Available online at www.sciencedirect.com
SCIENCE DIRECT®
Polymer Degradation and Stability 88 (2005) 268–274
Polymer Degradation and Stability
www.elsevier.com/locate/polydegstab

Photodegradation and photostabilisation of wood – the state of the art

Béatrice George[a,*], Ed Suttie[b], André Merlin[a], Xavier Deglise[a]

[a]LERMAB, UMR 1093 INRA/ENGREF/Université Henri Poincaré, Boulevard des Aiguillettes, BP239 54506 Vandoeuvre, France
[b]BRE, Centre for Timber Technology & Construction, Watford WD25 9XX, UK

Received 10 June 2004; received in revised form 9 October 2004; accepted 23 October 2004
Available online 6 January 2005

Abstract

In this article we try to give an overview of the photodegradation of wood and the different ways available to stabilise this complex substrate. The mechanisms of wood photodegradation have been investigated and it appeared that lignin is the key structure because this component is able to absorb in the UV/visible region due to its chromophoric groups. Thus, some solutions can be offered to protect wood against photodegradation. One of the easiest consists in applying finishes such as paints, coatings, varnishes etc., but it is also possible to modify the substrate chemically (e.g. by acetylation) or to stabilise its colour by thermal and photochemical pre-weathering. The use of UV absorbers, HALS, antioxidants and the recent development of new additives help to prevent the degradation of the coated wood system.

Keywords: Wood; Photodegradation; Stabilisation; UV absorbers; HALS

1. Introduction

It has been known for a long time that wood exposed to solar radiation is subject to surface degradation – primarily colour changes and mechanical breakdown [1]. Despite this behaviour and increasing pressures from competitor materials such as aluminium and PVC, wood remains a well accepted material for construction and decorative purpose such as furniture, parquetry, joinery, cladding and decking. To ensure its long term durability wood is usually coated with various decorative and protective finishes such as opaque paints and semi-transparent stains as well as penetrating finishes or film-forming clear varnishes. Studies of the weathering or accelerated ageing of coated wood systems have shown that protection depends not only on the top coat performance, but also on the substrate and particularly on the wood/coating interface [2–4].

2. Degradation of uncoated wood

In an outdoor service environment, uncoated wood like cladding, is subjected to two different kinds of degradation that vary as a function of time.

- In the short term, we observe mainly colour changes, darkening in the yellow–red region of the CIElab system [5,6] for softwoods (Fig. 1) and for hardwoods like oak (*Quercus robur* L. and *Quercus Petraea*), the colour changes are more complex (Fig. 2). We observe an increase of the colour differences between sapwood and heartwood. This result explains why it is important to eliminate sapwood from the timbers used for parquetry, for example.

* Corresponding author. Fax: +33 3 83 68 44 98.
E-mail address: beatrice.george@lermab.uhp-nancy.fr (B. George).

0141-3910/$ - see front matter © 2004 Elsevier Ltd. All rights reserved.
doi:10.1016/j.polymdegradstab.2004.10.018

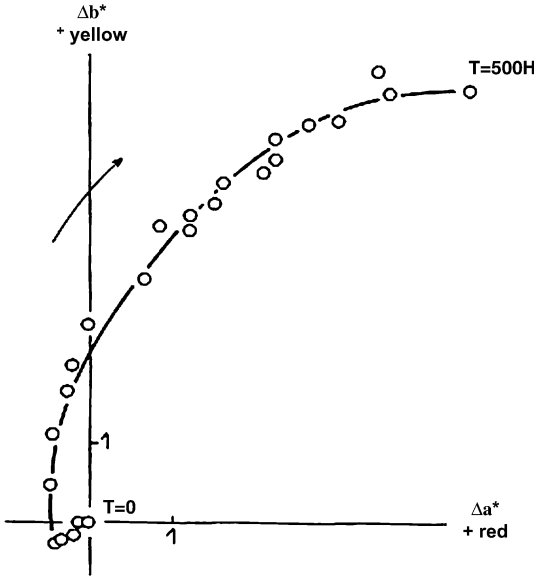

Fig. 1. Evolution of the chromatic coordinates of Vancouver fir, as a function of the time of exposure, to a mercury vapour lamp giving 2 mW/cm^2 at 360 nm [5].

- In the long term, we initially observe a variation of the viscoelastic properties of wood under irradiation. They are characterized by a decrease of the glass transition temperature (T_g) of irradiated wood, as measured by thermomechanical analysis [7]. After several years of exposure, the mechanical breakdown of the wood layers yields greater degradation in early wood than in late wood.

3. Degradation of coated wood

Wood protected by a coating and exposed outdoors is subjected to moisture changes, due to the uptake and release of water, which induces tension within the specimens, causing dimensional modifications and, depending on the coating characteristics, surface defects such as cracking and flaking. In order to carry out its protective function, a wood coating should be able to follow the dimensional changes of the substrate without cracking and peeling. Up to now, degradation is mostly related to the fracture of the wood/top coat interface than to a decrease in the film cohesiveness. Degradation is reduced by adding stabilisers, UV absorbers, antioxidant agents, and Hindered Amine Light Stabilisers (HALS) to the formulation resins as explained in Section 5.3.

In recent years there has been increased customer demand for film-forming transparent systems for exterior use which keep the natural aspect of wood such as colour, grain and texture. However, such transparent surface finishes inherently have more difficulty in providing long term performance. The main reason for such premature failure of the coating is the UV light transparency of the top coats and the reactivity of the underlying wood, particularly lignin, to UV light causing degradation. More recent research has highlighted the importance of the shorter visible wavelengths of light in causing lignin degradation. Wavelengths up to 450 nm have shown changes in surface properties. It is thought that the reaction results are the same as for UV light but they simply occur slowly [8].

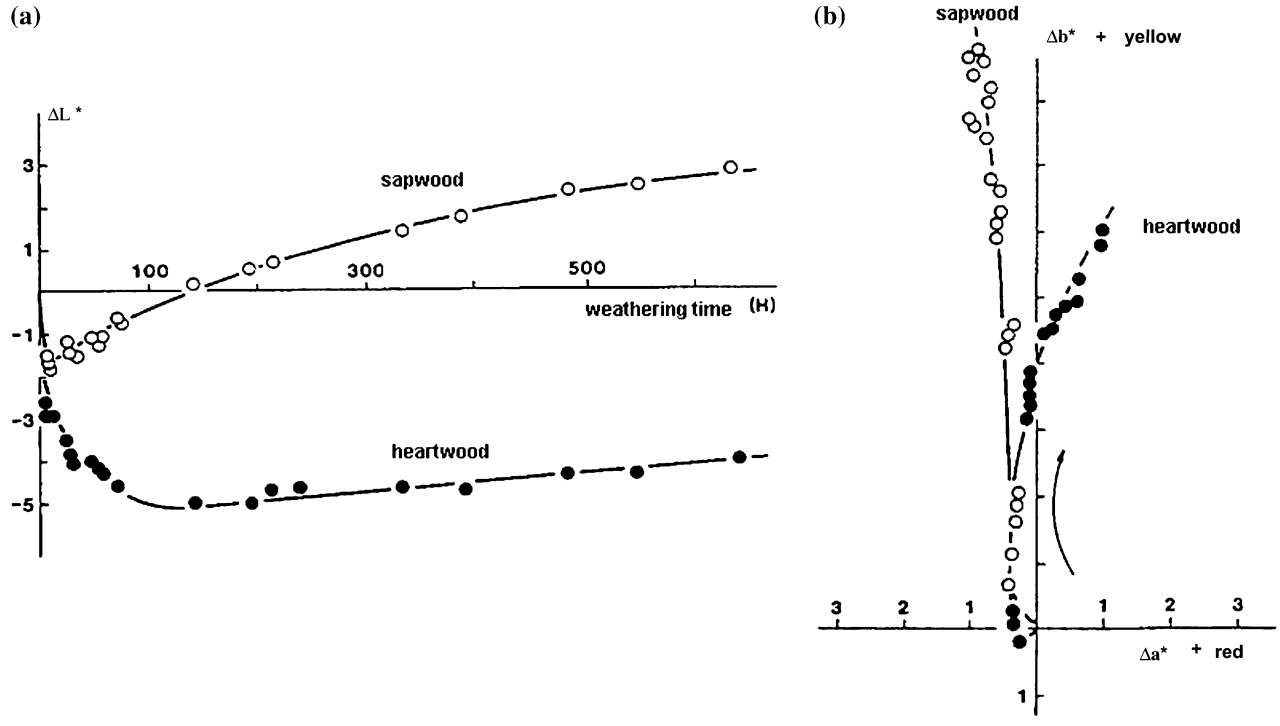

Fig. 2. Colour changes for oak (sapwood and heartwood) under irradiation: (a) luminance; (b) chromatic coordinates [5].