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Assessment of the impact of UV radiation on selected properties of the transparent coating for wood finishing

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Abstract: *Assessment of the impact of UV radiation on selected properties of the transparent coating for wood finishing.* Work presents the research on selected properties of the transparent coating for wood, exposed to UV irradiation, and then assessed against the impact of UV radiation on the selected properties. Resistance against abrasion and scratches and relative hardness of the coatings were investigated. Work was performed in accordance toapplicable standards. It was observed that UV exposure of acrylic-polyurethane and polyurethane-solvent coatings does not adversely affect relative hardness, scratch resistance and abrasion resistance.

Keywords: wood, polyurethane coatings, acrylic-polyurethane coatings, UV radiation.

INTRODUCTION

The market is full of many types of coatings used for surface treatment of wood. The most commonly used are solvent-based lacquers, which provide high durability and abrasion resistance, being relatively easy to apply and quick drying. Unfortunately, while drying, solvent vapor occuring is harmful to the environment. Because of that environmental aspect, solvent-based coatings are increasingly being replaced by water-based paints. Waterborne products are significantly less harmful to the environment and create coatings with quality comparable to solvent-based ones (Jabłoński et al. 2009).

Coatings delay aging of wood, but are undergoing such proces themselves. (Iezzi 1997, Schuetz et al. 1999) . Much quicker degradation of paints is observed outdoors, where coatings are exposed to environmental factors, like sunlight UV radiation (Gerlock et al. 2000) . In case of wood flooring coating system, aging does not occur evenly, because floor us usually only partially exposed to direct sunlight. Exposure is lower in covered places like under carpets or furniture, degradation is slower, therefore discoloration of such unexposed places occurs slower and color of exposed places may be significantly different than unexposed ones. (Thapliyal and Chandra 1991, Wilhelm et al. 1998, Schaller and Rogez 2008).

UV part of solar radiation consists, amongst others of UV-A radiation (wavelength between 315÷400 nm) and UV-B radiation (wavelength 315 nm). This radiation damages protective coatings (Pluta 2013). Resistance of coating to UV radiation depends on the type of binder and the content of photostabilizers. The main absorbers of radiation are carbonyl groups. The processes of the destruction of the paint's coating the by UV radiation is known as photodegradation and occurs due to excitation of free radicals of the polymers contained in the coating, which again shortens the polymer chain. The photodegradation process of coatings occurs only in the outer layer and usually starts with absorption of UV radiation by carbonyl groups (Ochrimenko and Wierchołancew 1982). This reaction leads to structural changes of coatings such as color change, flexibility, hardness and loss of gloss. In order to accelerate the process of photo-degradation of coatings in laboratories, equipment such as a xenon lamp imitating sunlight spectrum is being used (Schaller and Rogez 2008).

The aim of this work was to determine the effect of ultraviolet radiation on selected properties of single compound acrylic-polyurethane two-compound polyurethane floor finishing systems.

The scope of the work includes application of tested coating on the beech wood (*Fagus sylvatica* L.), exposure to UV radiation and determination of properties such as :

- Scratch resistance,
- Abrasion resistance (determination of Taber coefficient),
- Relative hardness

For comparison, two above coatings were tested on samples unexposed to UV radiation.

MATERIAL AND METHODS

Tests were performed in accordance to current standards:

- PN-EN ISO 1514:2006,
- PN-EN ISO 12137-2:2007,
- PN-EN ISO 7784-1:2006,
- PN-EN ISO 1522:2006.

Test material

Solid beech wood samples were used for the tests (*Fagus sylvatica* L.), dimensioned in accordance to PN-EN ISO 1514:2006 standard requirements. 112 samples were made in total. Samples before coating were sanded with paper of 120 grit, and then split into 2 groups. After cleaning, three layer of coat were applied, in 4-hour intervals, as required by product SDS. Varnishes were provided by general distributor in Poland. Both groups of samples were then split into subgroups, two of the subgroups were irradiated with UV in SOLARBOX 1500e unit. This apparatus utilizes lamps of emission characteristics similar to sunlight. Samples were subjected to 50 hour UV radiation exposure of intensity 550 W/m^2 at Black Standard Thermometer (BST) temperature of 55°C. Total energy emitted during the experiment was 98 MJ/m^2.

Characteristics of coating material "A"

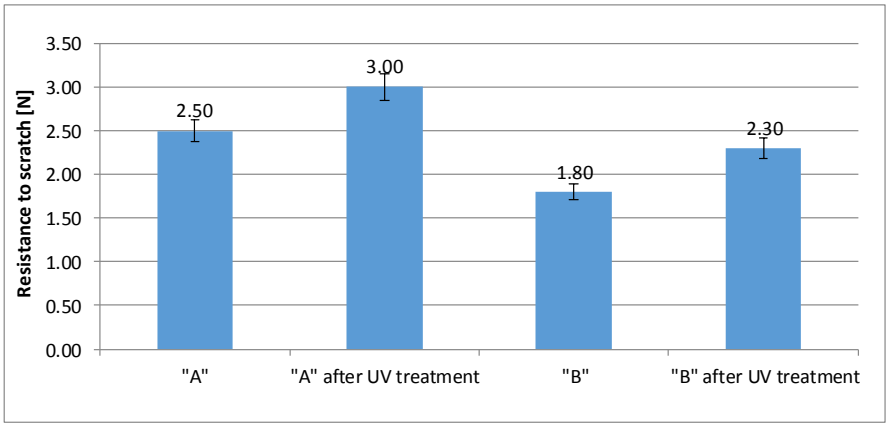
Paint 'A' is a transparent, single compound and waterborne acrylic-polyurethane varnish available in four glosses: 10, 30, 60 and 90. The study used lacquer of gloss 30. This is a product designated to indoor parquetry. Varnish "A" is made from aliphatic polyurethane resins of fatty acids and acrylic resins, therefore in the opinion of the manufacturer, coatings based on these resins are resistant to abrasion, and chemical agents as well as two-compound paints.

Characteristics of coating material "B"

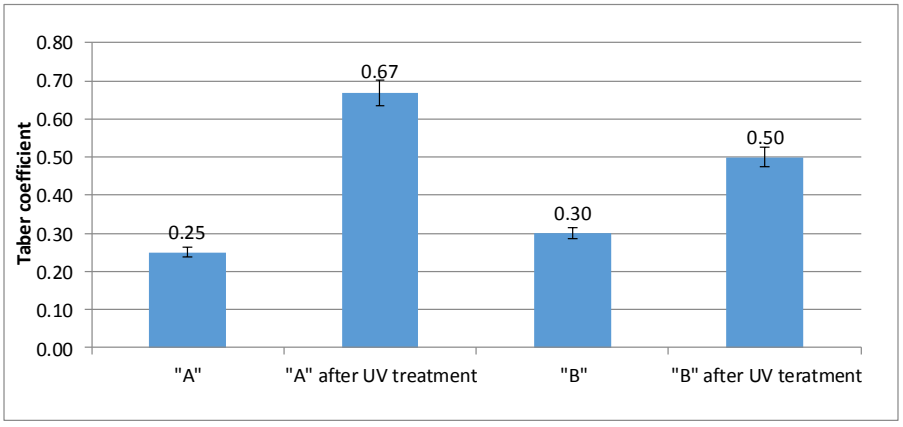
Paint 'B' is a transparent, two-compound solvent-based polyurethane product suitable for high gloss wooden parquet finising. The paint characterizes with high hardness and resistance to water and detergents. Varnish "B" contains a hardener, with isocyanine groups, which guarantees better film formation, and thus makes it more durable.

RESEARCH RESULTS

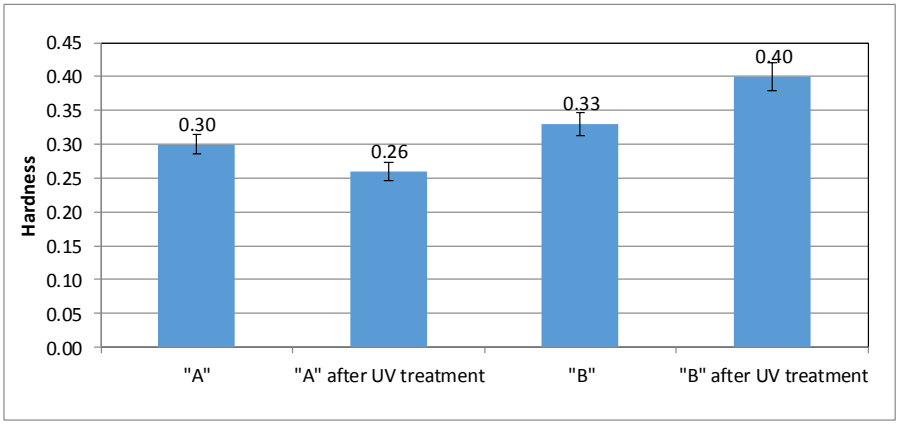
The results of the scratch resistance, abrasion resistance, expressed as Taber coefficient, and the relative hardness of the coatings tested before and after the UV radiation exposure are shown in graphs 1, 2 and 3.



Graph1. Average scratch resistance of tested coatings.



Graph 2. Average abrasion resistance (Tabera) of tested coatings



Graph 3. Average relative hardness of tested coatings (Persoz pendulum method)

Basing on the results of scratch resistance tests it was noted that waterborne and solvent lacquer coating shows higher resistance under the influence of UV radiation. Overall, the scratch resistance was found to be higher for an acrylic lacquer coating "A" (3.0 N for UV irradiated coatings, 2.5 N for the control samples). Coating film "B", which was not irradiated showed lowest resistance to scratches (1.8 N). UV radiation makes the surface of coating materials become harder and therefore it improves resistance to scratching.

Tests of abrasion resistance show that in general, UV irradiation improves abrasive resistance of both waterborne and solvent-based coatings. The abrasion resistance of coatings not exposed to UV rays, turned out to be lower for the solvent-based paint. It was noted that two-compound lacquer which has not been irradiated by UV rays shows lower abrasion resistance than a water-borne paint, which also have not been subjected to irradiation. However, UV radiation has a greater impact on the coating 'A', because their abrasion resistance after UV irradiation is more than two times better than coating not exposed to UV. It may also be concluded, that after UV irradiation coatings lose their flexibility.

Hardness tests show that UV irradiation insignificantly lowered hardness of "A" group, and caused some gain in "B" group. In general, solvent-based coating showed higher relative hardness than waterborne one. The impact of UV radiation on the 'B' group coatings resulted in an increase of their average relative hardness.

After the UV irradiation on the test coatings it has been observed that coating "A" significantly failed to secure the wood from color change. This could be seen with the naked eye. In the case of coatings 'B', subjected to UV radiation, it was found that these coatings to a much lower extent (than the "A" coatings) protect the wood from discoloration.

CONCLUSIONS

Basing on the results obtained, one may conclude:

1. UV irradiation has a significant effect on the scratch resistance of the coatings, increasing the resistance of both the acrylic-polyurethane and polyurethane-solvent lacquers.
2. UV irradiation increases the wear resistance of coatings, both acrylic-polyurethane and polyurethane-solvent, resulting from a decrease in their flexibility.
3. Exposure to UV increases the relative hardness of finishes based on two-compound polyurethane varnish (reverse phenomenon was observed in the case of one-component acrylic paint).

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Streszczenie: *Ocena wpływu promieniowania UV na wybrane właściwości transparentnych powłok wykańczających powierzchnię drewna.* W pracy przedstawiono badania wybranych właściwości transparentnych powłok wykańczających powierzchnię drewna, eksponowanych w warunkach wewnątrz pomieszczeń, a następnie powłoki poddano ocenie wpływu promieniowania UV na badane właściwości. Przeprowadzono badania odporności powłok na ścieranie, zarysowania. Wykonano także oznaczenie względnej twardości powłok.
Powyższe badania przeprowadzono zgodnie z obowiązującymi normami. Na podstawie analizy wyników zaobserwowano, że ekspozycja powłok akrylowo-poliuretanowych, jak i poliuretanowo-rozpuszczalnikowych w warunkach długotrwałego oddziaływania promieni UV nie wpływa ujemnie na właściwości powłok takie jak twardość względna, odporność na zarysowanie oraz odporność na ścieranie.

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