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THE STUDY OF COLOUR CHANGES OF CHOSEN SPECIES OF WOOD FROM SOUTHEAST ASIA CAUSED BY TRANSPARENT COATINGS AND EXPOSURE TO SUNLIGHT

In recent years the interest in exotic wood species has been increasing, which was caused by these species' specific properties. The aesthetic effect of the material, especially the colour, is the most important aspect. Unfortunately, wood is susceptible to strong discolouration caused by the coating process or exposure to sunlight. This paper describes the influence of these factors on the colour stability of Asian teak, merbau and kempas wood species that are mainly used for flooring. It was proved, using spherical spectrophotometer, that uncoated wood became darker when exposed to the action of varnishes and sunlight. Lacquering, waxing and shellac lacquering of wood does not protect it against discolouration, but makes the colour more even on the whole surface.

Keywords: exotic wood, *Intsia bijuga* (Colebr.) O. Ktze, *Koompassia malaccensis* Maing. ex Benth., *Tectona grandis* L., changes of wood colour, wood coatings

Introduction

The increasing popularity of exotic wood species has been visible in recent years (an over twelvefold increase – Kozakiewicz 2006). Floors made of exotic wood species change their colour due to external factors [Kozakiewicz 2005], especially due to light and oxygen in the air. This poses serious problems, especially when the floor is partially covered.

Colour is the reaction of sight to 400-700 nm light which enters the eye and is projected onto the retina (visible light) [Mielicki 1997]. The colour of wood can be changed using appropriate technical means such as application of a varnish coating or oil paints, which can completely cover the natural colour of wood, but at

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the same time provide a protective coating designed to preserve the wood against external factors. Transparent lacquering increases the natural colour intensiveness, but simultaneously accentuates all defects in pattern and colour.

Despite the exotic wood colour descriptions, the professional literature is limited to the data on colour change, but not obtained by organoleptic tests but using colorimeter. The aim of this study was to determine the colour change of coated merbau, kempas and teak wood resulting from exposure to sunlight.

Materials and methods

The following three Asian wood species, popular in Poland and often used for flooring, were selected for tests (nomenclature in accordance with PN-EN 13556:2005 standard): merbau (*Intsia bijuga* (Colebr.) O. Ktze.), kempas (*Koompassia malaccensis* Maing. ex Benth.), and teak (*Tectona grandis* L.). Their detailed descriptions and characteristics are provided by Kozakiewicz and Szkarłat [2004], and Kozakiewicz [2006, 2008]. Before the tests, samples were planed and sanded. The radial section of more uniform pattern was selected, rather than the coarser, tangential section. Moisture content in wood ranged from 8% up to 12%. Boards were cut into test samples of the following dimensions: 70×70×10 mm. The samples were grouped (except group A – standard samples, and group B – uncoated wood samples after solar radiation). In every group surface was finished with various coatings produced by various manufacturers:

- in group C with two-component water-based polyurethane lacquer,
- in group D with one-component polyurethane lacquer,
- in group E with nitrocellulose lacquer,
- in group F with polyurethane lacquer,
- in group G with shellac lacquer,
- in group H with wax.

The materials were used in line with the producers' suggestions. Then the coated samples were placed in a room where they were exposed to direct sunlight for one year (westward).

The analysis of colour change was based on the international CIE L*a*b* model. Until the time of exposure to sunlight, the samples were kept in isolation from it in order to preserve their natural colour. Measurements were taken before coating, after coating and then after exposure to sunlight.

X-Rite SP-60 spherical spectrophotometer was used for the tests. Colour coordinates (in the space dye) described the colour difference. Colour differences were calculated according to the following formula:

- total colour difference:

$$\Delta E^*_{ab} = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2} \quad (1)$$

where: ΔL^* - lightness difference,
Δa^* - red colour difference (a>0),
Δb^* - yellow colour difference (b>0).

– saturation difference:

$$C^*_{ab} = (a^{*2} + b^{*2})^{1/2} \tag{2}$$

– hue difference:

$$H^* = arctg(b^*/a^*) \tag{3}$$

The average values were calculated from obtained data (5 measurements per single sample). For lack of a wood discolouration standard this study is based on PN-ISO 7724-1:2003, PN-ISO 7724-2:2003, PN-ISO 7724-3:2003 standards concerning lacquer discolouration.

Results

Obtained results for merbau (*Intsia bijuga* (Colebr.) O. Ktze.), kempas (*Koompassia malaccensis* Maing. ex Benth.) and teak (*Tectona grandis* L.) wood are presented in table 1 and fig. 1-3. On the basis of the detailed analysis of gathered data it may be concluded that coated exotic wood changes its colour, which is caused by exposure to sunlight. Lightness values dropped in comparison to control samples (group A), i.e. the wood became darker. The greatest lightness change of merbau wood was observed in group E (samples coated with nitrocellulose lacquer), and the lowest in group C (samples coated with two-component water-based polyurethane lacquer). In the case of kempas wood the greatest lightness change was found in group G (shellac lacquer), and the smallest in group H containing samples coated with wax. The results of teak wood tests were as follows: the darkest samples were in group F (polyurethane lacquer coating) and the least darkened in group B (samples subjected to solar radiation, no painting and no paint coatings).

The analysis of the remaining two colour parameters showed that the saturation and hue of the exotic wood changed due to long exposure to sunlight. Colour saturation (C*) of merbau and teak wood became stronger in all studied groups. In the case of kempas wood chrome coating increased the paint systems of groups C, D, E, and H, and decreased in groups B, F, and G (the samples' surfaces became pale).

It was observed that the average value of hue (H*) decreased for tested wood species, which means that their colour changed. Based on this parameter it can be determined (not organoleptic) that the similar to orange-red colour of the samples of kempas wood and merbau wood became more similar to red-brown, while the colour of kempas wood samples was darker.

Table 1. The comparison of the colour parameters of wood species from Southeast Asia caused by varnishing coatings and exposure to sunlight
Tabela 1. Zestawienie parametrów barwy drewna pochodzącego z Azji Południowo-Wschodniej pod wpływem powłok lakierniczych i ekspozycji na działanie światła słonecznego

Wood species *Gatunek drewna*	Group *Grupa*		Colour parameters *Cecha barwy drewna*								
			Lightness (L*) *Wartość jasności*			Saturation (C*) *Wartość chromy*			Hue (H*) *Wartość odcienia*		
			L*min	L*av./śr	L*max	C*min	C*av./śr	C*max	H*min	H*av./śr	H*max
MERBAU (*Intsia bijuga* (Colebr.) O. Ktze.)	uncoated wood *drewno bez powłoki*	A	39.82	44.47	50.10	20.53	22.45	25.43	52.77	55.35	58.94
		B	42.09	42.98	44.39	21.73	22.89	24.09	54.70	55.11	55.55
	coated wood after exposure to sunlight *drewno z powłoką po naświetlaniu*	C	41.54	43.02	44.89	24.74	26.44	27.52	53.42	54.93	56.25
		D	40.62	41.77	42.70	23.15	24.86	26.23	52.45	53.30	54.37
		E	40.09	40.38	40.85	24.66	25.11	25.90	48.82	49.19	49.82
		F	41.20	41.88	42.58	23.68	24.06	24.58	48.71	49.36	50.18
		G	41.11	41.70	42.50	25.95	27.65	29.01	49.83	50.59	51.51
		H	41.39	42.53	44.22	25.67	26.44	28.35	49.35	50.38	51.33
KEMPAS (*Koompassia malaccensis* Maing. ex Benth.)	uncoated wood *drewno bez powłoki*	A	47.65	51.93	54.20	23.28	26.92	28.94	52.82	54.52	55.99
		B	39.41	40.81	41.83	21.95	22.94	23.62	48.41	48.83	49.35
	coated wood after exposure to sunlight *drewno z powłoką po naświetlaniu*	C	39.36	41.02	41.77	25.85	27.62	28.73	44.83	47.12	47.90
		D	40.83	42.14	43.05	25.33	27.45	29.35	47.14	48.69	48.71
		E	42.10	43.28	45.04	27.89	28.78	30.62	48.69	50.00	52.04
		F	37.83	38.83	39.99	22.33	23.96	24.92	40.21	41.28	42.07
		G	36.36	36.84	37.72	23.24	24.84	26.40	41.72	42.73	44.23
		H	44.36	44.77	45.65	26.82	27.86	28.58	50.28	50.81	51.74
TEAK (*Tectona grandis* L.)	uncoated wood *drewno bez powłoki*	A	45.57	54.37	60.89	23.18	26.71	31.50	63.11	67.52	69.32
		B	52.92	53.48	53.51	33.82	34.14	34.86	64.46	64.66	64.89
	coated wood after exposure to sunlight *drewno z powłoką po naświetlaniu*	C	50.32	51.31	53.20	30.72	31.23	31.78	62.56	63.72	65.13
		D	52.49	53.93	55.25	29.07	30.94	31.81	64.82	66.02	67.30
		E	42.12	46.57	49.94	26.99	30.62	33.10	58.68	61.26	63.24
		F	41.48	44.42	47.52	24.33	27.02	31.14	56.27	58.10	60.59
		G	47.39	47.80	48.35	33.14	34.45	35.32	60.60	61.44	62.12
		H	41.88	45.58	47.69	24.33	28.14	30.70	57.67	60.89	63.75

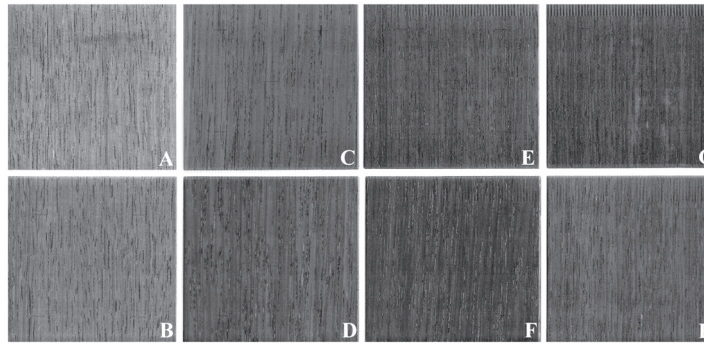

Fig. 1. The appearance of coated merbau wood samples (*Intsia bijuga* (Colebr.) O. Ktze.) after exposure to sunlight
Rys. 1. Wygląd próbek drewna merbau (Intsia bijuga (Colebr.) O. Ktze.) pokrytego powłokami po ekspozycji na działanie światła słonecznego

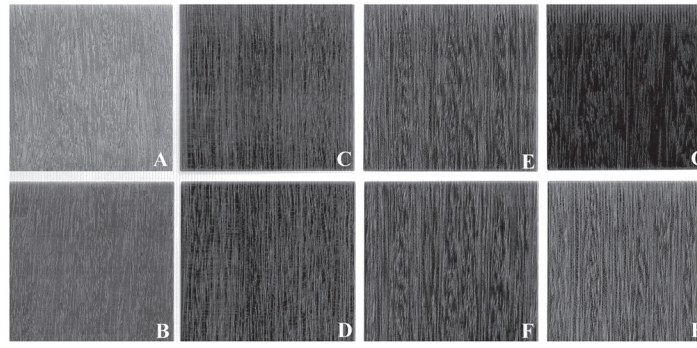

Fig. 2. The appearance of coated kempas wood samples (*Koompassia malaccensis* Maing. ex Benth.) after exposure to sunlight
Rys. 2. Wygląd próbek drewna kempas (Koompassia malaccensis Maing. ex Benth.) pokrytego powłokami po ekspozycji na działanie światła słonecznego

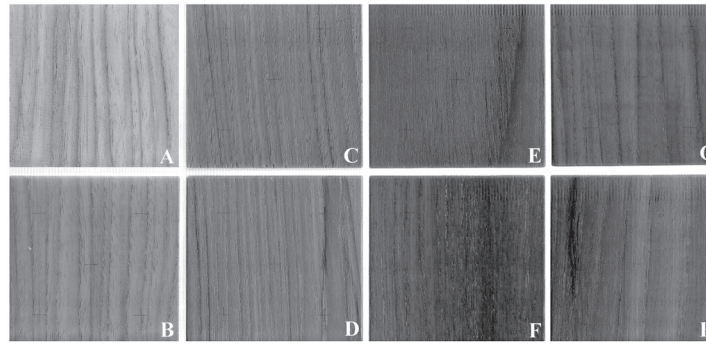

Fig. 3. The appearance of coated teak wood samples (*Tectona grandis* L.) after exposure to sunlight
Rys. 3. Wygląd próbek drewna tikowego (Tectona grandis L.) pokrytego powłokami po ekspozycji na działanie światła słonecznego

The biggest differences in this parameter were observed for a merbau wood sample from group C (two-component paint, water-based) and for kempas wood samples from group F (polyurethane lacquer). In the case of teak wood, it was observed that samples of a colour similar to yellow got a bit darker shade of yellow, and the biggest difference in hue was recorded for samples from group E (nitrocellulose lacquer).

For comparison of different coatings, a total colour difference criterion (fig. 4-6) and colour stabilisation was set. The scope of wood colour changes was set on the basis of a nine-step scale [Mielicki 1997] given in table 2.

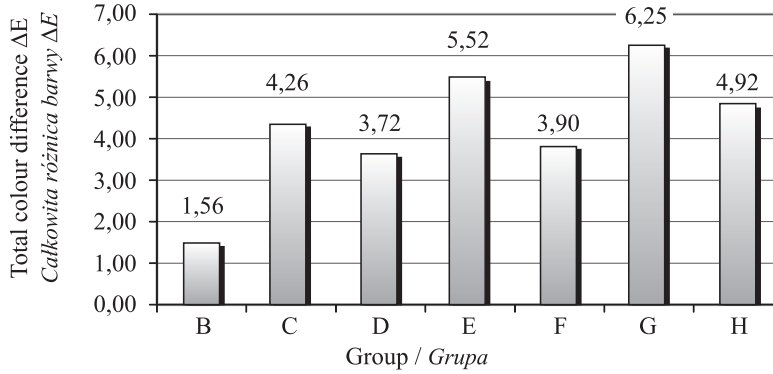

Fig. 4. The comparison of total colour difference of coated merbau wood (*Intsia bijuga* (Colebr.) O. Ktze.) caused by exposure to sunlight
Rys. 4. Zestawienie całkowitej różnicy barwy drewna merbau (Intsia bijuga (Colebr.) O. Ktze.) pokrytego powłokami po ekspozycji na działanie światła słonecznego

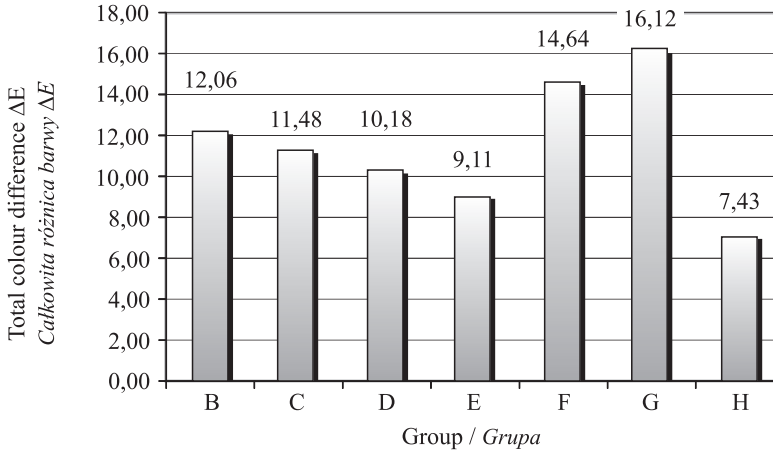

Fig. 5. The comparison of total colour difference of coated kempas wood (*Koompassia malaccensis* Maing. ex Benth.) caused by exposure to sunlight
Rys. 5. Zestawienie całkowitej różnicy barwy drewna kempas (Koompassia malaccensis Maing. ex Benth.) pokrytego powłokami po ekspozycji na działanie światła słonecznego

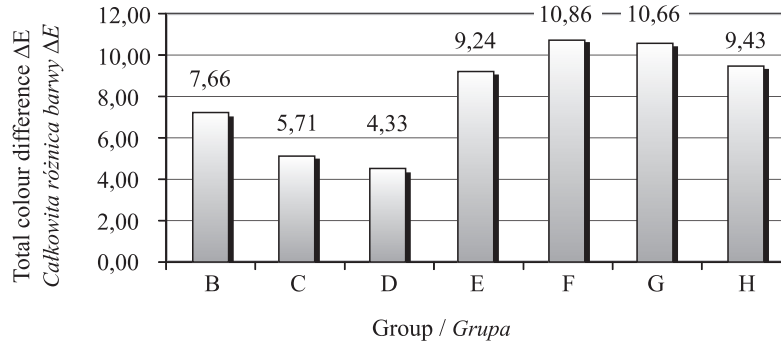

Fig. 6. The comparison of total colour difference of coated teak wood (*Tectona grandis* L.) caused by exposure to sunlight
Rys. 6. Zestawienie całkowitej różnicy barwy drewna tikowego (Tectona grandis L.) pokrytego powłokami po ekspozycji na działanie światła słonecznego

Table 2. Colour stability [Mielicki 1997]
Tabela 2. Stopnie trwałości barwy [Mielicki 1997]

Colour difference *Różnica barwy* ΔE	0 ± 0.2	0.8 ± 0.2	1.7 ± 0.3	2.5 ± 0.35	3.4 ± 0.4	4.8 ± 0.5	6.8 ± 0.6	9.6 ± 0.7	13.6 ± 1.0
Colour stability *Stopień trwałości barwy*	5	4-5	4	3-4	3	2-3	2	1-2	1

On the basis of the classification presented in table 2, it can be said that there was no correlation between tested wood species (the colour of each species covered with the same painting and varnish coatings reacted differently to exposure to natural sunlight). In the case of merbau wood the highest degree of colour stability was found in the group of samples subjected to solar radiation, but not coated with lacquer painting and coatings (group B). The most durable colour of kempas wood samples was found in the group of wax-coated samples (group H), and in the case of teak wood it was observed in the group of samples coated with one-component polyurethane varnish (group D).

Conclusions

The tests run on three popular wood species from Southeast Asia, i.e. merbau, kempas and teak wood, consisting in the evaluation of colour changes of wood caused by different transparent coatings and exposure to sunlight, allow the following conclusions:

1. transparent coatings (varnishes, wax, and shellac) and exposure to sunlight caused changes in colours of wood surface,

2. changes in colour were different in the three tested kinds of wood; the scope of changes depended on the finishing coating applied,
3. covering of the wood samples' surface with varnishes, waxes, and shellac, and then subjecting them to sunlight resulted in darker colour of the samples,
4. generally application of varnish, wax and shellac did not protect wood from changes of colour; however it made the colour more even on the entire wood surface.

References

Kozakiewicz P., **Szkarłat D.** [2004]: Tik (*Tectona grandis* Linn. f) – drewno egzotyczne z południowo-wschodniej Azji. Przemysł Drzewny 2: 27-30

Kozakiewicz P. [2006]: Merbau (*Intsia* sp.) – drewno egzotyczne z Azji i Oceanii. Przemysł Drzewny 9: 21-24

Kozakiewicz P. [2006]: Kempas (*Koompassia malaccensis* Maing) – drewno egzotyczne z południowowschodniej Azji. Przemysł Drzewny 4: 33-36

Mielicki J. [1997]: Zarys wiadomości o barwie. Wyd. Fundacja Rozwoju Polskiej Kolorystyki, Łódź

List of standards

PN-EN 13556:2005 Drewno okrągłe i tarcica. Terminologia stosowana w handlu drewnem w Europie

PN-ISO 7724-1:2003 Farby i lakiery – Kolorymetria – Część 1: Podstawy

PN-ISO 7724-2:2003 Farby i lakiery – Kolorymetria – Część 2: Pomiar barwy

PN-ISO 7724-3:2003 Farby i lakiery – Kolorymetria – Część 3: Obliczanie różnic barwy

BADANIE ZMIAN BARWY WYBRANYCH GATUNKÓW DREWNA Z AZJI POŁUDNIOWO-WSCHODNIEJ SPOWODOWANYCH TRANSPARENTNYMI POWŁOKAMI I ODDZIAŁYWANIEM ŚWIATŁA SŁONECZNEGO

Streszczenie

W ostatnich latach widoczna jest rosnąca popularność drewna egzotycznego na rynku europejskim. Podłogi wykonane z drewna egzotycznego zmieniają swoją barwę pod wpływem czynników zewnętrznych. W opisach barwy drewna egzotycznego w literaturze fachowej brak danych, pozyskanych nie organoleptycznie, lecz za pomocą kolorymetrów fizycznych. Celem niniejszej pracy było zbadanie, przy użyciu spektrofotometru sferycznego, zmian barwy wybranych gatunków drewna z Azji Południowo-Wschodniej (tik, merbau, kempas) z naniesionymi transparentnymi powłokami pod wpływem działa-

nia światła słonecznego. Analizę zmiany barwy wykonano na podstawie matematycznego modelu przestrzeni barw CIE L*a*b*, opracowanego przez Międzynarodową Komisję Oświetleniową, uwzględniającego zalecenia zawarte w normie PN-ISO 7724-3:2003.

Wyniki przeprowadzonych badań pozwalają stwierdzić, że transparentne powłoki (lakiery, wosk, politura) i ekspozycja na działanie światła słonecznego powodują zmiany barwy drewna. Zmiany barwne mają zróżnicowany charakter dla badanych gatunków drewna, a wielkość zmian jest zależna od zastosowanego środka uszlachetniającego. Większą zmienność barwy wykazuje drewno, które zostało pokryte powłokami niż drewno niczym niezabezpieczone. Lakierowanie, woskowanie i politurowanie drewna generalnie nie zabezpiecza go przed zmianami barwy, jednak wyrównuje jego kolorystykę (barwa drewna jest wyrównana na całej powierzchni).

Słowa kluczowe: drewno egzotyczne, *Intsia bijuga* (Colebr.) O. Ktze, *Koompassia malaccensis* Maing. ex Benth., *Tectona grandis* L., zmiany barwy drewna