Temperature dependence of the photodegradation of wood

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For determining the temperature dependence of photodegradation the investigated hardwood samples were: ash (*Fraxinus excelsior* L.) and poplar (*Populus x euramericana cv. Pannonia*), the softwood samples were: Scots pine (*Pinus sylvestris* L.) and spruce (*Picea abies* Karst.). The sample size was 100x30x10 (mm). Strong UV light emitter, mercury vapour lamp was used to irradiate specimens. The UV radiation was 80% of the total (UV and visible) light emission (31% UV-A, 24% UV-B and 25% UV-C). The total electric power of the applied double mercury lamps were 800 W and the samples were located 64 cm from the lamps. Four different air temperatures 30°C, 80°C, 120°C and 160°C were applied in the irradiation chamber. A series of samples were treated in the same chamber set for 30°C, 80°C, 120°C and 160°C but without light irradiation. The effect of pure thermal degradation was determined by this experiment. Total treatment time was 16 hours in all cases.

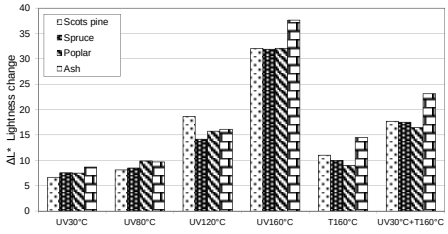

Fig.1 Lightness (L*) change of the investigated wood species caused by UV irradiation at different temperatures (UV) and dry thermal treatment (T) at 160°C. The duration of all treatments was 16 hours.

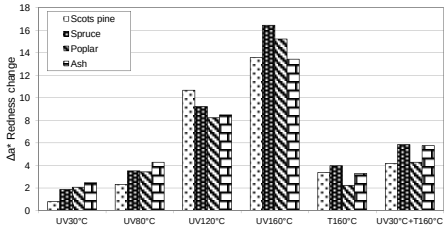

Fig. 2 Redness (a*) change of the investigated wood species caused by UV irradiation at different temperatures (UV) and dry thermal treatment (T) at 160°C. The duration of all treatments was 16 hours.

The change of lightness coordinate (darkening) increased by elevating the temperature in the case of simultaneous treatment (Fig. 1). There was a moderate increase between 30°C and 120°C. The only exception was the Scots pine having great increase (more than doubled) between 80-120°C. The other 3 species also doubled the lightness change but between 120-160°C. The samples in the totally dark chamber suffered considerably less darkening at 160°C than the light irradiated samples at 160°C.

The redness coordinate (Fig. 2) increased rapidly with elevated temperature. However this increase was more balanced in the investigated temperature range than the lightness decrease. The pure thermal treatment at 160°C resulted in much smaller redness change compared to the UV irradiation at the same temperature.

Fig. 3 shows that there was a significant yellow coordinate increase caused by UV irradiation even at 30°C. The light irradiation at 80°C produced similar yellowing as at 30°C. It seems that the light degradation products of lignin are not enough stable at 160°C.

Arrhenius equation:

$$\ln k = \frac{-E_a}{R}\frac{1}{T} + \ln A$$

where k; kinetic constant, 1/T:inverse temperature, E_a: activation energy and (A) is the pre-exponential factor .

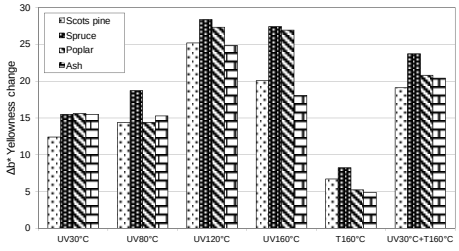

Fig. 3 Yellowness (b*) change of the investigated wood species caused by UV irradiation at different temperatures (UV) and dry thermal treatment (T) at 160°C. The duration of all treatments was 16 hours.

The simultaneous light irradiation and thermal treatment at 160°C generated much larger discoloration than the sum of the discolorations caused by UV light irradiation at 30°and by pure thermal treatment at 160°C. The thermal effect during photodegradation was not only the simple addition of two effects, but the elevated temperature multiplied the effect of photodegradation. The Arrhenius plots of all tree colour coordinates (Fig. 5-7) had a breaking point close to 100°C representing that above this temperature the chemical changes are more complex than below this value. Above 120°C the degradation products of lignin underwent further thermal degradation reducing the yellowness (compare Fig.3 and 4) . The redness change caused by the simultaneous light irradiation and thermal treatment did nit followed the Arrhenius law.

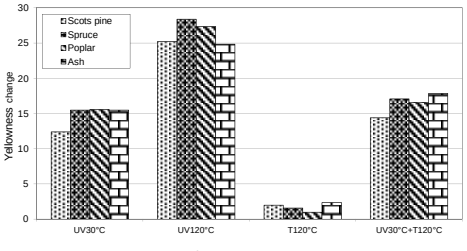

Fig. 4 Yellowness change of the investigated wood species caused by the indicated treatments (light irradiation (UV), pure thermal treatment (T)).

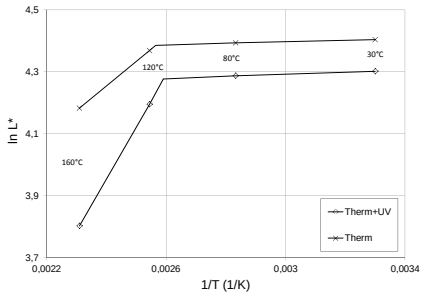

Fig. 5 The Arrhenius plots of lightness for ash samples created by UV irradiation (Therm+UV) and dry thermal treatment (Therm) at the indicated temperatures

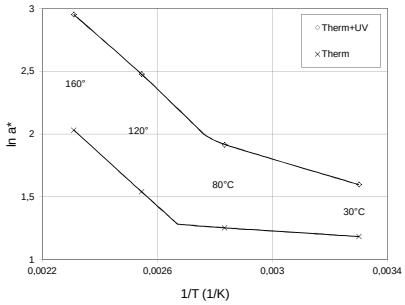

Fig. 6 The Arrhenius plots of redness for spruce samples created by UV irradiation (Therm+UV) and dry thermal treatment (Therm) at the indicated temperatures

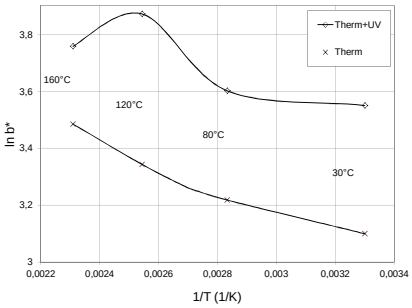

Fig. 7 The Arrhenius plots of yellowness for Scots pine samples created by UV irradiation (Therm+UV) and dry thermal treatment (Therm) at the indicated temperatures