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MOBİLYA ÜRETİM GİBİ KAYNAK VOC EMİSYONLARI İÇİN KULLANILAN MALZEMELER

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Özet- Mobilya için Kullanılan Malzemeler gelen uçucu organik madde emisyonları nicel ve nitel bir bileşim etkili olan faktörler odaklı Bu kağıt. Miktar ve VOC emisyonları kalitesine mobilya üretimi için Kullanılan Malzemeler çeşitli türleri etkisinin değerlendirilmesi odaklı deneysel bölüm. VOC emisyonları emici Tenax Ta ile sütun içinde toplanmıştır. Kütle Spektrometre ve Direk termal yayılım ile Birlikte gaz kromatografisi: Biz analitik yöntemle VOC Emisyonları Yani kullanıldı gerektiğini Sütunlar Analiz. Test edilen bu malzemeler VOC emisyonları örnekleme örnekleri metodolojisi 16000 bölüm 1, 5, 9, standart DİN EN ISO göre yapıldı

Anahtar Kelimeler- Mobilya, VOC, Kapalı hava kalitesi

MATERIALS USED FOR FURNITURE PRODUCTION LIKE SOURCE VOC EMISSIONS

Abstract-This paper focuses on factors which influence the quantitative and qualitative composition of Volatile Organic Compound emissions from materials used for furniture. The experimental part focuses on the assessment of influence of various types of materials used for furniture production on the quantity and quality of VOC emissions. The VOC emissions were collected in columns with absorbent Tenax Ta. We analyzed the columns with the VOC emissions by analytical method that was used: the gas chromatography in conjunction with mass spectrometer and Direct Thermal Desorption. The methodology of sampling samples of VOC emissions from tested materials was done according to standard ČSN EN ISO 16000 part 1, 5, 9.

Key Words- Furniture, VOC, Indoor air quality

1. GİRİŞ (INTRODUCTION)

Many building materials, furnishings and household products demonstrate emission of volatile organic compounds (VOCs) during usage [1] and have been documented as sources of reactive compounds and reaction products. The problem might become dominant when components of different materials can react with each other. This effect can be exemplified for the case of a

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typical flooring structure: Both, adhesive and floor covering could be ranked as low emitting materials under the conditions of a ‘‘single-product’’ chamber test as proposed by AgBB-Committee for Health-related Evaluation of Building Products (2005) [2]. However, the pattern of emitting species and emission rates looks different under ‘‘real-world’’ conditions due to interactions between flooring material, adhesive and concrete [1, 3]. A number of different factors can influence the emission characteristics [4, 5] and numerous investigations have shown that indoor chemistry is of particular importance for the indoor related evaluation of building products.

A lot of building materials emit volatile organic compounds (VOCs) which have the potential to affect health and comfort. Formaldehyde is a suspected human carcinogen that is known to be released from pressed-wood products used in home construction, including products made with urea formaldehyde (UF) resins (e.g., particleboard (PB), hardwood plywood, medium density fiberboard (MDF), and paneling) and those made with phenol-formaldehyde (PF) resin (e.g., softwood plywood, oriented strand board) [6, 7, 8, 9, 10].

It was concluded that VOCs such as benzene, formaldehyde, acetaldehyde, toluene and xylenes have to be considered as priority pollutants with respect to their health effects [11]. Many studies have shown significant VOC sources indoors. For example, the main sources of aldehydes and BTEX indoors may include building materials (BMs), such as hardwood, plywood, laminate floorings, adhesives, paints and varnishes [12, 13, 14, 15, 16, 17, 18], adhesives and decoration materials. In addition to these primary emissions, numerous past researches also indicated that ozone reactions with BMs result in secondary emissions of aliphatic aldehydes, secondary organic aerosols and other products that are more important [19, 20, 15, 21].

Although Green Building Material (GBM) is intended to have low toxicity and minimal chemical emission, measurement of primary emissions alone may not be sufficient since secondary emissions due to ozone reactions may affect the perceived air quality in the long run demonstrated that natural wood material with low formaldehyde emission after being exposed to ambient ozone produced secondary pollutants, including formaldehyde, acetaldehyde, cyklohexanone and benzaldehyde.

For many of these chemicals, the risk on human health and comfort is almost unknown and difficult to be predicted because of the lack of toxicological data. In the frame of the INDEX project [11] the existing knowledge worldwide has been assessed in terms of type and levels of chemicals in indoor air, as well as, the available toxicological information. It was concluded that VOCs such as benzene, formaldehyde, acetaldehyde, toluene and xylenes have to be considered as priority pollutants with respect to their health effects. On the other hand, chemicals such as limonene and α-pinene require further research with regard to human exposure or dose response and effects.

2. YÖNTEM (METHOD)

2.1. Araştırma amacı (Research objective)

This research describes the VOC emissions emitted by materials used for produce furniture (chipboard, chipboard with oak veneer and urea formaldehyde adhesive, further chipboard with oak veneer and PVAc adhesive and also paints – polyurethane lacquer and water borne lacquer). The focus was on the influence of various kinds of materials (carrier material, glues, paint) on the quality and quantity of volatile organic compounds, especially on the amount of emitted Buthoxy Ethanol a parameter TVOC. The emissions were analyzed as function of time after produce.

2.2. Test malzemeleri (Tested materials)

Samples were taken from the normal manufacturing process, wrapped in aluminium foil and delivered to the test laboratory. The samples of wood base materials were prepared on sizes: 700 x 700 x 18 mm (area $1m^2$) and put into the test chamber. The both kinds of paints were applied to wood based materials (veneered chipboard finished by various kind of water borne lacquer). As emission rate of VOCs also depends on age, the samples were put into the chamber as soon as possible after manufacture. In the present study, air samples were collected continuously onto the Tenax TA until their required testing days was obtained.

2.3. VOC emisyonları belirlenmesi için aletler (Equipment for determination VOC emissions)

- Short path thermal desorption tube, Silco trated Thermal Desorption Tube 786090-100, inner diameter 4 mm, fill in with 100 mg of Tenax TA (Scientific Instrument Services company) for collection of VOCs emissions emitted from tested samples in to the air in chamber
- Air sampler Gilian–LFS 113 SENSIDINE with air flow 6 l h^{-1} and 12 l h^{-1}
- Gas chromatograph Agilent GC 6890 with MS (mass spectrometer) detector 5973 with cryofocusation, thermal desorption and library of spectra NIS 05, column type HP – 5 (AGILENT USA)
- VOC was tested in a small-space chamber with a volume of 1 m^3. Air temperature: 23°C; relative humidity in the chamber: 50%; air changing rate: 1 m^3 per 1 h; air speed over the tested samples: 0.1 to 0.3 $m.s^{-1}$.

2.4. Kullanılan yöntemler (Used methods)

In the present study, air samples from tested sample were collected onto Tenax TA adsorbent (sampling rate 200 mL min^{-1}, time 180 min.) from small space chamber (a volume 1 m^3). Air samples were analysed with a gas chromatograph (HP 6890) equipped with a mass selective detector (MSD 5973) after thermal desorption at 250 °C for 3 min (Scientific Instrument Services TD4). The column was HP-5MS (column length 30 m, i.d. 0,25 mm, film thickness 1 μm), and the identification of the compounds was accomplished by retention times, standard compounds, and GC-MS data library.

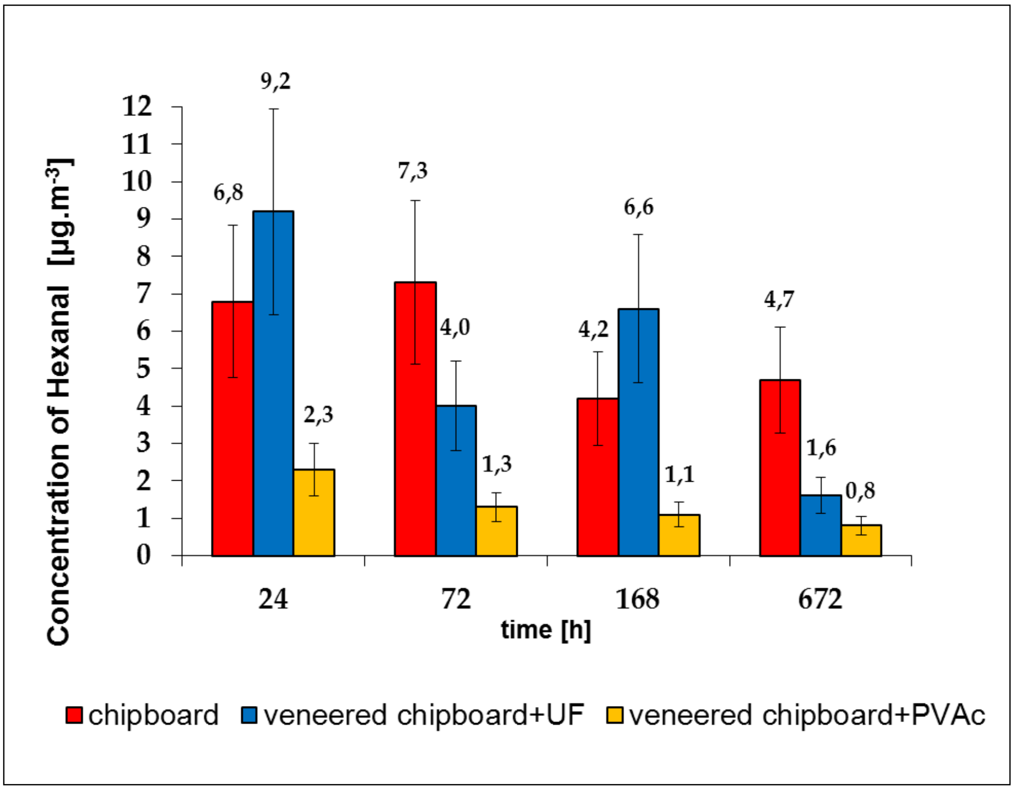
The total VOC emission was first calculated by combining the peak areas of all identified compounds, after which the relative proportion of individual compounds from the total emission was calculated. The TVOC value is defined to be the integrated detector response value in toluene equivalents of compounds eluting between and including C_6 to C_{16} as given in ISO 16000-6.

3. BULGULAR (FINDINGS)

Experimental part of this research is divided into three parts:

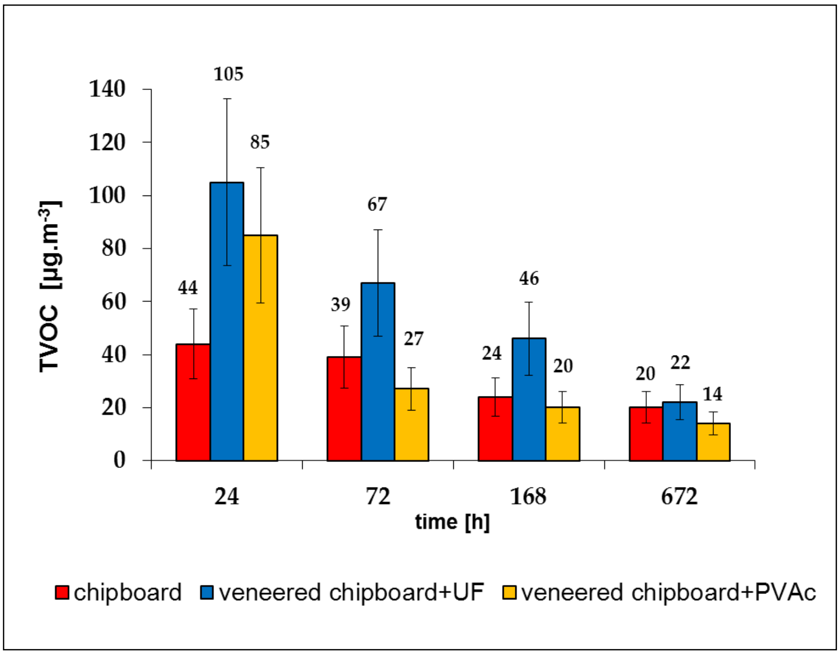
a) Comparison of VOC emissions from natural chipboard and veneered chipboard with different type of glue
b) Comparison of VOC emissions from veneered chipboard finished by different type of lacquer
c) Comparison of VOC emissions from various kind of lacquer applied on inert material (sheet glass)

3.1. Tutkal farklı tip doğal sunta VOC Emisyonlarının Karşılaştırılması ve kaplama sunta (Comparison of VOC emissions from natural chipboard and veneered chipboard with different type of glue)



Şekil 1. Doğal suntadan hekzanal ve yapıştırıcı farklı tip kaplama sunta (Hexanal from natural chipboard and veneered chipboard with different type of glue)

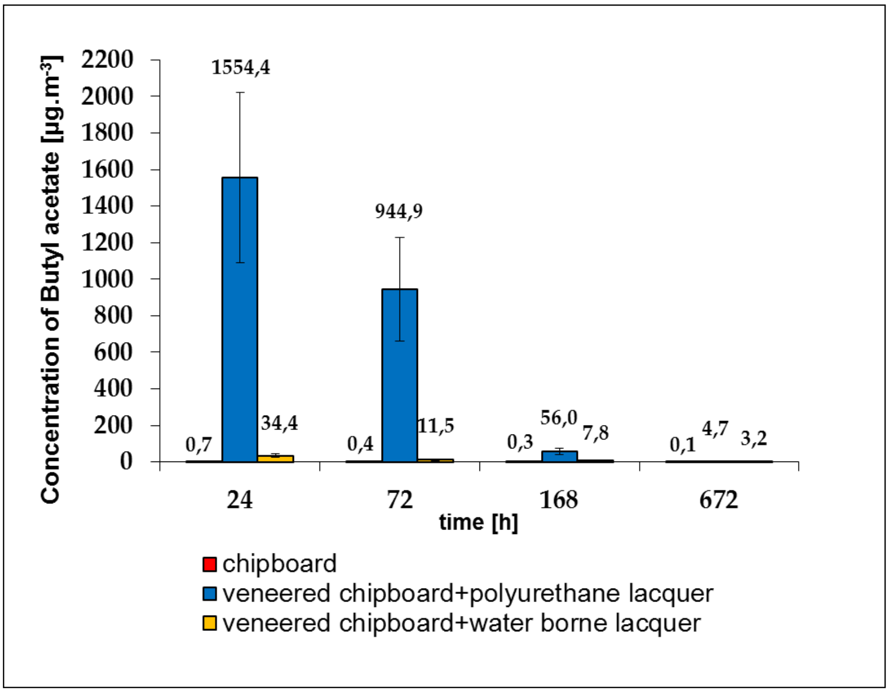
Fig.1 shows the influence of various type of material (natural or veneered chipboard) on the quality of indoor air, especially of Hexanal emissions emitted from tested materials. The highest concentration of Hexanal was found at measurements after 24 hours.



Şekil 2. Tutkal, farklı tip doğal suntadan TVOC ve kaplama sunta (TVOC from natural chipboard and veneered chipboard with different type of glue)

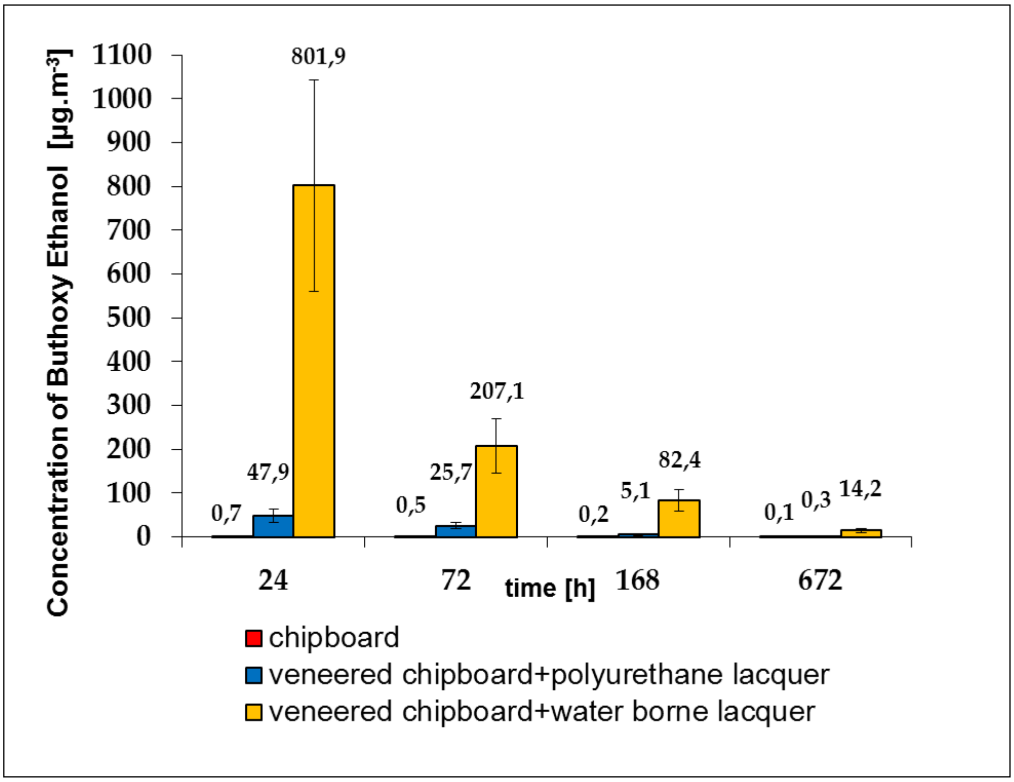
Fig.2 presents data of TVOC (Total Volatile Organic Compounds) from different types of materials (natural or veneered chipboard). The highest amount of TVOC emitted by veneered chipboard wit urea formaldehyde glue, especially then at measurements after 24 hours.

3.2. Kaplama sunta VOC Emisyonlarının Karşılaştırılması lake farklı türüne göre bitmiş (Comparison of VOC emissions from veneered chipboard finished by different type of lacquer)



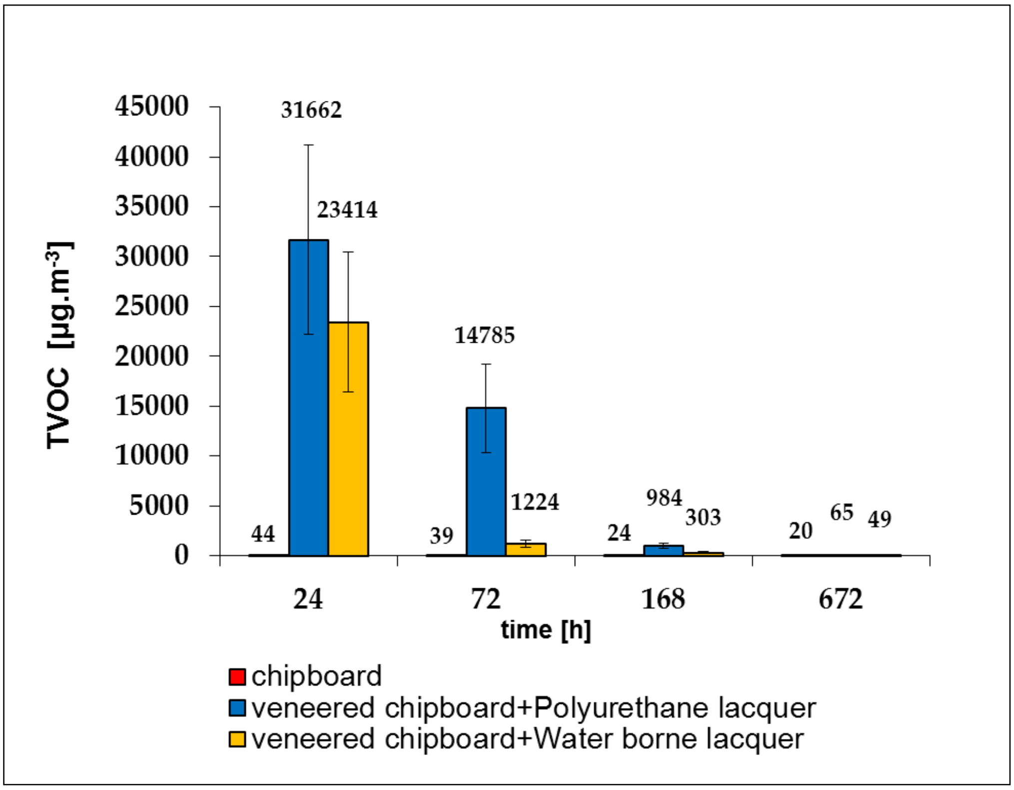
Şekil 3. Doğal sunta ve plakalanmış suntadan Butil asetat vernik farklı tip bitmiş (Butyl acetate from natural chipboard and veneered chipboard finished by different type of lacquer)

On the Fig. 3 there is presenting the influence of various kinds of testing materials on content of emissions VOC, especially of emissions of Butyl acetate, from natural chipboard and veneered chipboard finished by various kind of lacquer. The highest concentration of Butyl acetate was found at measurements after 24 hours from veneered chipboard finished by polyurethane lacquer in amount over 1 554 $\mu g.m^{-3}$.



Şekil 4. Lake farklı tip bitmiş doğal sunta ve plakalanmış suntadan butoksi-etanol (Buthoxy-ethanol from natural chipboard and veneered chipboard finished by different type of lacquer)

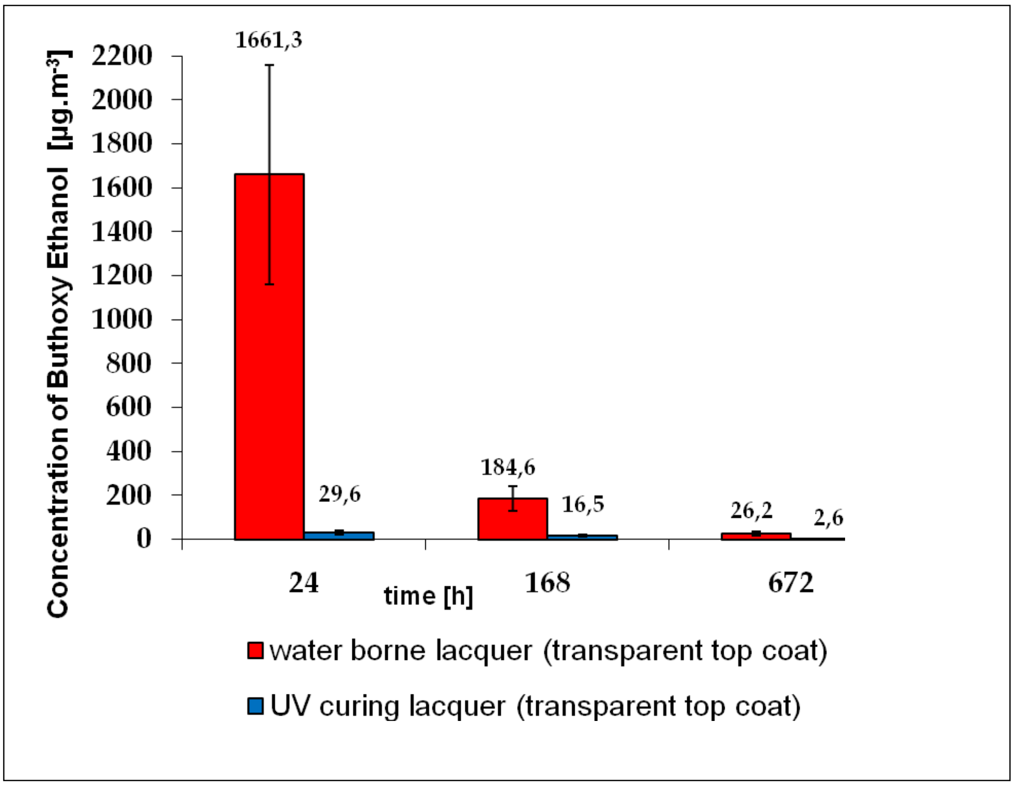
Fig. 4 shows the influence of various kinds of testing materials on content of emissions VOC, especially of emissions of Buthoxy Ethanol, from natural chipboard and veneered chipboard finished by various kind of lacquer. The highest concentration of Buthoxy Ethanol was found at measurements after 24 hours from veneered chipboard finished by water borne lacquer in amount over 801 $\mu g.m^{-3}$.



Şekil 5. Doğal Sunta ve kaplamalı sunta TVOC lake farklı türüne göre bitmiş (TVOC from natural chipboard and veneered chipboard finished by different type of lacquer)

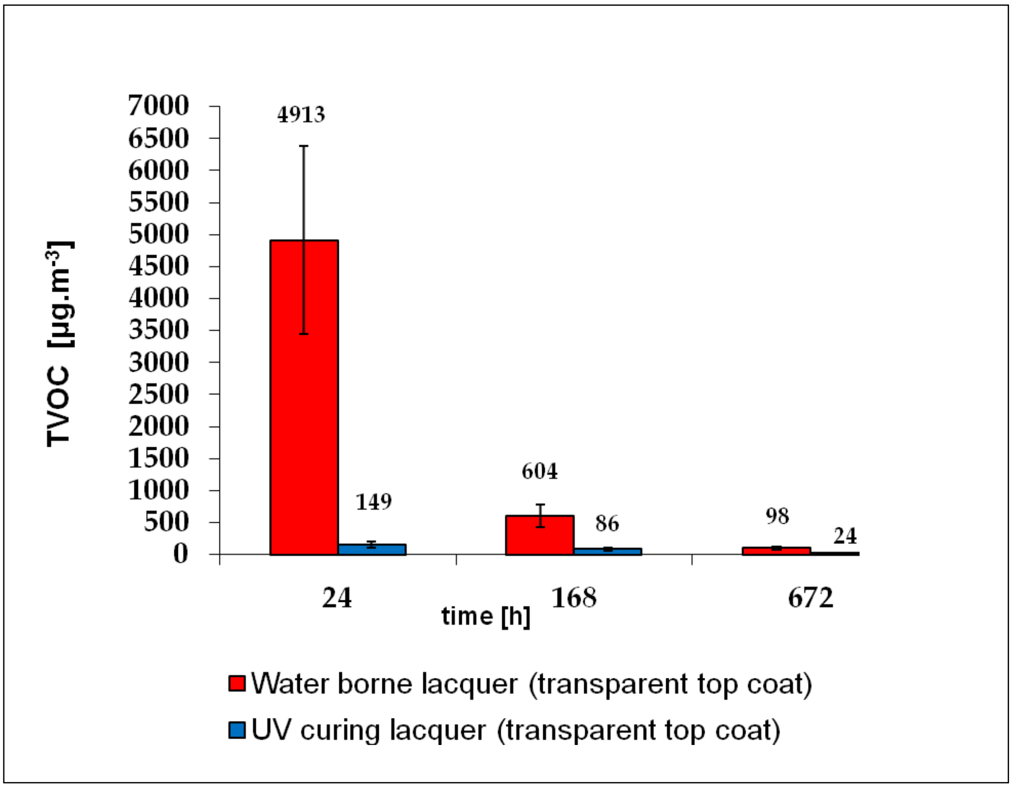
On the Fig. 5 we can see the influence of various kinds of testing materials on an amount of parameter TVOC emitted by natural chipboard and veneered chipboard finished by different type of lacquer. The highest values of TVOC were measured at measurements after 24 hours from veneered chipboard finished by polyurethane lacquer in amount 31 662μg.m^{-3}, followed by values of concentrations TVOC emitted by veneered chipboard finished by water borne lacquer (in amount 23 414 μg.m^{-3}).

3.3. Lake çeşitli tür VOC emisyonları karşılaştırılması inert malzeme üzerine uygulanan - cam levha (Comparison of VOC emissions from various kind of lacquer applied on inert material - sheet glass)



Şekil 6. Su esaslı lak etanol butoksi ve bir UV kürleme lake - Reaksiyonları Fiziksel ve kimyasal Kür (Buthoxy-ethanol from water borne lacquer-curing physical and chemical reactions) and UV curing lacquer)

Fig.6 shows the influence of method of curing painting films applied on inert material (sheet glass) on content of VOC emissions, especially emissions of Buthoxy ethanol emitted by different type of transparent lacquer. The highest concentration of Buthoxy Ethanol was found at measurements after 24 hours from water borne lacquer curing physical and chemical reactions, while the concentration of Buthoxy ethanol was determined in amount over 1 661$\mu g.m^{-3}$.



Şekil 7. Su bazlı lake TVOC ve bir UV kürleme lake (Reaksiyonları Fiziksel ve kimyasal Kür) (TVOC from water borne lacquer (curing physical and chemical reactions) and UV curing lacquer)

Fig.7 presents data of parameter TVOC, emitted by different type of lacquer. Parameter of TVOC is describing the total content of Volatile Organic Compounds emitted by selected species of lacquer in depends on the way of curing paintings films. The highest values of TVOC were measured at measurements after 24 hours from water borne lacquer in amount 4 913 $\mu g.m^{-3}$, followed by values of concentrations TVOC emitted by UV curing lacquer (in amount 149 $\mu g.m^{-3}$).

4. TARTIŞMA VE SONUÇ (DISCUSSION AND CONCULUSION)

4.1. TARTIŞMA (DISCUSSION)

Based on the results listed in this paper we can assess the load of emissions VOC emitted by individual tested materials.

a) Comparison of VOC emissions from natural chipboard and veneered chipboard with different type of glue

Results of VOC emission measurements are shown in Fig. 1 which show the impact of various kind of tested materials (natural chipboard and veneered chipboard with different of glue) on the amount of emitted volatile organic compounds, particularly aldehydes – namely Hexanal, in depends on time (during one month). The presented results reveal a dependence of the emitted Hexanal concentrations on the kind of tested material. The concentration of emitted compounds decreases in depends on time. The highest concentration was measured at measurements after 24 hours from veneered chipboard with urea formaldehyde adhesive, in amount over 9 $\mu g.m^{-3}$.

The measured data reveal a minimum impact of different tested materials on concentration of BTEX and terpenoid substances. Concentration of the said VOC was very low, which means that their amount was below the level of quantification (LOQ).

The values of the so-called total volatile organic compounds (TVOC) are among the key monitored parameters. TVOC represent the total amount of VOC emitted from individual tested materials. Figure 2 demonstrates the impact of different tested materials on the total amount of emitted VOC in relation on time of measured. The highest values of TVOC were measured at measurements after 24 hours from veneered chipboard with urea formaldehyde glue in amount 105 $\mu g.m^{-3}$, followed by values of concentrations TVOC emitted by veneered chipboard with polyvinyl acetate glue (in amount 85 $\mu g.m^{-3}$) and natural chipboard in amount 44 $\mu g.m^{-3}$.

b) Comparison of VOC emissions from veneered chipboard finished by different type of lacquer

Based on the conducted measurements of comparison of VOC emissions from veneered chipboard finished by different kind of lacquer, it can be stated that dependence between different type of lacquer on amounts of individual representative of VOC substances (Butyl acetate and Buthoxy ethanol) was established. In both cases the concentrations of monitored substances were highest at measurements after 24 hours.

These monitored substances were not chosen by chance, because Butyl acetate (Fig. 3) is a typical compound for polyurethane lacquer compared to Buthoxy ethanol (typical chemical for water borne lacquer). The highest concentrations of Butyl acetate was found from veneered chipboard finished by polyurethane lacquer (in amount over 1 554 $\mu g.m^{-3}$), while the highest value of concentrations of Buthoxy ethanol concentration was emitted by veneered chipboard finished by water borne lacquer in an amount over 801 $\mu g.m^{-3}$.

The total amount of emitted VOC (Fig.5), or the TVOC parameter, is dependent on a type of lacquer, which is illustrated by the fact, that the highest value of TVOC was found from veneered chipboard finished by polyurethane lacquer in amount 31 662 $\mu g.m^{-3}$, while veneered chipboard finished by water borne lacquer emitted parameter TVOC only in amount 23 414 $\mu g.m^{-3}$ (in both causes at measurements after 24 hours).

c) Comparison of VOC emissions from various kind of lacquer applied on inert material (sheet glass)

This part of the experimental part of the thesis was focused on comparison of VOC emissions from different type of lacquer depending on the method of curing coating films applied on inert material (sheet glass).

Based on the conducted measurements of comparison VOC emissions from transparent top of tested lacquers, it can be stated, dependence of concentrations of the monitored representatives of VOC substances (especially Buthoxy ethanol) on the method curing of coating films.

The concentration of emitted Buthoxy ethanol (Fig. 7) decreases in depends on time. The highest concentration was measured at measurements after 24 hours from water borne lacquer in amount over 1661 $\mu g.m^{-3}$, while the highest value of concentration Buthoxy ethanol emitted by UV curing lacquer, was found in amount only around 30 $\mu g.m^{-3}$. We explain this phenomenon by different method of curing tested transparent top coats. Water borne lacquer curing by physical and chemical reactions (the curing process takes longer), while curing process of UV curing lacquers is carried out by UV radiation (UV curing tunnel FUSION) and it is completed after a few minutes.

With respect to total emission load, or the TVOC parameter, dependence of TVOC concentration on different method of curing coating films was established. The highest values of TVOC were measured at measurements after 24 hours from coating films of water borne lacquer in amount 4 913 $\mu g.m^{-3}$, followed by values of concentrations TVOC emitted by coating films of UV curing lacquer (in amount 149 $\mu g.m^{-3}$).

4.2. SONUÇ (CONCULUSION)

The primary aim of this paper was to determine the impact of different type of materials used on furniture production on amount VOC emissions.
Based on the obtained measurement results it can be stated that concentrations of VOC emissions from individual tested materials are influenced not only by type of carrier material (inert material for example sheet glass or wood base materials), type of glue used for veneering of furniture parts and also different method curing of coating films.

Based on the results obtained in the experimental part of this paper we can conclude the following:

1. **The influence used different type of carrier material** (comparison of VOC emissions from natural chipboard and veneered chipboard with different type of glue)

   The presented results reveal a dependence of the emitted Hexanal concentrations on the type of tested material. The concentration of emitted compounds decreases in depends on time.

2. **The influence used different type of lacquer**
   (comparison of VOC emissions from veneered chipboard finished by different type of lacquer)

   Based on the conducted measurements of comparison of VOC emissions from veneered chipboard finished by different kind of lacquer, it can be stated that dependence between different type of lacquer on amounts of individual representative of VOC substances (Butyl acetate and Buthoxy ethanol) was established. In both cases the concentrations of monitored substances were highest at measurements after 24 hours. These monitored substances were not chosen by chance, because Butyl acetate is a typical compound for polyurethane lacquer compared to Buthoxy ethanol (typical chemical for water borne lacquer).

3. **The influence used lacquers depending on method curing**
(comparison of VOC emissions from lacquers depending on method of curing coatings films applied on inert material)

Based on the conducted measurements of comparison VOC emissions from transparent top of tested lacquers, it can be stated, dependence of concentrations of the monitored representatives of VOC substances (especially Buthoxy ethanol) on the method curing of coating films. The concentration of emitted Buthoxy ethanol (Fig. 7) decreases in depends on time. The concentration of emitted Buthoxy ethanol (Fig. 7) decreases in depends on time.

Water borne lacquer emitted high concentrations of Buthoxy ethanol (over 1661 $\mu g.m^{-3}$), while measured value of Buthoxy ethanol from UV curing lacquer, was found in amount around 30 $\mu g.m^{-3}$. We explain this phenomenon by different method of curing tested transparent top coats. Water borne lacquer curing by physical and chemical reactions (the curing process takes longer), while curing process of UV curing lacquers is carried out by UV radiation (UV curing tunnel FUSION) and it is completed after a few minutes.

5. TEŞEKKÜR (ACKNOWLEDGEMENTS)

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