

## Effects of Hardener Type and Particles Size on Formaldehyde Emission Pollution

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**ABSTRACT**—Formaldehyde is a poisonous gas for human health but urea formaldehyde (UF) resins composes more than 90% of resins used in manufacturing of particleboard in the world and particleboard is used in houses largely. In this research ,homogenous particleboard with 0.7 gr/cm<sup>3</sup> manufactured by poplar chips (*Populus alba*) and urea formaldehyde resin .Variables included of hardener type and particles size, and other conditions were constant .Hardener used were Ammonium Chloride, Ammonium Sulfate and Magnesium Chloride, and amount of hardener used was 2% .Particles prepared by a hammer chipper divided to two groups, small and large chips. After particleboard manufacturing and conditioning ,their formaldehyde emission was determined . Formaldehyde emission was measured by WKI method ,using acetyl acetone and photometric method (revised standard EN 120) .According the results ,formaldehyde emission of particleboards made of Ammonium Chloride was less than particleboards made of Magnesium Chloride significantly, but formaldehyde emission of particleboards made of Ammonium Sulfate had no difference with formaldehyde emission of particleboards made of Ammonium Chloride .Particles size had no effect on formaldehyde emission of boards .

**Keywords:** Particleboard, Formaldehyde emission, Hardener, Particles size

### I. INTRODUCTION

Particleboard is used in manufacturing of wooden products in houses, schools, offices and etc. but particleboard and other wood based panels bonded by aminoplast resins emit formaldehyde during its manufacture as well as during its usage. The formaldehyde release is influenced by exogenous (e.g. air humidity, temperature, air change) and also endogenous factors (wood species, type of resins used, conditions of manufacture). Therefore we can reduce formaldehyde emission of wood based panels by changing the manufacture conditions that lead to changing the physical and mechanical properties of particleboards. Roffael et. al.(1975) found that under the same production conditions, the formaldehyde release from oak particleboards was definitely lower than that from pine particleboards (Roffael 1993).

### II. MATERIALS AND METHODS

In this research, particleboard manufactured with poplar wood (*Populus nigra*) and urea formaldehyde resin having

50% concentration. Hardeners used were Ammonium Chloride, Ammonium Sulfate and Magnesium Chloride, and amount of hardener used was 2%. Particles prepared by a drum chipper divided to two groups, small and large chips according table 1.

Table1- Size of chips used in particleboard manufacturing

	Length (mm)	Width (mm)	Thickness (mm)
Small	10.68	1.60	0.48
Large	24.54	6.46	0.7

For manufacturing particleboards, mat pressed in a hot press at 175 °c temperature and 30 Kg/cm<sup>3</sup> pressure. After 5 minutes particleboards produced having 10 mm thickness and 0.7 gr/cm<sup>3</sup> density.

The formaldehyde release from particleboard can be measured from small samples in the laboratory (laboratory methods) as well as from large industrial samples in test chambers under defined climatic conditions (chamber methods). In this study WKI method (Flask method) was used to determine the formaldehyde release from particleboard. The principle of the method is as follows : Test samples, of size 25mm\*25mm\*thickness, are sawn from the board and their moisture content is measured. Each lot of samples, weighting about 20g, is tied together with rubber bands and suspended over 50 ml of distilled water in a closed 500 ml polyethylene flask. The flask is allowed to stand at the required temperature (normally 40 °c) in an oven for 48 hours. The flask is then cooled in ice water for half an hour to ensure a complete absorption of the formaldehyde in the water inside the flask. The formaldehyde emitted is determined iodometrically or photometrically and calculated on oven dry basis of the board (Figure 1).

Also, water absorption, thickness swelling (according EN 310 standard) and internal bonding, MOE and MOR of particleboard samples (according EN 317 standard) were determined.

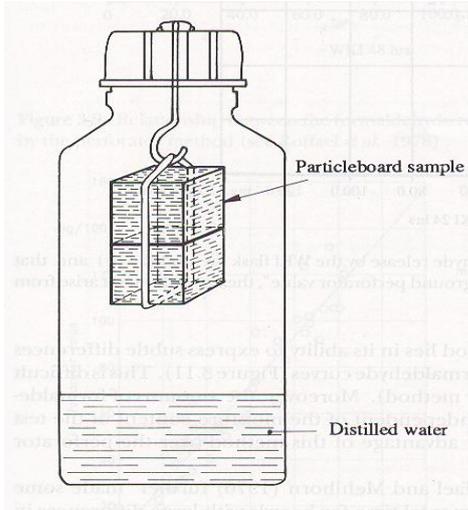


Figure 1-The WKI (Flask) method

### III. RESULTS AND DISCUSSIONS

#### Formaldehyde Emission

According to the results, hardener type had a significant effect on formaldehyde emission of particleboards. Minimum formaldehyde emission was measured in samples manufactured by ammonium chloride and maximum formaldehyde emission was observed in samples manufactured by magnesium chloride (Fig 2).

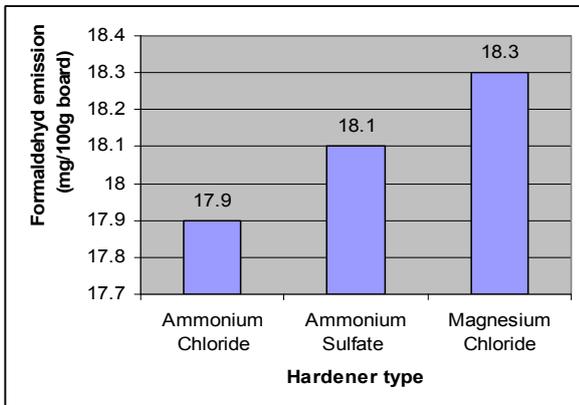


Figure 2-Effect of hardener type on formaldehyde emission

#### Physical Properties

##### Water Absorption 24 Hours

Hardener type had a significant effect on water absorption 24 hours too. Minimum water absorption 24 h belonged to particleboards manufactured by ammonium sulfate. Particleboards manufactured by magnesium chloride showed maximum water absorption 24 h (Fig 3).

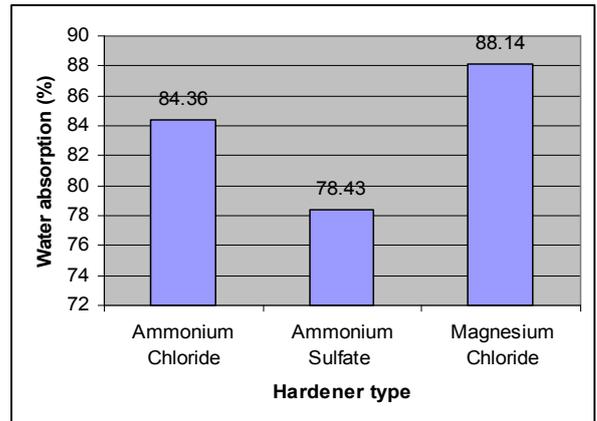


Figure 3-Effect of hardener type on water absorption 24 hours

##### Thickness Swelling 24 hours

This study showed that only particles size had a significant effect on thickness swelling 24 hours. Samples made of small chips showed more thickness swelling 24 hours than large chips (Fig 4).

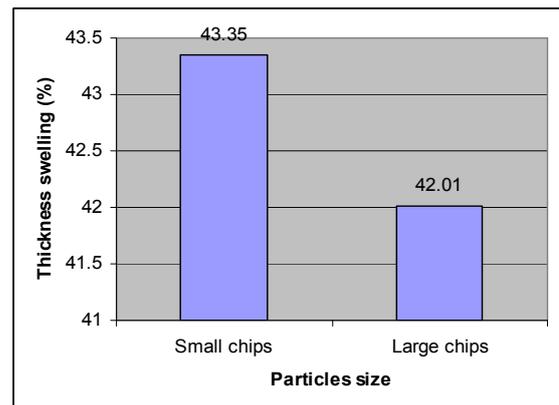


Figure 4-Effect of particles size on thickness swelling 24 hours

#### Mechanical Properties

##### Internal Bonding (IB)

According to the results, only particles size had a significant effect on IB. Hardener type had no significant effect on IB. Samples manufactured by small chips had higher IB than other samples (Fig 5).

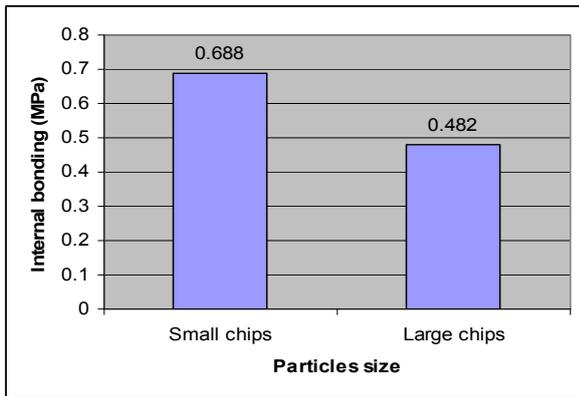


Figure 5-Effect of particles size on internal bonding

### Modulus of Elasticity (MOE)

Hardener type and particles size had significantly effects on MOE. Samples manufactured by magnesium Chloride showed the most MOE. Also particleboards made of large chips had the highest MOE (Fig 6-7).

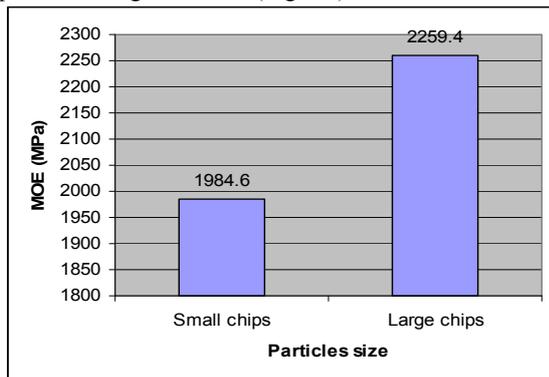


Figure 6-Effect of hardener type on MOE

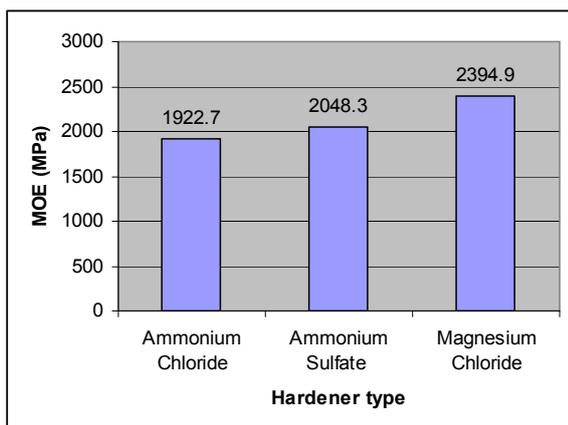


Figure 7-Effect of particles size on MOE

### Modulus of Rupture (MOR)

According the results, none of variables had no significantly effect on MOR.

### IV. CONCLUSIONS

Results of this study confirm that suitable hardener for manufacturing particleboard that having minimum formaldehyde emission is ammonium chloride and ammonium sulfate. Particleboard having the best physical properties was made of ammonium sulfate and small chips. Also Particleboard having the best mechanical properties was made of magnesium chloride hardener.

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