatives are available.

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50 The same conclusion was reached by Ineris (2022, p. 39-40)), see footnote 11.

51 It is noted that this is not only a helpful characteristic of borates. The disadvantage of this property is the fact that borates can leach easily from treated wood (see also footnote 42). This was confirmed by one interviewee.

52 This too is confirmed by Ineris (2022), see footnote 11. The methodology applied in this investigation does not include a further assessment of alternatives for specific applications.

53 Meaning: Wood used in a loadbearing capacity in buildings and structures where the strength of the timber is the primary consideration, such as sheds, joists, bridges, jetties, poles, decking, fence poles, etc.'' (EU 2023/2596)

Several interviewees emphasize the importance of having boron-based products on the market for remedial purposes, particularly when the wood has a high moisture content, for lack of effective alternatives for applications that are crucial for society.[54]

3.3.4. Authorised alternatives for propiconazole and tebuconazole in wood preservation

- *The INERIS study*

Ineris (2022) investigates the potential for substitution of substances used in wood preservatives.[11] Based on a broad inventory of hazard properties and market volumes, its study prioritises three active substances for which it looks for potential substitutes: creosote, propiconazole and boric acid. In addition, it is noted that tebuconazole may also meet an exclusion criterion, which is why it is also included in the substitution study.

The objective of the study is to find out whether there are products on the market that cover all the uses currently associated with the products based on the substance to substitute. To come to this, assessment reports (to register each substance's function, type of treatment, use class, users, and mode of application), the French 'Simmbad'-database and the database of the ECHA website are analysed. For propiconazole and tebuconazole, this leads to the following conclusions:[55]

- For use class 2 and 3, twelve alternative products without propiconazole are found. Four of these contain other active substances that meet exclusion criteria. Table 8 describes on which (combinations of) active substances these alternatives are based.
- For use class 2, 3, 3.1 and 4, twelve alternative products without tebuconazole are found. Three of these contain other active substances that meet exclusion criteria. Table 8 shows that alternatives are based on (combinations of) the same active substances as for products without propiconazole.

Table 8: Active substances (fungicides) of alternative wood preservation products without propiconazole and/or tebuconazole *(Source: Ineris, 2022)*

Active substances (fungicides)	Number of alternative products* for propiconazole-based products (also) based on this active substance	Number of alternative products* for tebuconazole-based products (also) based on this active substance
ADBAC/BKC (C12-16)	1	3
Bardap 26	1	1
Basic copper carbonate	3	3
DDAC	2	2
DDACarbonate	2	2
Copper hydroxide	1	1
Cu-HDO	1	1
IBPC	1	2
Penflufen	3	2
Total number of products	**8**	**9**

* Alternative products = products that do not contain substances that are classified as exclusion and/or substitution substances

[54] One interviewee submitted a comparative assessment by the Danish competent authority that reached the same conclusion.

[55] The conclusions about substitutes for borates match with those drawn by the BPC; see footnotes 50 and 52.

- The authors add some disclaimers to these findings. First, possible technical and economic implications of substituting these substances have not been taken into consideration in this study. Next, not all factors have been included that lead economic actors to favour the use of a particular substance or product. Also, only the criteria of the BPR have been used (and not, for instance, those of the Water Framework Directive). Finally, they point out that in the field of wood preservation, the number of approved active substances is low, and the number of substances that are actually used is even lower.

- *The interviews*

In the interviews, several comments were made regarding the use of alternative active substances. For example, it was stated several times that the beneficial properties of propiconazole (both in terms of performance and hazard characteristics), particularly when combined with IPBC, can hardly or not be parallelled by any other (combination of) actives. Also, it was pointed out that, other than the broad-spectrum fungicidal effect of the azoles, quaternary ammoniums like DDAC only have superficial effect and are not effective against wood rot. Penflufen is said not to work sufficiently against surface and wood discolouring fungi, IBPC not against all wood destroying and discolouring fungi. Therefore, effective formulations always require combinations of different active substances (which, as one interviewee puts it, 'also results in combinations of hazardous properties'). Consequently, according to interviewees, there is only limited availability of real alternatives for the formulation of effective (and less hazardous) wood preservatives.[56] This is confirmed by Ineris: "The path is narrow" (2022, p.57).

Several interviewees stress the importance of distinguishing between specific applications:

- *Vacuum pressure treatment:* Two interviewees point out that for wood in outdoor applications in use classes 3 and 4 there are only a few products that contain neither boron, nor propiconazole or tebuconazole. It is concluded that apart from using these substances, only two product types with two different modes of action are available to make European timber species durable in outdoor uses: one is copper with quaternary ammonium salts (quats), the other is copper and Cu-HDO.[57] This conclusion is not completely confirmed by our own analysis of products in the Ctgb-database. We do indeed find formulations with copper with quats and copper and Cu-HDO. However, we also find the use of copper with penflufen for use classes 3 and 4. Moreover, for use class 3 we also find a formulation based on ADBAC/BKC.[58] The discrepancy is explained by two interviewees as follows: biocides without copper are not (yet) considered as true alternatives in UC 3 and 4 because their long-term performance is yet unknown (for both penflufen and ADBAC/BKC), especially in harsher exposure situations. The interviewees state, moreover, that products that are solely based on penflufen or ADBAC lack efficacy against amongst others blue staining fungi and soft rot fungi.[59]
- *Dipping and metal-free vacuum pressure treatment:* Reportedly (2 interviewees), products for these applications often contain propiconazole, sometimes in combination with other fungicides (IBPC, tebuconazole) and in combination with insecticides (e.g. permethrin). Alternatives are based on penflufen and permethrin. These are not considered to be comparable to propiconazole-based products, as penflufen as sole fungicide lacks efficacy against wood-discolouring fungi. Again, in our own analysis of products in the Ctgb-database we do indeed find the same formulations. However, we also find two formulations based on ADBAC/BKC. The two interviewees explain that, besides the drawbacks mentioned in the paragraph above, an important drawback in the use of quaternary ammonium salts is the corrosiveness of the

[56] According to one expert, this is also a marketing problem for producers, as this makes it hardly possible to distinguish oneself and one's products from the competition.

[57] One of the interviewees says not to know whether these products can fully replace the established copper/azole formulations, especially in terms of long-term performance.

[58] ADBAC/BKC = Alkyl (C12-16) dimethylbenzylammoniumchloride

[59] One interviewee states another downside to the use of ADBAC/BKC: the treated wood may have a slippery surface when wet, as quaternary ammonium compounds are soaps.

compound, affecting nails, screws and fittings. Therefore, these preservatives are not recommended for applications where metal connectors or fittings are essential, such as lead bearings, structural timbers and joinery (beams, roofing timbers, dormer windows, windows and doors, fences and rails etc.).

- *Industrial treatment of joinery (use classes 1-3):* One interviewee states that 'typical products' contain a combination of tebuconazole and/or propiconazole and IBPC. Alternatives are based on IBPC only. These are not considered alternatives, because of its weakness against white rot fungi. Alternatives based on penflufen and IBPC are not yet authorised and are not expected to be available in the next 2 to 3 years.
  Our own analysis of products in the Ctgb-database confirms this statement.
- *Primers:* One interviewee presents an inventory of authorized primers. According to this inventory, all authorized primers in Germany and Austria contain IBPC and either propiconazole or tebuconazole. Only one primer is authorized in Norway and Sweden that does not contain propiconazole.

Several interviewees indicate that they are working on substituting tebuconazole and propiconazole in new formulations (particularly for dipping, metal-free vacuum pressure treatment and treatment of joinery). One of them resorts to substantially higher doses of IBPC. Others work on formulations that include penflufen ('the only new active substance that has come on the market in recent years'). They expect to be successful in the end[60] but are still in the phase of authorisation or of getting data packages ready for submission. So, according to them, replacing tebuconazole and propiconazole in all product categories is at least 6-11 years away when also considering the time needed to set up production and convert customers' treatment plants.

Specific remarks are made about possible resistance of fungi against penflufen. As this substance is relatively new on the market, it is not yet known whether such resistance may occur – in relation to which the importance is stressed of maintaining substances with known performance available on the market for the time being.

- *Consideration for Propiconazole reapproval 2023*

In its Implementing Regulation,[61] the European Commission summarizes its considerations for the reapproval of propiconazole as an active substance for PT8. These considerations are:

- There are several applications for which propiconazole is still needed. They are:
  - *Anti-sapstain treatment:* There are no real alternatives. Tebuconazole has a lower efficacy and is very persistent (vP) and toxic (T). Borates are exclusion substances. IBPC is not effective against all discolouring fungi.
  - *Industrial and professional treatment of structural wood, particularly for use classes 3 and 4*: Tebuconazole is no alternative, see above. Quaternary ammonium compounds (quats) have a low efficacy against discolouring and wood-rotting fungi. Mixtures of copper and quats present several technical limitations. Boron compounds are prone to leaching. Oil-based biocidal products based on penflufen have been recently developed and need more time for testing and gaining sufficient experience.
  - *industrial and professional treatment of joinery*: Tebuconazole and IBPC are no alternatives, see above (IBPC in higher concentrations may lead to yellowing of treated wood). Possible alternatives based on OIT or DCOIT[62] present technical limitations and are not yet on the market. With products based on penflufen more experience is needed (see above).

[60] One interviewee remarks that products based on Penflufen as sole fungicide lack efficacy against blue staining fungi, which is not a structural issue, but which may lead to a reduced acceptance of the treated wood, as laymen may not be able to distinguish wood staining fungi from wood degrading fungi.

[61] Commission Implementing Regulation (EU) 2023/2596

[62] OIT and DCOIT are biocides based on isothiazole. These active substances are approved since 2018 and 2013 respectively, though there are no related authorised biocidal products for PT8 on the EU-market.

    - *In situ brush, spraying or injection applications for use classes 2 and 3*: The same considerations as mentioned above hold true here for tebuconazole, IBPC (which in higher concentrations could also provoke skin sensitising issues) and penflufen.
- Alternative methods to extend the durability of wood against fungi exist. Heat treatment and chemical modification are however not suitable for all forms of timber construction materials. Durable tropical hardwood is less available, results in higher costs and negative impacts on sustainability.
- Alternative materials, such as steel, plastic, aluminium, and concrete, may not always be technically or economically feasible and may raise their own sustainability issues.
- It is concluded:
    - that the conditions of Article 5(2), point (c) of the BPR are satisfied ('non-renewal would have a disproportionate negative impact on society');
    - that there are no unacceptable risks to human health and the environment, leaving aside the endocrine disrupting properties of propiconazole when proper risk mitigation measures are applied;
    - that it is therefore appropriate to renew the approval of propiconazole for PT8, subject to compliance with certain conditions. These conditions concern amongst others a maximum renewal period of 7 years, minimisation of exposure to the environment 'since no conclusion on the risk derived from the endocrine disrupting properties of propiconazole could be established,' and conditions for trading in and labelling of treated articles (see next chapter of this report);
    - that products may only be authorised for use in Member States where the condition set out in Article 5(2), point (c) is satisfied.

3.4. Conclusions about current use and alternatives

In this chapter the use of and alternatives for wood preservatives based on borates, propiconazole and tebuconazole have been described for different applications. Based on this, the following can be concluded regarding the research questions.

- *Use*

In the Netherlands (and in the EU), wood preservatives based on borates only seem to be used on a limited scale, for some anti-sapstain treatment of pallets and against dry rot fungus on wood and brickwork; the latter for both preventive and curative purposes.
Propiconazole and/or tebuconazole based wood preservatives are widely used in the Netherlands for the preservation of soft wood; even more as several other active substances have disappeared from the market.

- *Non-chemical alternatives*

Several non-chemical alternatives are available to prevent the decay of wood.
- One is to refrain from wood preservation and to conduct adequate monitoring and repair operations. This is sometimes feasible in the lower use classes but may bring along high costs and is often not possible.
- Using durable woods can be an alternative. However, tropical hardwood has an unfavourable sustainability record. More in general, there is a mismatch between supply (of slow growing hardwood) and demand.
- Drying wood to less than 21% moisture content prevents rot and can be a (bio) energy-intensive alternative for anti-sapstain treatment with biocides. However, it has limited residual efficacy (the wood must stay dry).

- Wood modification of soft wood is a clear alternative. Chemical and thermal modification are the two most commonly used methods. Both methods deliver wood of higher durability, but with limitations to its use. Modified wood is only suitable for certain use classes and not for in-ground use, and it is not protected against the full range of moulds and insects. Also, thermally modified wood cannot be used for structural elements.
- There are other non-chemical alternatives (microwave, genetic selection and modification) that are in early stages of development and that do not yet offer real alternatives.

- *Low-risk chemical alternatives*

A low-risk chemical alternative that is mentioned, is Xyhlo-biofinish: a combination of water-repellent natural oils and a pigmented fungus that prevents wood degradation. This product is not considered a biocide as the fungus is an auxiliary agent, not an active substance. The product is still rather new and up till now applied in several smaller projects in the Netherlands. A main drawback is that due to the colouring of the fungi, Xyhlo-treated wood is usually black.

- *Acceptable risk chemical alternatives*

For most of the remaining applications (i.e. applications for which there are no feasible non-chemical or low-risk chemical alternatives) there are alternatives to borate-based wood preservatives that have acceptable risks and that cover the same use. However, for some specific applications the availability of borate-based preservatives is deemed crucial. They are:

- Use in internal building structures and control of the dry rot fungus;
- Control of sapstain in freshly cut timber;
- Curative and (subsequent) preservative treatment of piles and grillages.

Also, for most of the remaining applications there are alternatives to propiconazole and/or tebuconazole-based wood preservatives that have acceptable risks. However, not all alternatives offer the same broad-spectrum fungicidal effectiveness of these azoles. Therefore, effective formulations always require combinations of different active substances. Consequently, there is only limited availability of real alternatives for the formulation of effective (and less hazardous) wood preservatives. This also holds true when focusing on different specific applications (vacuum pressure treatment, dipping and metal-free vacuum pressure treatment, industrial treatment of joinery).

It has been established that at present no acceptable risk alternatives to propiconazole are available for:

- Control of sapstain in freshly cut timber;
- Industrial and professional treatment of structural wood, particularly for use classes 3 and 4;
- Industrial and professional treatment of joinery;
- In situ brush, spraying or injection applications for use classes 2 and 3.

Alternatives are being developed that include the use of penflufen ('the only new active substance that has come on the market in recent years'). However, it is expected to take another 6 – 11 years before they can fully replace preservatives based on propiconazole and/or tebuconazole. In the meantime, uncertainties concerning possible resistance against penflufen call for maintaining substances with known performance on the market, according to interviewees.

4. Preserved wood: current use and alternatives

4.1. Introduction

The following paragraph describes – for as far as data are available – how much wood that is preserved with borates, propiconazole and/or tebuconazole is on the Dutch market and for what purposes it is being used. The next paragraph looks from a preventative perspective into current options for substituting preserved wood with other materials or solutions.

4.2. Current use of preserved wood

In the Netherlands, about 22 million m^3 of roundwood equivalents of primary wood products were used in 2021. Around 16% of this wood was grown in the Netherlands, 84% was imported.[63] Wood consumption is expected to grow in the upcoming years, because of policies to promote biobased building.[64]
There are no data available on what part of this volume concerns preserved wood (let alone which part concerns wood preserved with borates, propiconazole and/or tebuconazole).

A rough indication of the sectors in which preserved wood is used, comes from Tauw (2022).[65] They distinguish between three types of applications:

1. *Long lasting applications of wood* (in residential and non-residential construction, infrastructure, and furniture). In residential and non-residential construction mostly soft wood is used, of which the lifespan is extended through maintenance, repair, treatment, and product design (for example by preventing exposure to moisture). For infrastructure (particularly water works) mostly hard wood is used. In the furniture industry, weather resistance is only important for garden furniture.

   About garden wood: according to (unpublished) market research carried out by Tuinbranche Nederland (the branch association of garden retailers), the total market size of (mostly preserved) garden fencing made of wood and wooden garden sheds amounts to € 700 million in 2022. The market share of garden retailers is 5%. Most of these wooden applications are sold to consumers via gardeners/contractors (30%) and via the timber trade (28%).

2. *Medium term applications of wood* (logistic aids, various utensils). For wooden logistics aids (pallets and boxes) often preserved wood is used, particularly wood that is treated against sapstain. The totals of pallets and boxes that were brought on the market in the Netherlands and that were repaired in 2019 and 2020 are shown in the table below.

63 See: https://www.bosenhoutcijfers.nl/de-houtmarkt/houtverbruik/

64 In November 2023 the Ministry of the Interior and Kingdom Relations issued the 'National Approach to Biobased Construction; From farmland to building materials' ('Nationale Aanpak Biobased Bouwen; Van boerenland tot bouwmateriaal'). As the subtitle indicates, the focus of this approach is on the use of bio-resources produced by Dutch famers for building purposes in the Netherlands. Consequentially, its emphasis lies on biofibres ("There is no explicit focus on the production side of timber construction chains, because timber production happens largely abroad and the growth time of most trees is approximately 30 years, meaning that no prospects can be offered to Dutch farmers in the short term"; p.5). Still, some of the measures that are announced (like the use of environmental and biobased indicators) will also stimulate the use of wood in construction.

65 Tauw (2022): *Verkenning Ketenplan Hout voor het Circulair Materialen Plan.* Deventer.

Table 9: Totals of pallets and boxes brought on market or repaired in Netherlands in 2019 and 2020 (kton) (Source: Tauw, 2022, 13).

	2019	2020
Total pallets brought on NL market (kton)	331	246
Total pallets repaired for re-use on NL market (kton)	287	237

3. *Short term applications of wood* (single-use wooden packaging and utensils with a short lifespan). These applications are not preserved since there is no need to extend their lifespan.

Other indications of the amount of treated wood on the Dutch market can be inferred from data on collected wood waste. In the Netherlands around 2 million tons of wood waste is collected annually.[66,67] Wood waste is a collection of so-called A-wood (unprocessed wood), B-wood (wood that has been treated with environmentally harmless substances) and C-wood (wood that has been treated with hazardous substances to preserve it). Within the category of C-wood a distinction is made between 'non-wolmanized' and 'wolmanized' wood; the latter is considered so dangerous that it may not be burned and can only be dumped in a controlled landfill site. The 'non-wolmanized' wood is burned in a bioenergy power plant, where energy is generated (this is done in Germany, as there is no bioenergy power plant in the Netherlands that is suitable for burning this type of waste).[68]
Of the annual 2 million tons of waste wood, around 100 ton (5%) is C-wood (CE, 2020).[69]

The further discussion in this chapter will focus on the following use types of wood that is preserved (with borates, propiconazole and/or tebuconazole) (probably leaving out several smaller, more specific uses).

- Preserved wood for residential and non-residential construction purposes, with subcategories wood for joinery and wood for structural elements
- Preserved garden wood (for garden fences and furniture)
- Preserved wood for pallets

It is not clear which exact part of these wooden applications is treated with preservatives based on borates, propiconazole and/or tebuconazole.

66 CE (2022): *Verwerkingsroutes van afvalhout; mogelijkheden en milieukundige evaluatie middels mLCA*. Delft.
67 CE (2022) mentions an amount of 2,5 million in a period between 2015 and 2017; Tauw (2022) an amount of 1,7 million ton in 2018.
68 See also: Ministerie IenW, beleidstekst sectorplan LAP3; sectorplan 36 (hout).
69 See also: https://www.bosenhoutcijfers.nl/de-houtmarkt/houtproducten/gebruikt-hout/

New requirements for wood treated with propiconazole

As part of the EC's renewal of the approval of propiconazole as an active substance for PT8, [70] the following conditions have been formulated for the trading in and labelling of wood that is treated with wood preservatives based on propiconazole.

- To ensure a high level of safety for health and the environment and to ensure equal treatment between EU-manufactured and imported treated articles, wood treated with propiconazole may be placed on the market only for use as wood treated for protection against wood-discolouring fungi, as structural wood for use class 3 and 4, and as joinery for use class 2 and 3.
- In order to guarantee safe use and to enable users to make informed choices, the label of wood treated with propiconazole provides information on, amongst others, the names of all active substances and relevant instructions for use. Member States competent authorities should specify relevant instructions for use and precautions to be included on the label of the treated articles (including measures to reduce leaching and minimise exposure of humans, animals and the environment as far as possible).
- Taking into account that no conclusion on the risk derived from endocrine disrupting properties could be established, wood treated with propiconazole should not be placed on the market to produce furniture and play structures

4.3. Alternatives to preserved wood for construction purposes

In Dutch construction, different from building practices in some other EU countries,[71] wooden parts that are not directly exposed to the weather (roof constructions and other wood for indoor use) are often not preserved. The use of preserved wood is mostly restricted to joinery for outside frames and doors and for cladding. It is not clear to what extent preserved wood is used for structural elements at this moment. It may be expected, however, that the drive for biobased building is also a stimulus for timber frame constructions (either preserved or not).
Some interviewees indicate that warmer temperatures due to climate change may pave the way for new invasive exotic insects, that may bring along a need to protect wood for indoor use against insects (e.g. termites).

Several interviewees point out that wood that is preserved (with borates, propiconazole and/or tebuconazole) is to be preferred to other materials like plastics, aluminium, or concrete. This is argued both from a cost and a sustainability perspective. From the latter perspective, it is emphasized that the production of plastic, aluminium and concrete parts requires a lot of energy and brings along a big CO_2 footprint, whereas wood is a carbon sink. Also, the use of European softwood is said to be far more sustainable – from points of view of sustainable forestry, transport, and supply – than the use of other types of wood; even though European softwood requires preservation for use in higher use classes. According to some of these interviewees, the drive to ban borates, propiconazole and/or tebuconazole is shortsighted in the light of the climate crisis and of the importance of biobased building, which calls for the increased use of (preserved) wood.

As part of the Dutch policy drive to promote biobased building, the use of a calculation method has been introduced for the environmental assessment in (sustainable) tendering of new building designs, the so-called 'environmental cost indicator (Milieukostenindicator; MKI). This indicator expresses the environmental costs (or quality) of a product in one number, based on Lifecycle assessment (LCA) data that are stored in the National Environmental Database (NMD). Suppliers of wood for use in buildings (preserved or not) need to have an independent institute conduct an LCA study of their products

[70] Commission Implementing Regulation (EU) 2023/2596

[71] According to one expert, in some other EU countries sometimes more rules apply to avoid the use of biocides. In his view the full spectrum of potential biocide-reducing measures is not structurally applied in the Netherlands, due to lack of a complete timber processing chain and lack of knowledge in planning and design.

(which in turn is reviewed by another independent institute), and to submit the outcome of this study to the NMD. Summaries of these studies are made public (the so-called Environmental Product Declarations or EPDs).
In an interview, one of the institutes that conducts these LCA's explained that the prescribed calculation method for an LCA of wood puts heavy (negative) weight on the content of chemical substances in wood that are toxic for humans. Consequently, wood that is preserved with borates, propiconazole and/or tebuconazole often has a bad score for the MKI, which is said to outweigh the extended lifespan caused by the preservation.
Clearly, these calculation and tendering methods can be expected to have a stimulating effect on the use of non-preserved woods (or at least: of wood that is not treated with any of these active substances). At the same time, however, there are also other considerations, apart from environmental ones, like technical and economic considerations (availability and price), that play a role when choosing building materials. Altogether, these considerations may still lead to preserved wood as the preferred option.

Several building companies are developing initiatives for biobased (and sustainable) building, often relying heavily on the use of wood for most part of the construction. To find out more about what type of wood is used and how (also in the light of the MKI discussed above), an interview was held with a major construction company. Spokespersons from this company answered that in its timber constructions and timber frame constructions no use is made of preserved wood. Instead, wood is used that has been artificially dried to < 20% moisture content, and that is therefore not susceptible to moulds and cannot rot. Facade filling elements and house separating elements are used in 'dry' construction. The dry building elements of wood consist of SLS/CLS wood (i.e. wood that meets Scandinavian and Canadian Lumber Standards) that is filled with insulation and that is protected on the outside by a water-repellent vapour-open facade foil, sometimes supplemented with a wind stopper. On the indoor climate side, a vapour-tight foil is applied with the inner plate on top.
This example could serve to illustrate that a targeted design of wooden structures may indeed be effective in preventing attack by fungi (as an element of what Arcadis (2022, p.31-32)[10] calls 'Integral wood protection') (Although the Dutch climate and moist soils are complicating factors in this respect).

A new alternative that is mentioned by other interviewees, is the reuse of wooden frames that have been recycled from facades of buildings that are being demolished (so-called eco-frames). (It should be noted that this practice is not yet fully facilitated by the present dealing with waste wood, since end-of-life preserved wood is burned or dumped (see above)).

4.4. Alternatives to preserved garden wood

Reportedly, garden wood retail organisations (mostly timber trade retail, see paragraph 4.2) are hardly or not aware of the wood preservatives that the wood they trade is treated with. What matters to (most of) them is the KOMO quality mark ('KOMO Keur'; see paragraph 3.2.1), as an indicator that the wood is preserved according to standards. Therefore, it appears that retailers do not take the type of wood preservative that is used into consideration in their selection of garden wood – let alone consumers that buy garden wood.

On a webinar on preserved wood organised in 2021 by the Dutch Biocides Knowledge Network (KNB)[72] the results of a small inventory were presented, which indicated that for consumers who are buying preserved garden wood, hardly or no information on the type of preservation is available. The labels on the wood (if any) often say nothing about the treatment of the wood, or only in terms such

[72] https://www.kennisnetwerkbiociden.nl/knb-events/knb-webinar-met-biociden-behandeld-hout; also see RIVM-rapport 2023-0376 (Verkenning risicofactoren biocidegebruik).

as 'green' or 'impregnated' (without saying with what). Several labels were not in Dutch (contrary to the obligation in Article 58 of the BPR). Also, consumers are not informed about the use classes of the wood. The same holds true for the websites of these stores; also there, consumers will not find any information about the use of biocides or other treatments of the wood.
In the context of the present study, three hardware stores and their websites were visited, where the findings described above were once again confirmed.[73]

As to alternatives for preserved garden wood, the same arguments are given in the interviews as for construction wood: other materials like steel, aluminium, or concrete are more expensive and less sustainable. Moreover, they lack the natural look of wood in a garden. One exception may be the use of hedges and shrubs as more sustainable and natural looking alternatives for fences made of wood.

No further information is available about alternatives to preserved garden wood.

4.5. Alternatives to preserved wood for pallets

Besides earlier anti-sapstain treatment (against moulds), wooden pallets also get treated against attacks by insects when they are used for international transport. This treatment, which is to prevent the transportation of invasive exotic insects, is required by ISPM 15 (International Standards for Phytosanitary Measure 15), a standard that was drawn up by the International Plant Protection Convention (IPPC). The IPPC is part of the United Nations Food and Agriculture Organization (UNFAO).[74] ISPM 15 prescribes the treatment methods with which wood must be treated to ensure that no harmful organisms are present in pallets and packaging wood. After treatment, the wood is certified with an imprint of the ISPM 15 logo together with the country of origin.
Two methods of treatment are permitted: heat treatment and heat treatment using Dielectric Heating. Fumigation with Methyl Bromide (MB) is no longer permitted in Europe since March 18, 2010. ISPM 15 also requires the use of debarked wood.
According to one expert, plastic pallets have replaced wooden pallets in exports to countries that require(d) chemical treatment (using the ozone depleting substance MB) to prevent invasive species entering.

The BPC (2020, 12) has looked at the use of plastic pallets as an alternative for wooden pallets (treated with borates against sapstain). From a technical point of view, there are several advantages of using plastic pallets. Apart from not having to be treated with biocides, the technical advantages are in their longer lifespan, their better suitability for food, beverages, chemicals and pharma, and the higher fire safety rating of some plastics. On the other hand, plastic pallets cannot easily be repaired, are not biodegradable and can hold less weight than wooden pallets. From a hazard and risks point of view, the BPC states that the use of plastic pallets is achieved without the use of chemicals and free of the risks and hazards associated with the use of dangerous chemicals.
Major disadvantages of plastic pallets as compared to wooden ones are in their price (3 times more expensive), in their lifecycle impact (global warming potential) and in their availability (only 5% of pallets are currently made of plastic and insufficient production capacity is currently available for a significant increase).
Based on all this, the BPC concludes that plastic pallets are not considered a suitable alternative to the use of wooden ones treated with borate-based wood preservatives.

[73] One website makes mention of 'impregnation class' (fence planks are 'impregnation class 3'). It is not clear what this signifies. Also, for garden poles it is mentioned that impregnation prolongs the lifespan 'even with ground contact'. No such mention is made for fence planks.
[74] See website: https://www.smhv.nl/ispm-15-merkteken

4.6. Conclusions

In this chapter the use of and alternatives for wood that is preserved (with preservatives based on borates, propiconazole and tebuconazole) have been described for different applications. Based on this, the following can be concluded regarding the research questions.

- *Use*

Of the 22 million m^3 of roundwood equivalents of primary wood products that were used in the Netherlands in 2021, 84% was imported. It is not known which part of this volume concerns preserved wood. Of the annual 2 million tons of waste wood that is collected in the Netherlands annually, around 5% is preserved wood.

Preserved wood (with preservatives based on borates, propiconazole and tebuconazole) is mostly used for residential and non-residential construction purposes, for garden wood and for pallets (around 250-300 kton per year). It is not clear which exact part of these wooden applications is treated with preservatives based on borates, propiconazole and/or tebuconazole.

In general, the market of preserved wood appears to be rather untransparent and chain communication appears to be poor. Obviously, wood preservation companies and maintenance professionals know the types of wood preservatives are applied, and probably, so do importers of treated wood and manufacturers of joinery. It is unclear whether contractors and builders are aware of the types of preservatives that have been applied on the wood they use. It is suggested that retailers are not aware of this, and that they only pay attention to the KOMO quality mark. Consumers and the general public are only informed *that* the wood is impregnated (with KOMO quality mark), and that it may or may not have ground contact. The compulsory information about treated articles (cf. art. 58 BPR) is not communicated to consumers.

- *Alternatives for construction purposes*

Alternatives for preserved wood in construction are non-preserved wood and other building materials like plastic, concrete, steel, and aluminium. In the Netherlands, and different from many other countries, for indoor applications often non-preserved wood is used. Preserved wood is often used for joinery, cladding and structural elements that can become moist and/or are on the outside of buildings. According to many interviewees, this is preferable both for economic and sustainability reasons (CO_2 footprint, sustainable forestry, transport, and supply). However, in a calculation method that is used to indicate the environmental impact of building products (and to guide design and tendering), presence of chemicals toxic for humans weighs heavily on the negative side. Consequentially, wood that is preserved with borates, propiconazole and/or tebuconazole often has a bad score, which is said to outweigh the extended lifespan caused by the preservation. Nevertheless, technical and economic considerations may still lead to these types of preserved wood as the preferred option.
A big building company that is very active on the biobased building market and that relies heavily on the use of wood for its constructions, states it succeeds in building these constructions without the use of preserved wood (which could illustrate that a targeted design of wooden structures can prevent attack by fungi).
A relatively new (and as yet small) development is the use of recycled (preserved) wooden frames.

- *Alternatives for garden wood*

According to interviewees, the sustainability and cost benefits of using (preserved) wood also hold true for garden wood (together with its natural look). An exception may be the use of hedges and shrubs as alternative for fences made of wood.

It appears that retailers of garden wood are not aware of the active substances that are used for the preservation and of their possible risks. The same holds true for consumers, for whom close to no information is available about the preservation of the wood (including none of the information that should be made available according to art. 58 BPR).

- *Alternatives for pallets*

The use of plastic pallets could be – and sometimes is used as – an alternative to the use of wooden ones treated with borates (and often also with heat treatment to prevent the transportation of invasive exotic insects, as required by ISPM 15). The use of plastic pallets would bring along advantages in lifespan, fire safety, suitability for certain products and less risks associated with the use of hazardous chemicals. However, major disadvantages include higher price, larger life cycle impact, non-biodegradability, and limited availability. It is therefore concluded that plastic pallets are no suitable alternative to wooden pallets treated with borate-based wood preservatives.

5. Other matters

5.1. Introduction

In addition to what has been said about the use of, and alternatives for wood preservatives based on borates, propiconazole and/or tebuconazole, several interview partners referred to other issues with relevance for the reassessment of these active substances. The following paragraphs are about this.

5.2. Biocides in PT7

One expert points out that wood preservation sometimes takes place by means of biocides in PT7: film preservatives. These are products used for the preservation of films or coatings by the control of microbial deterioration or algal growth in order to protect the initial properties of the surface of materials or objects such as paints, plastics, sealants, wall adhesives, binders, papers, art works (BPR, annex V). Propiconazole and tebuconazole are both approved active substances for PT7.

According to this expert, 'coated wood' with a PT7 biocide may be a 'grey' area in the use of these active substances for wood preservation, possibly in particular where garden wood is concerned; a grey area that does not come to the fore when solely focusing on PT8.
A specific example is the treatment of SLS/CLS wooden elements (i.e. wood that meets Scandinavian and Canadian Lumber Standards) with a thin water-repellent coating for protection during transport and at the building site. Many of these coatings contain propiconazole and/or tebuconazole, according to the expert. Hence, even though this is not considered to be preserved wood, there is a probability that the wood has been treated with these substances (in very low concentrations) without the knowledge of building companies.

Another possible grey area that is mentioned, is the treatment of wood with flame retardants that have (intentional) biocidal side-effects.

5.3. Possible business case deficiency

In paragraph 3.4.3 of this report, it was described that for some applications there is a limited availability of real alternative active substances to replace propiconazole and tebuconazole. "The path is narrow", as Ineris stated. The BPR offers the possibility to include considerations about the availability of alternatives in the reassessment of an approval. Article 5.2 of the BPR states: "When deciding whether an active substance [that meets the exclusion criteria] may be approved [...], the availability of suitable and sufficient alternative substances or technologies shall be a key consideration."

For borates there is, however, an additional factor at play. The analysis that is described in paragraph 3.4.2. of this report shows that no or few real alternatives are available for a number of specific applications (i.e.: anti-sapstain, internal building structures (especially against dry rot fungus), and piles and grillages (all preventative), and wood with high moisture content (curative)). Obviously, these are the applications (all or some of them) for which specific reapproval can be considered.

The question that is raised by some interviewees is, however, whether a restrictive reapproval for only (some of) these applications would leave the producers of these wood preservatives with a viable business case for keeping on producing and marketing these products, and for filing a new application for the next upcoming reassessment. If not, this might mean that at some point in time for some of the applications mentioned above no preservatives will be available, due to business decisions made

by producers outside of the regulatory domain. This is a particular matter of concern in cases in which it was established that not being able to use the active substance (i.e. borates) has a disproportionate negative impact on society (as article 5.2 under (c) of the BPR puts it).

An indication that this mechanism may indeed be at work, is that in the present period the authorization of two (out of four) biocidal products containing borates expired (see paragraph **Fout! Verwijzingsbron niet gevonden.**) (although also one new product containing borates was authorized).

5.4. Lack of innovation

Several interviewees point to the fact that there is very little innovation going on in the field of wood preservatives (PT8). This is even more pressing as the number of alternative active substances is becoming small (to the effect that the authorization and use of substances that meet exclusion criteria are prolonged). Very few new active substances have been authorized and are applied on the market (penflufen is mentioned as the only really applicable new fungicide, which was approved in 2019). Some innovation is taking place in the field of low-risk biocides, with Xyhlo-biofinish as an example.

The main reason that is mentioned for this lack of innovation, is the absence of a viable business case for investing in a research and development process with a very long and often protracted lead time and an uncertain outcome, mostly due to the approval and authorization procedures. The costs for both R&D and procedures are high, markets and margins are small, lead times are long; the combination of which lead to Return-on-Investment (ROI) times that are unacceptable in business (which also explains the ongoing concentration in the market of wood preservatives production). Underlying root causes that are mentioned are similar to what has been said by producers of active substances and biocides in other fields and PTs.[75] They concern legal and policy conditions that make the development and marketing of biocides unduly difficult; assessment frameworks for approval and admission of biocides that are too one-sidedly focused on hazardous properties and too strict; too slow, expensive and demanding procedures with uncertain outcome; changing rules during procedures, with new requirements and research demands; insufficient harmonization between Member States; and a review program that is taking too long and for which deadlines keep being postponed.

According to these interviewees, alternatives for biocides based on borates, propiconazole and tebuconazole will only be developed if a viable business case for this development is created by effectively addressing these barriers to innovation.

[75] See: *Verkenning marktpartijen biocidenbeleid.* Bureau KLB, 2021; and: *Beleidsverkenning biociden; eindrapport verkenning onder overheids- en marktpartijen van knelpunten en oplossingsrichtingen met betrekking tot het Nederlandse biocidenbeleid.* Bureau KLB, 2022.

6. Conclusions

6.1. Introduction

The previous chapters presented the findings of desk research and consultation with stakeholders on the use of and alternatives to borates (boric acid and/or tetraborate), propiconazole and tebuconazole for wood preservation in PT8. In the following paragraphs we draw conclusions based on this - in a pointed manner – about the authorizations for, the use of, the risks of and the alternatives for wood preservatives based on borates, propiconazole and tebuconazole for PT8. Finally, we deduce from all this what the consequences would be of renewed approval or of a decision to withholding approval for borates, propiconazole and tebuconazole as active substances for these applications.

6.2. Authorisations of wood preservatives

The first main question was: which wood preservatives for PT8 based on the active ingredient borates, propiconazole and/or tebuconazole are currently permitted and for which applications?

The conclusions are:

- Wood preservatives with borates are authorized for:
  - Preventive and curative treatment of wood (use class 2 and adjacent brickwork) (1 product)
  - Preventive treatment of wood (use class 1 and 2) (1 product)
  - Preventive and curative treatment of wood (use class(es) not specified) (1 product)
- Wood preservatives with propiconazole and/or tebuconazole are authorized for:
  - Preventive treatment of wood ((soft) wood, use classes 1, 2, 3 and 4)
    - Based on propiconazole: 4 products
    - Based on tebuconazole: 2 products
    - Based on propiconazole and tebuconazole: 5 products
  - Curative and preventive treatment of wood (wood, use classes 1, 2 and 3)
    - Based on propiconazole: 3 products
- Application of these products may only be done by professional applicators and/or in industrial settings. (Authorizations for private use of two propiconazole based preservatives expires February 2025 at the latest).

6.3. Use of wood preservatives

The second main question was: what is known about the current use of wood preservatives for PT8 based on the active substances borates, propiconazole and/or tebuconazole, both qualitatively (nature of application, field of application, function) and quantitatively (volumes)?

The conclusions in qualitative terms are:

- It is assumed that most of the wood used in the Netherlands is treated with wood preservatives abroad, as the largest part of wood that is used (> 80%) is imported.
- Borates-based biocides are hardly used anymore in the Netherlands for wood preservation. The few last applications that are mentioned are some anti-sapstain treatment of pallet wood and use against dry rot fungus on wood and brickwork, the latter both preventive and curative.
- Propiconazole and tebuconazole based wood preservatives are widely used for the preservation of (European) soft wood. Application is done, among others, by specialised companies, pallet producers and manufacturers of joinery and construction wood.

The conclusions in quantitative terms are:

- Since there is no registration of quantities of traded biocides in the Netherlands and since (most) companies consider this information to be confidential, it is not easy to give an accurate picture of the amount of traded wood preservatives, nor of the amount of traded borates, propiconazole and tebuconazole.
- Some information has been obtained about the amount of traded borates, propiconazole and tebuconazole as active substances on the Belgian, French and Croatian market. A general overview is presented in the table below.

Table 10: Market quantities of borates, propiconazole and tebuconazole in BE, FR and HR (in tonnes)

	Belgium (average 2018 – 2019)	France (2021)	Croatia (average 2010 – 2022)
Borates	20	20	n.a.
Propiconazole	11	54	0,13
Tebuconazole	5	22	0,1

- It should be noted that quantities of active substances on markets are different from quantities (and numbers) of wood preservatives. In France, only one borates-based wood preservative is on the market (with a borate concentration of 5%), next to twenty wood preservatives based on propiconazole (with concentrations of propiconazole ranging from 0,05 to 1,45%).
- The Belgian market for PT8 is reportedly fairly comparable to the Dutch; the French and Croatian markets are not.

6.4. Risks of using these wood preservatives

The next main question is: what is known about the dangers and risks of using these products?

The conclusions are:

- The hazard properties of the different active substances are:
  - Borates can cause adverse effects on sexual function and fertility and on the development of the unborn child (classified as reprotoxic 1b). Disodium tetraborates can cause serious eye irritation.
  - Propiconazole is classified as reprotoxic 1b as well. It is suspected to have endocrine disrupting properties. It is (moderately) acute toxic when swallowed and may cause allergic skin reactions. It is hazardous to the aquatic environment, with both acute and long-term effects.
    The use of propiconazole can lead to the development of resistance in fungi against these compounds. Metabolites of propiconazole (and tebuconazole) are used in human healthcare. Resistance of fungi can thus lead to treatment failure.
  - Tebuconazole is suspected of being reprotoxic (classified as reprotoxic 2). It is suspected to harbour embryotoxic effects. Its toxicity through the oral route is low. Like propiconazole, it is hazardous to the aquatic environment, with both acute and long-term effects.
    Similar like with propiconazole, the use of tebuconazole can lead to the development of resistance in fungi, leading to treatment failure in human healthcare.
- Industrial wood preservation takes place in controlled and sometimes closed systems (for vacuum preservation) (following KOMO guidelines). Operators work with personal protection equipment and are sometimes trained by their wood preservative suppliers. According to interviewees, under these circumstances the risks for humans and the environment are properly controlled.

6.5. Alternatives in wood preservation

From a preventative (integrated pest management) perspective, the main questions are: what is the risk awareness of the parties involved, what are the current possibilities for prevention of wood decay and for substituting borates, propiconazole and/or tebuconazole, can their use be reduced, and what drives and hinders substitution?

The conclusions are:

- Reportedly, risk awareness in wood preservation companies and among professionals is high.
- Several non-chemical alternatives are available to prevent the decay of wood.
  - Refraining from wood preservation and conducting adequate monitoring and repair operations is sometimes feasible in the lower use classes but may bring along high costs and is often not possible.
  - Improved wood management, both in logistics (timing of felling trees, faster removal, sawing and drying of wood) and in the wood application (moisture reduction, use classes, short time of wetness and reduction of the risk of deterioration), can help to reduce the use of biocides. However, this requires expertise and more time, and therefore also entails higher costs.
  - Hardwoods are used as an alternative. However, there is a mismatch between supply of (slow growing) hardwood and demand. Moreover, tropical hardwood can be unsustainable.
  - Drying wood to less than 21% moisture content prevents rot and can be a (bio) energy-intensive alternative for anti-sapstain treatment with biocides. However, it has limited residual efficacy (the wood must stay dry).
  - Wood modification of soft wood is a relatively often used alternative. Both chemical and thermal modification deliver wood of higher durability, but with limitations to its use (only for certain use classes and not for in-ground use), and with protection that does not cover the full range of moulds and insects. Thermally modified wood cannot be used for structural elements.
  - Other non-chemical technologies are in early stages of development and do not yet offer real alternatives.
- Low-risk chemical alternatives
  - A low-risk chemical alternative that is mentioned, is Xyhlo-biofinish. This product is not considered a biocide, as its mode of action results from the combination of water-repellent natural oils and a pigmented fungus preventing wood degradation. This fungus is not seen as an active substance. The product still has to prove its market potential. Also, a drawback is that Xyhlo-treated wood is usually black.
- Acceptable risk chemical alternatives
  - There are alternatives to borate-based wood preservatives that have acceptable risks and that cover the same use. However, for some specific applications the availability of borate-based preservatives is deemed crucial. They are:
    - use in internal building structures and control of the dry rot fungus;
    - control of sapstain in freshly cut timber;
    - curative and (subsequent) preservative treatment of piles and grillages.
  - There are also alternatives to propiconazole and/or tebuconazole-based wood preservatives with acceptable risks. However, not all alternatives offer the same broad-spectrum fungicidal effectiveness. Effective formulations require combinations of different active substances. Consequently, there is only limited availability of real alternatives for the formulation of effective (and less hazardous) wood preservatives. This holds even more true when focusing on different specific applications.
  - For some specific applications the availability of propiconazole-based preservatives is deemed crucial. They are:
    - Control of sapstain in freshly cut timber;

- Industrial and professional treatment of structural wood, particularly for use classes 3 and 4;
- Industrial and professional treatment of joinery;
- In situ brush, spraying or injection applications for use classes 2 and 3.

- There are alternatives being developed that include the active substance penflufen. However, it will probably take another 6 – 11 years before they can fully replace preservatives based on propiconazole and/or tebuconazole. In the meantime, uncertainties concerning hazard properties of alternatives call for maintaining substances with known performance on the market, according to interviewees.

6.6. Use of, and alternatives for preserved wood

The next main questions are: for what purposes is the treated wood used, what are alternative ways to realise these purposes, to what extent can they substitute the treated wood, and what drives and hinders this substitution?

The conclusions are:

- Preserved wood (with preservatives based on borates, propiconazole and tebuconazole) is mostly used for residential and non-residential construction purposes, for garden wood and for pallets (around 250-300 kton per year). It is not clear which exact part of these wooden applications is treated with preservatives based on borates, propiconazole and/or tebuconazole.
- Chain communication appears to be poor. Deeper into the value chain (contractors, retailers, consumers) there is little awareness of the preservatives that the wood has been treated with. Most of these parties appear to rely on the KOMO quality mark. Compulsory information about these treated articles (cf. art. 58 BPR) is not communicated to consumers.
- About the use of alternatives for these applications:
  - Alternatives for preserved wood in construction are non-preserved wood and other building materials like plastic, concrete, steel, and aluminium. In the Netherlands, preserved wood is mostly used for joinery, cladding and structural elements that can become moist and/or are on the outside of buildings. For indoor applications often non-preserved wood is used. Interviewees argue that the use of (preserved) wood is preferable both for economic and sustainability reasons (CO_2 footprint, sustainable forestry, transport, and supply). However, in the LCA calculation of environmental impact of building products wood that is preserved with borates, propiconazole and/or tebuconazole has a bad score, due to their human toxicity. Nevertheless, technical and economic considerations may still lead to these types of preserved wood as the preferred option. There are examples of biobased building of houses without the use of preserved wood (which could illustrate that a targeted design of wooden structures can prevent attack by fungi).
  - For garden wood, sustainability and cost benefits are also mentioned as main advantages (together with its natural look). Retailers of garden wood are hardly aware of the active substances used for preservation and their possible risks. The same holds true for consumers, for whom close to no information is available about the preservation of the wood.
  - As an alternative for wooden pallets treated with borates, plastic pallets are mentioned. Their use would indeed bring along advantages in lifespan, fire safety, suitability for certain products and less risks associated with the use of hazardous chemicals. However, major disadvantages are in their price, their life cycle impact, their non-biodegradability and severe limits to their availability. It is therefore concluded that plastic pallets are no suitable alternative to wooden pallets treated with borate-based wood preservatives.

6.7. What if approval is granted or withheld?

The final question is: what will be the impact of renewed approval or of a decision to withhold approval of these three active substances?

The conclusions are:

- In a general sense, the impact of withholding approval will be disruptive for a serious part of wood preservation activities and for several applications that rely heavily on wood preservatives based on one or more of these active substances and for which no alternatives are readily available. This will specifically be the case for:
  - Applications for which the availability of borate-based preservatives is crucial:
    - (Preventive and curative) control of the dry rot fungus;
    - Control of sapstain in freshly cut timber (e.g. wood used for pallets);
    - Curative and (subsequent) preservative treatment of piles and grillages.
  - Applications that rely heavily on preservatives based on propiconazole and/or tebuconazole (which currently are the majority of wood preservatives, and for which alternatives are hardly or not (yet) available. These applications concern (parts of):
    - Control of sapstain in freshly cut timber;
    - Wood for residential and non-residential construction purposes (joinery (specifically for use class 2 and 3) and structural wood (specifically for use class 3 and 4);
    - Garden wood.
- This disruption may have effects on the availability and use of preserved wood for these purposes, and on the possibility to effectively cure some cases of rotting wood. The use of alternatives may have detrimental effects in terms of sustainability (a shift to other, less sustainable materials with a higher CO_2 footprint) and/or in terms of strengths and durability of constructions, on the life span of wood, with negative economic consequences.
- To some extent, this disruption may be softened by the – possibly illegal, depending on the type of restriction – use of imported preserved wood. At present, it is not always transparent what preservatives are used for preserved wood that is imported.
- However, for wood that is preserved in the Netherlands and/or which is traded using the quality mark of KOMO (which includes trade to retailers and consumers), the auditing that is done by the KOMO auditors will exert control on the use of authorized wood preservatives. This will mean that for wood that is preserved and/or traded through these channels, there is no way around the restriction of these active substances.
- A major reason for the disruptive effects of withholding approval, is that little innovation has taken place in recent years for alternatives that can replace these active substances. There is a lack of viable business cases to engage in such innovations, partly because of current legal and policy conditions. In recent years only few new active substances have come to the market, the most promising of which still needing 6 – 11 years before it can fully replace the present exclusion substances.
- On the other hand, the expected impact of unconditional renewed approval is that the current use of wood preservatives based on borates, propiconazole and/or tebuconazole will probably remain as it is now. The research shows that the following conditions may be worth considering:
  - Consider a restrictive reapproval of borates, propiconazole and/or tebuconazole for only (some of) the applications mentioned above. However, in this consideration the question should be included whether a restrictive approval leaves producers of active substances and wood preservatives with a viable business case for keeping on producing and marketing these products, and for filing a new application for the next upcoming reassessment.
  - Substitution of propiconazole and/or tebuconazole for most applications could be a matter of time, in the light of development of alternatives with IPBC and penflufen. These developments and their outcomes are still uncertain. Even though withholding approval for propiconazole and tebuconazole may be (too) disruptive at this stage, the processes of

looking for alternatives and of substitution can (and should) be stimulated by other means. One practical instrument that is already applied in the Netherlands is designing and tendering new buildings with the use of indicators based on LCAs (that favour the use of less toxic preservatives). Design and maintenance principles should be promoted that foster the prevention of decay of wood and its protection from humidity. Besides, measures should be considered – in European concertation – that help to overcome the barriers to innovation that are (at least partly) caused by present legal and policy conditions.

- Stimulating or enforcing communication through the value chain may improve awareness of types and risks of preservatives that have been used to treat the wood that is traded and used. This may in turn inform choices in and responsible handling of these treated articles. Article 58 BPR provides clear guidance for this. In future, also the (digital) product passport may provide solutions here and may possibly also open new avenues for recycling of preserved wood.
- Finally, in the consideration of banning the use of borates, propiconazole and/or tebuconazole (for specific applications), attention should be paid to the control of imported wood that may be treated with these substances.

Appendix 1
List of sources

Appendix 1 List of sources

Consulted organisations

Suppliers and/or authorisation holders
Cercam B.V (= Woodchem BV)
Douglas products
Janssen PMP, a division of Janssen Pharmaceutica NV
Koppers Performance Chemicals Denmark ApS
KRS ApS
LANXESS Deutschland GmbH
Qchem
Remmers Bouwchemie B.V.
Troy Chemical Company B.V. (=Lonza Cologne GmbH); (=YOU Solutions Germany GmbH); (= ARCH TIMBER PROTECTION LIMITED (M/I))
Wolman Wood and Fire Protection GmbH
Xyhlo

(Representatives of) applicants
BAM wonen
Koninklijke VVNH (Koninklijke Vereniging van Nederlandse Houtondernemingen)
Tuinbranche Nederland
Van der Swaay duurzaam hout
VHN (Verduurzaamd Hout Nederland)

Experts
Agrodome
FOD België
Health Canada
Dhr. Hortensius
Ministerie van BZK
Ministerie van IenW DLCE
Ministry of Health, Republic of Croatia
Nederlandse Arbeidsinspectie
RWS
Saxion Hogeschool
SKH (Certificeringsinstelling)
Stichting Probos

Consultations:

College voor de toelating van gewasbeschermingsmiddelen en biociden (Ctgb)	Authorising body
Inspectie Leefomgeving en Transport (ILT)	Inspectorate
Nederlandse Voedsel- en Warenautoriteit (NVWA)	Inspectorate
Rijksinstituut voor Volksgezondheid en Milieu (RIVM)	Knowledge institute

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Appendix 2
Overview of authorised wood preservatives PT8 with selected active substances

Appendix 2 Overview of authorised wood preservatives PT8 with selected active substances

Product name	Total number of identical authorisations	Active substance(s)	Authorisation holder	Application
Propiconazole and tebuconazole				
ANTIBLU Select 3787	1	IPBC*, propiconazole, tebuconazole	YOU Solutions Germany GmbH	As fungicide for the preventive treatment of wood; freshly sawn or felled wood and young wood, use class 2 and 3
(Preventol) Aqua Primer PIP (new) /02/03, including Aqua Primer concentrate	19	IPBC*, permethrin, propiconazole	Lanxess Deutschland GmbH	As fungicide and insecticide for the preventive treatment of wood; hard- and softwood, use class 2 and 3
Embalit P	3	propiconazole	Hoetmer B.V.	As fungicide for the preventive and curative treatment of wood; hard- and softwood, use class 2 and 3
Impralit ACA protect	2	Basic copper carbonate, propiconazole, tebuconazole	Rütgers Organics GmbH	As fungicide and insecticide for the preventive treatment of wood; softwood, use class 1, 2, 3 and 4a
Induline SW-900	1	IPBC*, propiconazole	Remmers Baustofftechnik GmbH	As fungicide for the preventive treatment of wood; hard- and softwood, use class 3
Koranol Holzbau Grund; Embasol PPI	7	IPBC*, permethrin, propiconazole	Kurt Obermeier GmbH & Co. KG	As fungicide and insecticide for the curative and preventive treatment of wood; hard- and softwood, use class 1, 2 and 3
Korasit NG; Korasit Cut & Treat; Korasit TT25P; Korasit TT40P	60	permethrin, propiconazole, tebuconazole	Kurt Obermeier GmbH & Co. KG	As fungicide and insecticide for the preventive treatment of wood; hardwood, use class 1 and 2; softwood, use class 2 and 3**
Sikkens Cetol WP 567BPD	2	IPBC*, propiconazole, tebuconazole	Akzo Nobel Industrial Coatings AB	As fungicide for the preventive treatment of wood; softwood, use class 2 and 3
Tanalith E 3462; Tanalith E 3475	1	basic copper carbonate, propiconazole, tebuconazole	YOU Solutions Germany GmbH	As fungicide and insecticide for the preventive treatment of wood; hard- and softwood, use class 1, 2, 3 and 4
TEKNOL AQUA 1411-01	4	IPBC*, propiconazole	Teknos A/S	As fungicide for the preventive treatment of wood; hard- and softwood, use class 2 and 3
TWP 085 BPF	4	IPBC*, propiconazole	Troy Chemical Company B.V.	As fungicide for the preventive treatment of wood; hard- and softwood, use class not specified**
Wolsit KD 10	4	propiconazole	Wolman Wood and Fire Protection GmbH	As fungicide for the preventive and curative treatment of wood; hard- and softwood, use class 2 and 3
Celcure MC-T4	1	tebuconazole, basic copper carbonate, N,N-didecyl-N-methylpoly(oxyethyl)	Koppers Performance Chemicals Denmark ApS	As fungicide and insecticide for the preventive treatment of wood; Softwood, use class 1, 2, 3 and 4

		ammoniumpropionate		
Celcure MC-T3 ; Celcure MC-T2	1	basic copper carbonate, tebuconazole	Koppers Performance Chemicals Denmark ApS	As fungicide and insecticide for the preventive treatment of wood; Softwood, use class 1, 2 and 3
Bochemit	*2, expired*	*Propiconazole, thiacloprid, tebuconazole*	*Rütgers Organics GmbH*	-
Delta Imprägnierlasur 3.01 BPD	*9, cancelled*	*Propiconazole, IPBC**	*Kurt Obermeier GmbH*	-
Drywood Improstain	*1, expired*	*Propiconazole, IPBC**	*Teknos Drywood BV*	-
Embadecor	*26, cancelled*	*Propiconazole, IPBC**	*Hoetmer b.v.*	-
Embadecor	*13, cancelled by 10-2025*	*Propiconazole, IPBC**	*Hoetmer b.v.*	-
Endseal; Ensele Tanalised	*7, expired or cancelled*	*Propiconazole, IPBC*, thiacloprid, tebuconazole*	*ARCH TIMBER PROTECTION LIMITED (M/I)*	-
Koralan Imprägniergrund Farblos	*1, expired*	*Propiconazole, IPBC**	*Kurt Obermeier GmbH*	-
Osmo Houtimpregneer	*1, expired*	*Propiconazole, IPBC**	*Osmo Holz und Color GmbH & Co. KG*	-
SCOMRID 100 SL	*1, expired*	*Propiconazole*	*Denka REGISTRATIONS bv*	-
Sikkens Cetol WP 562 (BPD)	*1, cancelled*	*Propiconazole, IPBC**	*Akzo Nobel Decorative Coatings B.V.*	-
Swingcolor	*2, expired*	*Propiconazole, IPBC**	*FHG-Münster*	-
Visir Oljegrunning Pigmentert	*1, cancelled*	*IPBC*, tebuconazole*	*Jotun A/S*	-
Valtti Plus Base	*1, expired*	*Propiconazole, IPBC**	*Tikkurila Oyj*	-
Wocosen	*2, expired*	*Propiconazole*	*Janssen PMP*	-
"product"	*1, expired*	*Propiconazole, thiacloprid, tebuconazole*	*Kurt Obermeier GmbH*	-
Borates				
Boracol 10	1***	Boric acid, didecyldimethylammoniumchloride (DDAC)	KRS ApS	As fungicide and insecticide for the preventive and curative treatment of wood and brickwork; hard- and softwood, use class 2 and adjacent brickwork
SINESTO B	1	Disodium tetraborate, quaternary ammonium compounds (kokos alkyltrimethyl, chlorides)	Wolman Wood and Fire Protection GmbH	As fungicide and general biocide for the preventive treatment of wood; hard- and softwood, use class(es) not specified

Impralit ACQ-2200 / Impralit-KDS 30	1	Alkyl (C12-16) dimethylbenzylammoniumchloride, basiskopercarbonate, boric acid	Rütgers Organics GmbH	As fungicide and insecticide for the preventive treatment of wood; use classes 1 and 2
Diffusit M	*5, expired*	*Boric acid, disodium tetraborate*	*Wolman Wood and Fire Protection GmbH*	-
Basilit B, Impralit B	*1, expired*	*Boric acid*	*Rütgers Organics GmbH*	-

* IPBC = Iodopropynyl Butyl Carbamate
** The instructions of use allow non-professional use
*** Authorization end date is 20/12/2024

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Antea Group is home to 1500 proud engineers and consultants. Together we build a safe, healthy and future-proof living environment every day. With us you will find the very best specialists in the Netherlands, but also innovative solutions in the field of data, sensoring and IT. In this way we contribute to the development of infrastructure, residential areas or water works. But also issues surrounding climate adaptation, energy transition and the replacement task. From research to design, from realization to management: we bring the right knowledge to the table for every assignment. We think critically and always from the mindset of going for the best results together. In this way, we anticipate today's questions and tomorrow's solutions. For 70 years.

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