ERPem
Edinburgh Research Partnership in Engineering and Mathematics
http://www.erp.ac.uk

UV Stability of Wood Surfaces

Victoria Sharratt BSc (Hons) & Prof. Callum Hill
Centre for Timber Engineering, Napier University.
v.sharratt@napier.ac.uk

Why does wood need protection.

Wood is made up of three main constituents – cellulose, hemicelluloses and lignin, of these 3, lignin is the primary absorber of UV and Visible radiation, although all three are degraded by UV light to some degree.

UV radiation, especially UV-B, causes twice much damage to the chemical structure of lignin as the effects from the visible spectrum.

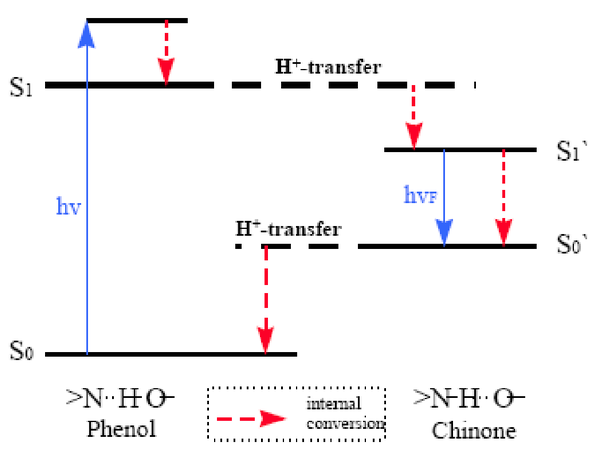
Photodegradation causes the lignin matrix to degrade via multiple mechanisms creating free phenoxy radicals including a long lasting guaiacoxy radical. The free radicals formed undergo further reactions creating quinoid structures which cause discolouration of the timber surface.

On a cellular level, cracks form between individual cells and also across cell walls as lignin is degraded. This causes loss of cellulose microfibrils and therefore timber surface material.

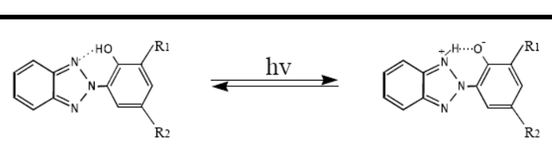
An outdoor exposure experiment showing the differences between coated and uncoated specimens upon natural weathering which includes exposure to solar UV radiation.

UV Absorbers (UVA's).

In a clear coated system UV can pass through the coating causing damage to the timber beneath. One possible way to prevent this damage is to include UV Absorbers in the coatings. UV Absorbers work by absorbing harmful UV frequencies and releasing it in smaller amounts of heat or at different frequencies.



Energy dissipation photochemical/thermic
mechanism shown with a
Benzotriazole-UV-Absorber



Acknowledgements

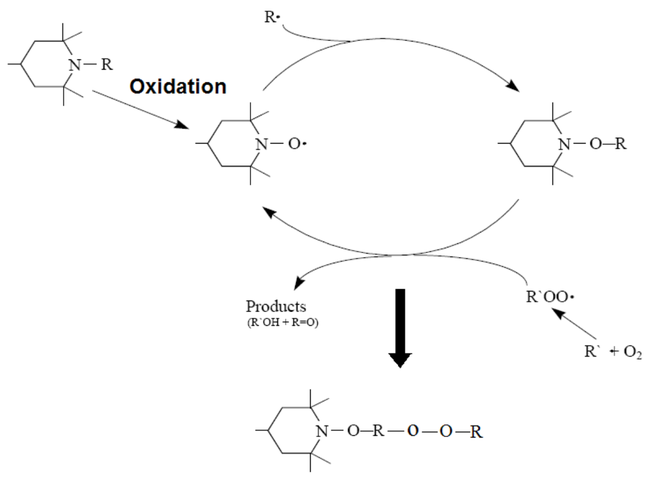
The authors would like to thank ICI paints/Akzo Nobel for their assistance and funding on this project.

Hindered Amine Light Stabilisers (HALS).

HALS are derivatives of tetramethylpiperidine (TMP) used in coatings and pre-treatments to prevent damage caused by free radical species as they are generated by UV radiation. There are two forms of HALS; a Hindered Amine which has to undergo oxidation to a nitroxyl radical before starting to protect wood; and a pre radicalised nitroxyl radical which skips the first step being delivered in a form which starts working immediately.

HALS are believed to regenerate via a Denisov cycle bonding with photo induced free radicals to form aminoethers which react further terminating peroxy radicals formed during photodegradation. The product of this reaction undergoes a S_H2-C reaction regenerating the nitroxyl radical and either alcohols, ketones, or aldehydes.

Modified Denisov cycle



Benefits of UV Absorbers and HALS.

UVA's

Protects against – Colour change
Blistering
De-lamination

HALS
Protects against – Loss of gloss
Cracking
Colour change

Toxicological and Environmental Issues

Some of the best performing chemical treatments have become unusable due to toxicological or environmental reasons. Copper Chromium Arsenate was used extensively as a treatment to protect timber from both photodegradation and decay until it was banned for the majority of uses in Europe and the UK(2003) and later USA (2004) and Australia(2006).Other potential treatments are now under further scrutiny and threat of limitations in use due to new legislation, most recently the REACH (EC 1907/2006) legislation.

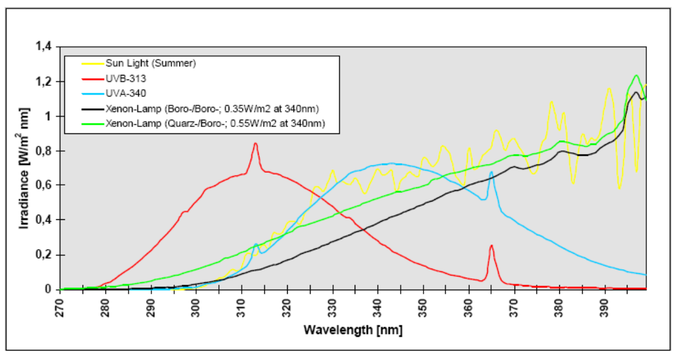
Opaque coatings.

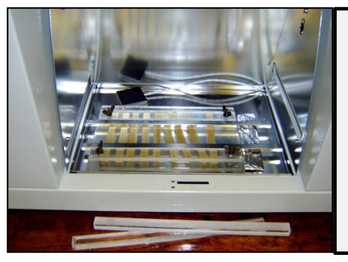
One possible form of protection is Opaque coatings act as a barrier to UV and visible light but loose the natural look of the timber beneath. Opaque coatings have to be made with flexibility in mind as moisture can enter through microscopic cracks or uncoated areas such as joints in joinery causing the wood beneath to swell. This causes the cracks to grow or new ones to form in the inflexible coatings. Once a crack forms light can penetrate the coating barrier and cause the timber beneath to degrade. This causes further coating damage as the timber surface becomes friable and leads to peeling of the coatings.

Acceleration of exposures to UV-Vis light.

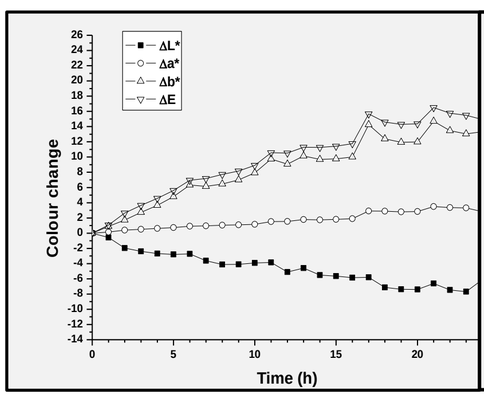
Waiting for a coating to fail in natural conditions can take a long time, especially as coatings are improving. Acceleration of exposure is desirable to allow testing of different chemicals or different formulations. There are two main types of testers available allowing accelerated weathering. UV only testers such as Q labs QUV, and Xenon testers such as Q labs Q-Sun or Atlas Suntester. The spectra of radiation differs for the machines however a desire to mimic long term natural exposure means that testers closely mimicking the spectra of natural sunlight are preferred.

Accelerated Weathering Lamp Spectra
Source: Q-Panel Company





Thin microtomed strips used for colour monitoring and tensile strength tests after being exposed in an Atlas Suntester.



An example of the colour changes in Scots pine as seen within 24 hours of exposure to UV-Visible radiation. This project tests colour monitoring as a method of accelerating testing.

CEE
Civil & Environmental Engineering