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F.1

INFLUENCE OF MELAMINE FORMALDEHYDE ADDITION INTO THE UREA FORMALDEHYDE ADHESIVE ON SOME PROPERTIES OF PARTICLEBOARD

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Abstract

In this study, influence of melamine formaldehyde addition into the urea formaldehyde adhesive on some physical (thickness swelling) and mechanical (static bending, modulus of elasticity and internal bond) properties of particleboard was investigated. Melamine formaldehyde addition did not affect the mechanical properties, statistically. However, this application improved the thickness swelling of particleboard. The particleboards produced with 30% melamine formaldehyde and 70% urea formaldehyde usage had the required levels of physical and mechanical properties by the standards. This study showed that melamine formaldehyde addition into the urea formaldehyde should not exceed 30%.

Keywords: Particleboard, Melamine-formaldehyde, Urea-formaldehyde, Physical properties, Mechanical properties.

1. INTRODUCTION

Particleboard is a panel material manufactured under pressure, essentially from particles of wood and / or other ligno–cellulosic fibrous materials (for example wood chips, sawdust and flax shaves). In the past years we have seen the successful developments in the forest products industry especially on products generally referred to as particleboards. Much of this success can be attributed to the decided economic advantage of low cost wood raw material and inexpensive processing with binders.

Amino resins are an important class of industrial chemicals, which find application in many industries as well as wood based panel manufacture. The principal types of amino resins used, as cross-linking agents are urea formaldehyde and melamine formaldehyde resins (BARRETT 1993).

Urea formaldehyde (UF) resins are the most important and most used class of amino resin adhesives in particleboard industry. The advantages of UF adhesives are their initial water solubility, hardness, non flammability, good thermal properties, absence of color in cured polymers, and easy adaptability to a variety of curing conditions (PIZZI 1983; MALONEY 1977; KOLLMANN 1966).

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Melamine formaldehyde and melamine-urea formaldehyde adhesives are among the most used adhesives for exterior and semi exterior wood panels and for the preparation and bonding of both low and high pressure paper laminates and overlays (NEMLI 2000).

HSE and HE (1990) stated that melamine modified urea formaldehyde adhesives had good performance as flake board binders. GRAVES (1993) reported that internal bond strength and formaldehyde emission from panels made with melamine modified urea formaldehyde adhesive were equal to those made with the urea formaldehyde adhesive. RAMMON (1997) found that internal bond strength of the panels made with melamine modified urea formaldehyde adhesive was equal to that of the panels made with urea formaldehyde. The particleboard bonded with the melamine modified urea formaldehyde adhesive showed significantly lower thickness swell values than those bonded with the control urea formaldehyde (OH 1999).

In this study, the influence of the melamine formaldehyde addition into the urea formaldehyde adhesive on some properties of particleboard was investigated. Evaluated properties were thickness swelling, static bending strength, modulus of elasticity and internal bond strength.

2. MATERIALS AND METHODS

Particles used in this study were obtained from a particleboard factory in Turkey. They consist of pine (40%), beech (50%) and poplar (10%).

A hacker was used to initially break the raw material down, and then a Pallman was used to reduce the hacker chips to particles. After these processes, particles were dried with a laboratory made hot air dryer to 3% moisture content. Before blending, wood particles were screened by a screening machine through screen with 3 mm, 1.5 mm and 0.8 mm apertures to remove oversize and undersize, and separate the core and surface layer particles. For the blending, urea formaldehyde adhesive of E_1 grade + melamine formaldehyde which were 9% and 11% of the oven dry weight of core and surface layers particles, respectively, were used in the production of particleboards. As a hardener, 25% of ammonium chloride solution which was 1% of the oven dry weight of resin, were used in the production of particleboards.

The mat composition was three-layer and formed by hand distribution after adhesive application in blender. The shelling ratio (face: core) was 40:60%. The boards were pressed by the single daylight press under 27.5 kg cm^{-2} pressure, at 150 °C press temperature for 5 minutes. The dimensions of particleboards were 56.5 x 56.5 x 2 cm. After pressing, particleboards were conditioned at a temperature of 20 °C and 65% relative humidity, edge trimmed to 55 x 55 cm. Three panels were made for each group. The target density was 0.65 g cm^{-3}. In the production of particleboards, melamine formaldehyde (solid content: 55%) was added into the urea formaldehyde adhesive (solid content: 55%) based on 5%, 10%, 20%, 30%, 40% and 50%. Table 1 shows the experimental design of the study.

Thickness swelling (in 2 h. immersion) (TS), static bending strength (SB), modulus of elasticity (MOE), and internal bond strength (IB) were conducted according to the DIN 68761(1982), EN 310 (1993), and EN 319 (1993) standards, respectively. All samples were conditioned to equilibrium at a temperature of 20 °C and 65% relative humidity. Thirty samples were used for the each test. ANOVA and Tukey tests were used to compare the results of each group.

Table 1: The Experimental Design of The Study
Tablo 1: Araştırmanın Deneysel Planı

Board Type Levha Tipi	Melamine Formaldehyde Addition (%) Melamin Formaldehit İlavesi (%)
1	5
2	10
3	20
4	30
5	40
6	50
7	0

3. RESULTS AND DISCUSSION

The physical and mechanical properties of particleboard and the results of the statistical analysis are given in Table 2.

Table 2: The Physical and Mechanical Properties of Particleboard and the Results of Statistical Analysis ($p<0.05$)
Tablo 2: Levhaların Fiziksel ve Mekanik Özellikleri ile İstatistik Analiz Sonuçları ($p<0.05$)

Board Type Levha Tipi	SB (N mm^{-2}) Eğilme direnci (N mm^{-2})	MOE (N mm^{-2}) Elastikiyet modülü (N mm^{-2})	IB (N mm^{-2}) Y.Dik Çekme Direnci (N mm^{-2})	TS (%) Kalınlığına Şişme (%)
1	13.47 a*	1609.12 a*	0.36 a*	9.75 a*
2	13.34 a	1605.77 a	0.35 a	8.61 b
3	13.20 a	1602.24 a	0.35 a	8.04 c
4	13.18 a	1600.71 a	0.35 a	7.16 d
5	12.98 a	1599.70 a	0.34 a	6.34 e
6	12.90 a	1588.43 a	0.34 a	5.13 f
7	13.59 a	1618.96 a	0.36 a	9.98 a

* Note: Different letters represent statistical differences at a 95% confidence level.

Static bending strength results ranged from 12.90 to 13.59 N mm $^{-2}$. The static bending requirement for general-purpose boards including furniture is 13.0 N mm^{-2} by EN 312-3 (1996). Except for board types 5 and 6, all boards had higher static bending than the general-purpose requirement including furniture.

The range of result in the modulus of elasticity was from 1588.43 to 1618.96 N mm^{-2}. The modulus of elasticity requirement is 1600.0 N mm^{-2} for general-purpose boards. Board types 1-4 and 7 had the required level of modulus of elasticity.

Internal bond strengths ranged from 0.34 to 0.36 N mm^{-2}. The minimal requirement of internal bond for general-purpose boards including furniture is 0.35 N mm^{-2}. Except for board types 5 and 6, all boards were higher than the requirement for general purpose.

The maximum thickness swelling (2 h) requirement by DIN 68761(1982) is 8%. Board types 4-6 had the required level of thickness swelling. The thickness swellings of the other boards were poor (i.e. high).

Tests showed that melamine formaldehyde addition into the urea formaldehyde adhesive did not affect the mechanical properties of particleboard, significantly. This may be explained that melamine can be incorporated into urea formaldehyde adhesive due to similarity of the molecular structure, such as amino group, between melamine and urea.

According to the variance analysis, melamine formaldehyde addition by about 5% did not change the thickness swelling, statistically. However, increasing melamine formaldehyde addition from 5% to 50% decreased the thickness swelling with a 95% confidence level. This is due to insoluble property of melamine in water. In addition, the aminomethylene linkage in the urea formaldehyde is susceptible to hydrolysis and therefore is not stable at higher relative humidity. Water also causes degradation of the urea formaldehyde adhesive. Effect of melamine formaldehyde addition on the thickness swelling of particleboard is showed in Figure 1.

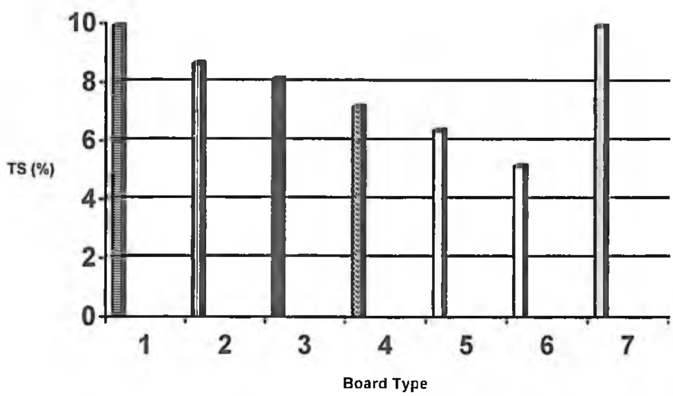

Figure 1: Effect of melamine formaldehyde addition on thickness swelling (TS) of particleboard.
Şekil 1: Kalınlığına şişme üzerine melamin formaldehit ilavesinin etkisi

Urea formaldehyde adhesive is a major commercial adhesive, especially for the forest products industry. The use of urea formaldehyde adhesive as a major adhesive by the forest products industry is due to a number of advantages, including low cost, ease of use under a wide variety of curing conditions, low cure temperatures e.g. The major disadvantage associated with urea formaldehyde adhesives as compared with other thermosetting wood adhesives are the lack of resistance to moist conditions and high degree water solubility. These properties lead to higher thickness swelling values of particleboard. For this reason, urea formaldehyde resins are usually used for the manufacture of products intended for interior use only.

This study showed that maximum 30% melamine formaldehyde can be added to the urea formaldehyde adhesive for decreasing the thickness swelling of particleboard. Exceeding of melamine formaldehyde addition by about 30% caused a decrease on the mechanical properties. Particleboards including more than 30% melamine formaldehyde adhesive had lower mechanical properties than those of the requirements for general purpose by EN standards. Particleboards made from melamine formaldehyde (30%) and urea formaldehyde (70%) usage had the required levels of physical and mechanical properties for general purpose. In this study, it was stated that melamine formaldehyde addition into the urea formaldehyde adhesive should not exceed maximum 30%.

The incorporation of melamine formaldehyde improved the low resistance of urea formaldehyde bonds to the influence of water. Additionally, the costs for these fortified products are not comparable because of the much price of melamine compared with urea.

In future, co-condensation with other monomers and with other adhesives will become more important, in order to combine their individual properties and advantages with the low price of the urea formaldehyde adhesive.

ÜRE FORMALDEHİT TUTKALINA MELAMİN FORMALDEHİT İLAVESİNİN YONGA LEVHANIN BAZI ÖZELLİKLERİ ÜZERİNE ETKİLERİ

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Kısa Özet

Bu çalışmada üre formaldehit tutkalına melamin formaldehit ilavesinin yonga levhanın fiziksel (kalınlığına şişme oranı) ve mekanik (eğilme direnci, elastikiyet modülü ve yüzeye dik çekme direnci) özellikleri üzerine etkisi incelenmiştir. Melamin formaldehit ilavesi mekanik özellikleri istatistiki anlamda etkilememiştir. Bununla birlikte, bu uygulama yonga levhanın kalınlığına şişme oranını azaltmıştır. %30 melamin formaldehit ve %70 üre formaldehit kullanılarak üretilen yonga levhalar standartlarda öngörülen fiziksel ve mekanik özellik değerlerini karşılamışlardır. Bu çalışma; üre formaldehit tutkalına melamin formaldehit ilavesinin % 30'u aşmaması gerektiğini göstermiştir.

Anahtar Kelimeler: **Yongalevha, Melamin Formaldehit, Üre formaldehit, Fiziksel Özellikler, Mekanik Özellikler**

ÖZET

Üre formaldehit reçineleri yongalevha endüstrisinde en çok kullanılan ve en önemli yapıştırıcılardır. Çünkü Üre formaldehit reçineleri ucuz, düşük sıcaklıklarda ve kısa sürede sertleşebilmekte, renksiz ya da açık renklidir (PIZZI 1983; MALONEY 1977; KOLLMANN; 1966).

HSE ve HE (1990) melaminle modifiye edilmiş Üre formaldehit reçinesinin etiket yongalı levhalarda çok iyi performans gösterdiğini belirtmektedir. GRAVES (1993) melaminle modifiye edilmiş Üre formaldehit reçinesi ile üretilen levhaların yüzeye dik çekme direnci ve formaldehit emisyonu bakımından yalnız Üre formaldehitle üretilen levhalarla eşit özellikler gösterdiğini belirtmektedir. Benzer sonuçları RAMMON (1997) tespit etmiştir. Melaminle modifiye edilmiş Üre formaldehit reçinesi ile üretilen levhalar Üre formaldehitle üretilen levhalarlardan kalınlığına şişme bakımından daha düşük değerler göstermiştir (OH 1999).

Bu çalışmada, Üre formaldehit reçinesine Melamin formaldehit ilavesinin yongalevhanın bazı özellikleri üzerine etkisi araştırılmıştır.

Araştırmada kullanılan yongalar çam (% 40), kayın (% 50) ve kavak (% 10)'tan elde edilmiştir. Yongalar %3 rutubete kadar kurutulduktan sonra, elenerek çok kaba yongalar ile tozlar uzaklaştırılmış ayrıca yüzey ve orta tabaka yongaları ayrıştırılmıştır. Bunun için 3 mm, 1.5 mm ve 0.8 mm elek açıklıkları olan üç katlı bir sarsak elek kullanılmıştır.

Yapıştırıcı olarak yüzey tabaka yongaları için kuru yonga ağırlığının % 11'i, orta tabaka yongaları için ise % 9'u olacak şekilde Üre formaldehit+melamin formaldehit kullanılmıştır. Üretilen levha tiplerinde Üre formaldehit reçinesine katılan Melamin formaldehit oranları Tablo 1'de verilmiştir. Sertleştirici olarak % 25'lik Amonyum klörür çözeltisinden katı tutkal ağırlığının % 1'i kadar kullanılmıştır.

Tablo 1:Araştırmanın Deneysel Planı

Levha Tipi	Melamin Formaldehit İlavesi (%)
1	5
2	10
3	20
4	30
5	40
6	50
7	0

Taslak, yüzey tabaka yongaları toplam ağırlığın % 40'ını, orta tabaka yongaları ise % 60'ını teşkil edecek şeklilde 56.5 x 56.5 x 2 cm. boyutlarında oluşturulmuştur. Taslaklar tek katlı hidrolik sıcak preste 2.75 N mm^{-2} basınç, 150 °C sıcaklık altında 5 dakika sure ile preslenmiştir. Her bir levha grubundan 3 adet üretilmiştir.

Üretilen levhalardan kalınlığına şişme, eğilme direnci ve elastikiyet modülü ile yüzeye dik çekme direnci örnekleri hazırlanarak hava kurusu hale getirilmiştir. 2 saat suda bekleme sonucu kalınlığına şişme DIN 68761 (1982), eğilme direnci ve elastikiyet modülü EN 319 (1993) ve yüzeye dik çekme direnci EN 319 (1993) standardına göre test edilmiştir. Her bir deney için 30 örnek kullanılmıştır.

Levha gruplarına ait sonuçların karşılaştırılmasında basit varyans analizi kullanılmış (α=0.05), sonucun significant olması durumunda aritmetik ortalamalar Tukey testi ile karşılaştırılmıştır.

Levhaların fiziksel ve mekanik özellikleri ile istatistik analiz sonuçları Tablo 2'de topluca verilmiş bulunmaktadır.

Tablo 2: Levhaların Fiziksel ve Mekanik Özellikleri Ile Istatistik Analiz Sonuçları ($p<0.05$).

Levha Tipi	Eğilme direnci (N mm^{-2})	Elastikiyet modülü (N mm^{-2})	Y.Dik Çekme Direnci (N mm^{-2})	Kalınlığına Şişme (%)
1	13.47 a*	1609.12 a*	0.36 a*	9.75 a*
2	13.34 a	1605.77 a	0.35 a	8.61 b
3	13.20 a	1602.24 a	0.35 a	8.04 c
4	13.18 a	1600.71 a	0.35 a	7.16 d
5	12.98 a	1599.70 a	0.34 a	6.34 e
6	12.90 a	1588.43 a	0.34 a	5.13 f
7	13.59 a	1618.96 a	0.36 a	9.98 a

*) Aynı harf ile gösterilen gruplar arasında significant bir farklılık yoktur.

Tablo 2'ninn incelenmesinden görüldüğü gibi Üre formaldehit reçinesi içerisine Melamin formaldehit ilavesi arttıkça mekanik özelliklerde bir azalma olmakla birlikte, bu azalma istatistik bakımdan signifikant değildir. Mekanik özelliklerin tersine Melamin formaldehit ilavesi arttıkça kalınlığına şişme oranı iyileşmektedir. Çünkü melamin formaldehit suda çözünmemekte ve yüksek rutubete karşı daha stabil kalabilmektedir.

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