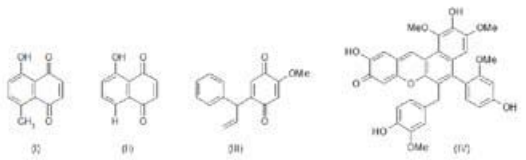
Development of Procedures for the Manufacture of Products from Transparently Coated, Naturally Dark Timbers and Thermally Modified Timber (TMT)

Project Leader: Dr. habil. Mario Beyer
Dr. Lars Passauer
In-charge: Dr. Lars Passauer
Dipl.-Ing. Simone Wenk
Funding Institution: BMWi/AiF/ZIM

Objective and Approach

The objective of the project was to develop procedures to manufacture colourfast structural elements from naturally dark, and thermally modified timbers (TMT) for top-quality interior design as well as for the deck area on yachts. The respective species of wood show a distinct tendency towards light-induced discolouration. This can frequently be seen in bleaching ($\Delta L^* > 0$) and yellowing ($\Delta b^* > 0$) in selected timbers, such as cherry, also in the darkening ($\Delta L^* > 0$) of light-exposed, transparently coated wood surfaces (Fig. 1). Light-protecting additives available in the market (organic and nano-scaled UV absorbers, radical catchers, e.g., HALS compounds) are designed especially for colour stabilisation of light-coloured timbers, thanks to their absorption behaviour, and show little effect in the respective wood species or even result, as compared to untreated dark timbers, in increased bleaching of the wood surface.

Hence, constituent parts of the project were 1) the development of novel, lightfast wood impregnations that allow to be adapted to the requirements of various light-sensitive timbers, and 2) the development of an impregnation technology providing dark timbers and TMT with permanent light protection. The development of impregnating coating systems should especially serve the depth effect of novel light-protecting additives. Thereby, the works performed within the framework of the project picked up on the knowledge obtained in a predecessor project (IGF 15840BR) on the light-induced discolouration of dark timbers and TMT. There it was also shown that light-induced greying or photo bleaching of the surfaces of respective species of wood is caused by light in the visible range ($\lambda < 400$ nm) and that, therefore, the resulting changes in colour are caused considerably by extractive matter contained in the wood. The chromophore structures of methyl-juglone (I), juglone (II), 4-hydroxyalberdigion (III) and santalin A (IV), as described in the literature and which were identified in the wood extracts from macassar, walnut, rio rosewood and padouk, can be named as examples for that.



It was the aim to stabilise or immobilise such light-sensitive wood ingredients by applying the impregnations that were to be developed. In order to guarantee an acceptance of the stabilising formulations, it was necessary to consider that the initial colour and texture of the treated wood surfaces were largely maintained. The effectiveness of the stabilisers was determined by Xenon-arc radiation and natural light exposure of impregnated and coated timbers behind window glazing.

Results

The focus of the investigations was on the development of aqueous, polymer-based low-viscous formulations of impregnating character, which were to serve as carriers for a new group of agents of stabilising effect to wood ingredients responsible for light-sensitive and wood-intrinsic discolouration of the timber. As a result of extensive testing, formulations of several light-protecting agents could be elaborated, involving various bonding-

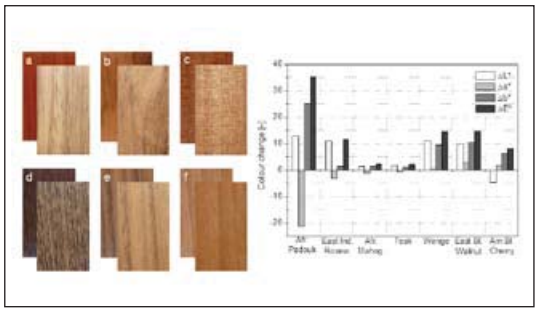


Fig. 1: Left: Transparently coated, non-stabilised timbers (a African padouk, b East-Indian rosewood, c African mahogany, d wengè, e American walnut, f American mountain black cherry) before (back) and after 42-day outdoor light exposure behind window glass (front) acc. to ISO 877-2:2009; right: corresponding CIELab colour value changes

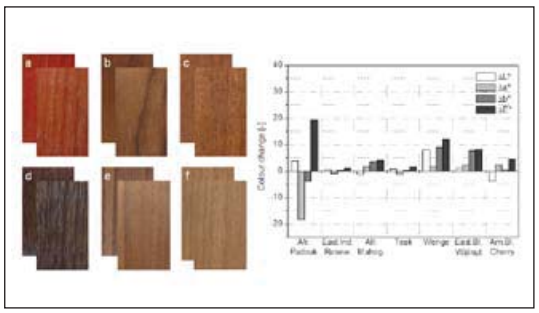


Fig. 2: Left: Transparently coated, stabilised timbers (a African padouk, b East-Indian rosewood, c African mahogany, d wengè, e American walnut, f American mountain black cherry) before (back) and after 42-day outdoor light exposure behind window glass (front) acc. to ISO 877-2:2009; right: corresponding CIELab colour value changes

agent systems and a multitude of potentially stabilising agents, which can preferably be formulated in aqueous alkyd and polyester-resin-based impregnation primers. They can be applied by brushing, rolling and spraying. Light stability clearly improved in the wood species under review by applying stabilising impregnations (Fig. 2).

The effect of novel light-protecting systems is specific to wood species, which requires to adjust the light protection impregnation to the wood species or groups of wood species to be protected (Tab. 1).

An especially stabilising effect of the light protection impregnations onto all CIELab colour components could be identified in wood species, such as East-Indian rosewood and teak (Fig. 2, right).

Thereby, photobleaching (ΔL^*) and yellowing (Δb^*), in particular, could be clearly reduced, as contrasted to unprotected surfaces (Fig. 1). Also, thorough effectiveness was achieved in especially light-sensitive timbers, such as padouk, wengè and walnut, whereas photo stabilisation of the flavonoid santalin A responsible for the red colouring of padouk (Fig. 2) remains an issue ($\Delta a^* = -18.5$). It was noticed that selected formulations are suitable for the colour stabilisation of domestic timbers, especially beech and, to a limited extent, also oak.

With respect to the processing properties of light protection impregnations, there is still demand for further optimisation. Especially further adaptation of the bonding agent components of the light protection impregnations is required in order to guarantee their processing viscosity to be sufficiently low, which should allow to be efficiently applied, e.g., by spraying or as depth impregnation of treated wood surfaces.

Tab. 1: Grouping of wood species and effective light protection impregnations

Light protection solution	Wood species
LS-1	TMT (spruce, beech, ash), wengè, East-Indian rosewood
LS-2	American walnut, oak, African padouk
LS-3	mahogany, African padouk
LS-4	beech, American mountain black cherry