# Study The Effect of Urea – weight and Adhesion Promoter on Mechanical Properties 0f Urea – Melamine - Formaldehyde Resin

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## ABSTRACT

A study was made on preparation of urea – melamine – formaldehyde (UMF) resin by condensation polymerization technique to produce polymeric adhesive for wood –wood surface.

Different weight of urea are used in formulation of resin to achieve the best balance between cost and performance of melamine adhesive which have excellent water resistance, and all prepared samples exhibited high resistance to water.

The best results were obtained from the sample (UMF) in using urea (4.8) gm. For this sample different weight of resorcinol are used as reinforcement to prepare tricomponent bonding system (resorcinol, hexamethylenetetramine, and silica) as curing system of adhesive for wood – wood surfaces.

Mechanical properties test such as (Impact test, Compression test, and Bending test) was carried on. All results were discussed.

## INTRODUCTION

Adhesives based on amino resins can be simple reaction products of urea or melamine with formaldehyde, or can be complex formulated products that include curing agents, hardeners. Large- volume products such as urea – resins – based plywood and chipboard glues.

Melamine adhesives have excellent water resistance, whereas urea-formaldehyde adhesives are cheaper but more sensitive to water (1). So the main advantage of the melamine – urea copolymer is the low cost of urea compared with melamine which making the best balance between cost and performance (2).

Urea and melamine adhesives are simple reaction products of urea and/ or melamine with formaldehyde. They are set or cured by the use of hardeners, either acidic substance themselves, or they are capable of liberating acid when mixed with resins. Ammonium salts of strong acid are widely used as hardeners (3).

Additives are selected to be compatible with the material and the process conditions for shaping the material; the improvement of specific property of material by addition of an additive is usually at the expense of some other property.

To achieve the desired improvement in the specific property such as to enhance the mechanical properties of resin and strength adhesion, additives used as adhesion promoters (4). So in this work we try to prepare urea-melamine formaldehyde resin with using various weight percentages of urea and tricomponent system (Resorcinol, Hexamethylenetetramine, and Silica) as adhesion promoter to improve the mechanical and chemical properties.

## EXPERIMENTAL (5)

P- Formaldehyde (5.17gm) was mixed with (50ml) of water heated to 80 C$^o$ and its PH adjusted to 10 with NaOH solution (10N). After complete dissolution of P- formaldehyde, (3.78 gm) of melamine and different weight of urea were added as shown in table (1). The reaction mixture was heated at 80° C with continues stirring until it became clear, and its PH was lowered to 3.5 by rapid addition of $H_2SO_4$ (15N).

The solution was stirred continuously for 60 min. then its PH was raised to 9.0 by adding NaOH (6N) and kept at 80° C with continuous stirring for 40 min.. After cooling, the solution was readjusted to 20% solid content. The final product was treated with hexamethylenetetramine (HMTA) (1gm), or with adhesion-promoter [Resorcinol (various weight, 5, 10, and15 gm), HMTA (1gm), and Silica (3gm)] to obtain solid cured product..

## RESULTS AND DISCUSSION

### Chemistry of resin

Linear and crosslinked chains of melamine and urea formaldehyde are always formed by condensation reactions involving the N-Methylol groups.

In the formation of N, N-dimethylene bridges, an N-methylol group and an amino group are involved; in the formation of either linkages, two N-methylol groups are involved, and in the formation of methylene bridges by the elimination of water and formaldehyde, two N-methylol groups are involved. Therefore, the presence of N – methylol groups should increase the degree of polymerization and branching in all cases (6).

## Effect of Urea Weight on Preparation and Chemical Properties

Increasing the percentage of urea in the melamine mixture while maintaining all other reaction conditions constant causes a gradual decrease in water resistance of final product, and this due to differences between the chemistry of melamine formaldehyde resins (7).

- The three – $NH_2$ groups in melamine provide more possibilities for cross-linking, thus giving more complex 3-dimensional structure.
- The- $NH_2$ groups in melamine behave more like amide groups than the – $NH_2$ groups in urea, they are highly reactive and methylene bridges are readily formed even under basic condition.
- The methylol melamine is more resistant to dissociation into formaldehyde and melamine than their urea counterparts.

## Mechanical properties

### 1-Impact test

Charpy impact instrument was used for this test; the samples were prepared according to ((ISO - 179)) with fixed dimensions as in figure (1) and the test was carried out at 25°C.

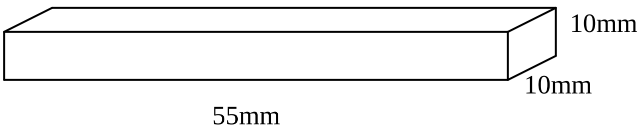



Fig. (1) Dimensions of sample used in impact test.

Impact strength is the measure of polymer's resistance to fracture under conditions of high – strain rates; the impact strength was calculated from following relation (8).

$$\text{Impact strength} = \frac{\text{Energy of fracture}}{\text{Cross sectional area}}$$

As shown from fig. (2) the value of impact strength increased with increasing the weight of urea in UMF resins and with increasing the weight of resorcinol in adhesive promoter as shown in fig. (5).

## Compressive strength

Compressive strength is the maximum stress that a rigid material will with stand under longitudinal compression. Compressive strength is measured as a force per unit area of initial cross – section, and is listed as Kg/ $mm^2$ (9).

$$\text{Compressive strength} = \frac{\text{Load}}{\text{Cross – sectional of sample before deformation}} \text{ (MPa)}$$

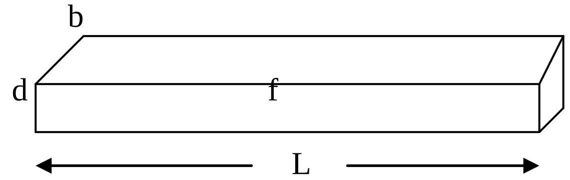
When resin matrix has high cross – link density the polymer become rigid and has a high value of compressive strength (10). In current work it was found that the higher value of compressive strength with increasing the weight of urea in resin and resorcinol in tricomponent system of adhesion promoter as shown in fig. (3) and (6).

## Bending Test

This test is used to determine the flexural properties of resins that were prepared in this work. The instrument type PHYWE was used to measure the deflection values of the resins at different loads ranging from 100 grams to 1000 grams. The relation between modulus (E) and Deflection (D) is as follow;

$$E = \frac{\text{Mass}}{D}\left(\frac{9.8\,L^3}{48\,I}\right)$$

Where L is the distance between the two loaded points and I is the geometric band moment which is equal to ($bd^3$ / 12), where (b) is the breadth and (d) is thickness of beam (11) .



From figures (5 and 7) it is shown that the optimum value of bending obtained in using (4.8 gm) of urea in UMF resin and (15 gm) of resorcinol in tricomponent system.

The differences in value of mechanical properties observed in the behavior of formulations containing varying weights of urea to melamine and formaldehyde, were also observed during the condensation, so the substitution of melamine by urea is expected to lead to resins that are effective super plasticizer, (2) in addition to that and raising the N- methylol groups which increase the degree of polymerization and branching, so that we attained to optimum value of mechanical properties in using (4.8) gm of urea.

The different weights of bonding system were used shows a variation in mechanical properties when increasing the weight of resorcinol and optimum value is obtained if (15) gm of resorcinol is used. More recently (12). great interest has been aroused in adding resorcinol as adherent property, which improve the adhesion strength. It was suggested that, the addition of silica along with additives result in some further increase in adhesion.

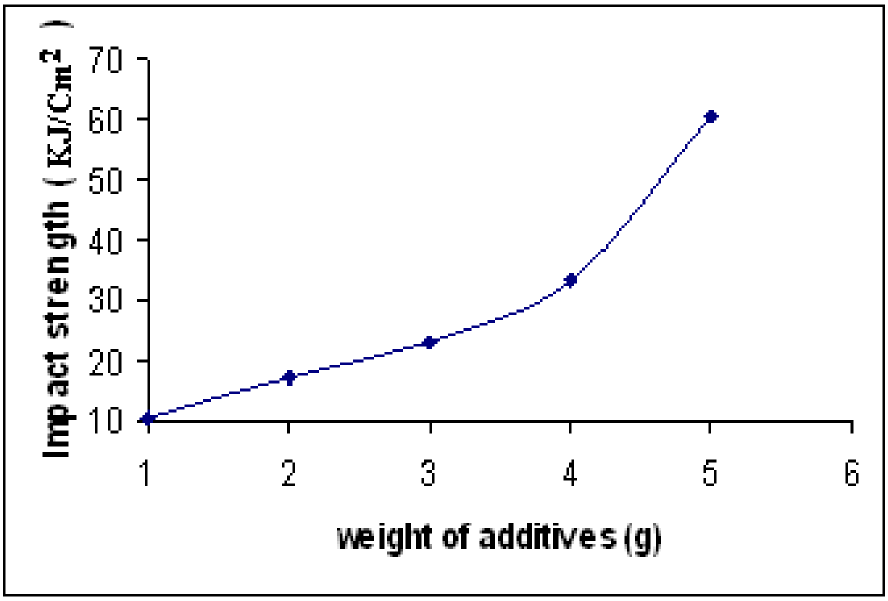
Table (1)
Formulation of (UMF) Resins with Curing Reagent
Melamine (3.78gm), Formaldehyde (5.78 gm), HMTA (1 gm)

| Sample No. | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Urea Weight | 2.4 | 3.0 | 3.6 | 4.2 | 4.8 |

Table (2)
Mechanical Properties of Samples

| Sample. (gm) | Impact Strength ($KJ/Cm^2$) | Compression Strength (MPa) | Bending Strength (mm) |
|---|---|---|---|
| U 2.4 | 10.5 | 0.8 | 5 |
| U 3 | 17.3 | 1.2 | 7.6 |
| U 3.6 | 23.1 | 2.7 | 9.1 |
| U 4.2 | 33.4 | 3.9 | 11.5 |
| U 4.8 | 60.7 | 5.1 | 15.1 |
| R 5 | 15 | 1.4 | 20 |
| R 10 | 23 | 2.5 | 25 |
| R 15 | 42 | 5.6 | 33 |

*U = Urea ** R = Resorcinol




Fig(1) Effect of urea additives on Impact strength of M.F

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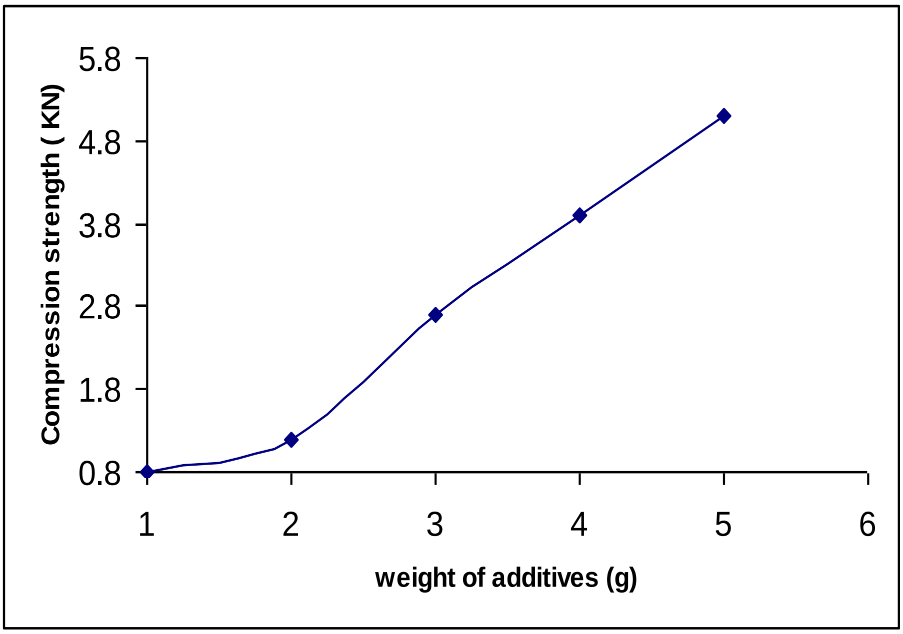
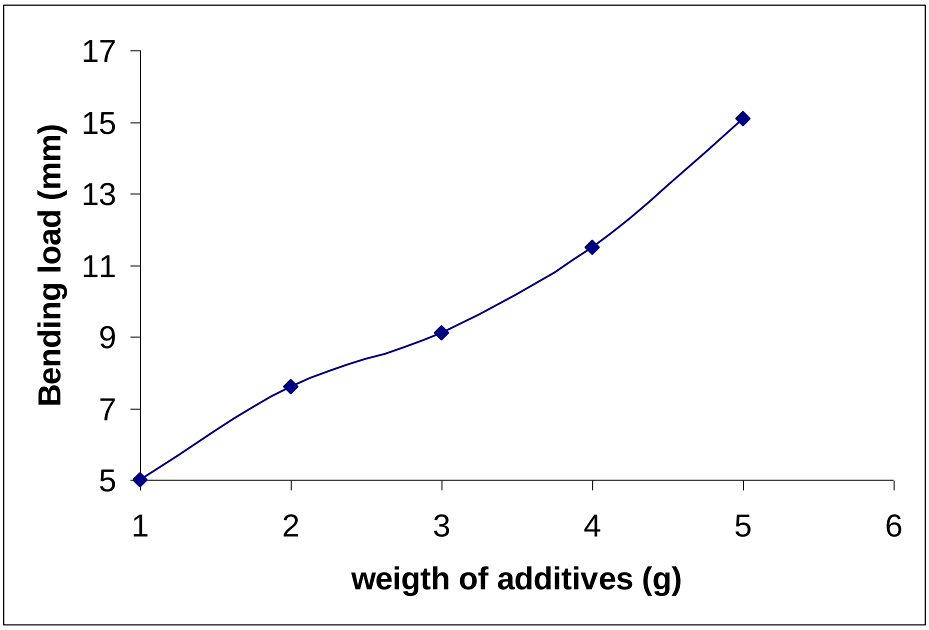
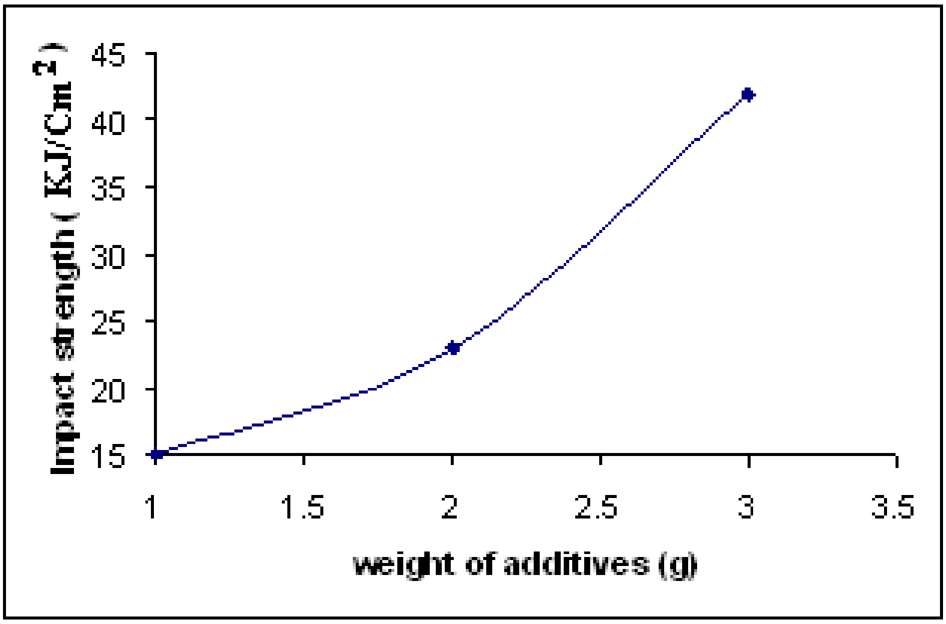


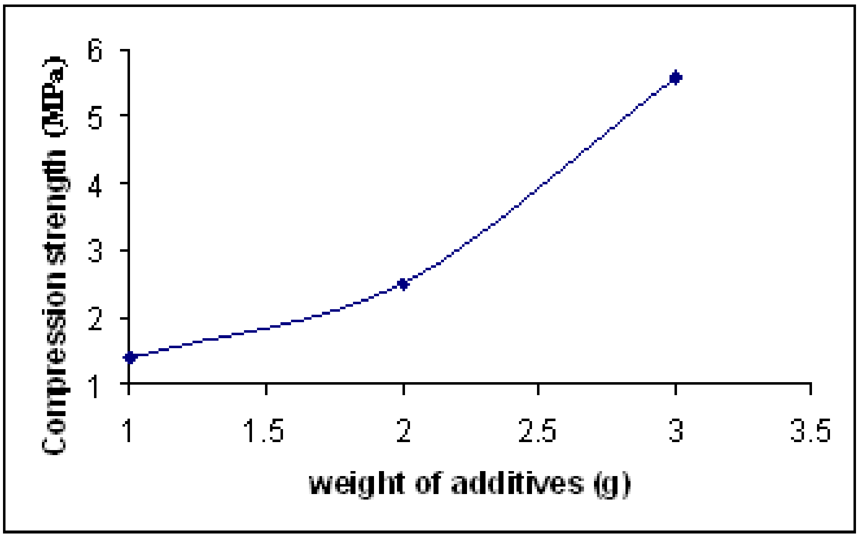

Fig(2) Effect of urea additives on compression strength of M.F



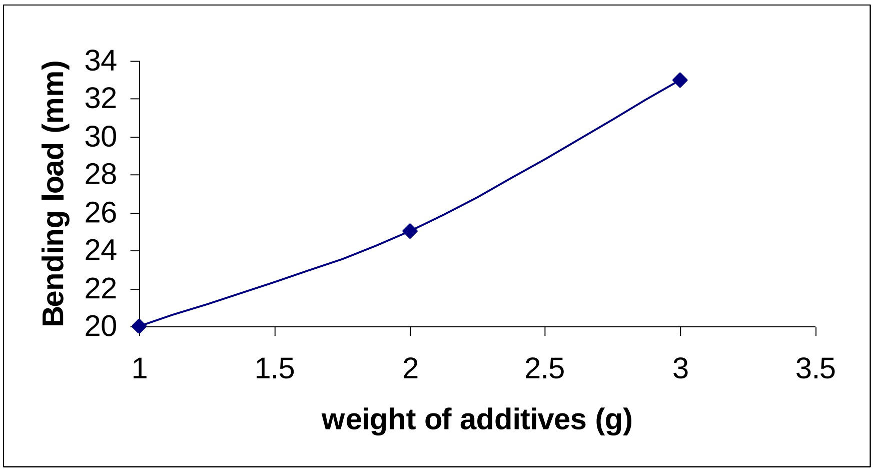

Fig(3) Effect of urea additives on bending load of M.F




Fig(4) Effect of Resorcinol additives on impact strength of U.M.F




Fig(5) Effect of Resorcinol additives on compression strength of U.M.F




Fig(6) Effect of Resorcinol additives on bending load of U.M.F

## دراسة تاثير وزن اليوريا ومعزز التلاصق على الخصائص الميكانيكية لراتنج يوريا- ميلامين – فورمالديهايد

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## الخلاصة

اجريت هذه الدراسة لتحضير راتنج يوريا ميلامين فورمالديهايد ( UMF ) باستخدام تقنية البلمرة التكثيفية لانتاج لاصق بولمري لسطح خشب - خشب . استخدم اوزان مختلفة من اليوريا في تركيب الراتنج المحضر لتحقيق افضل توازن بين التكاليف وكفائة لاصق الميلامين في مقاومته للماء حيث ان جميع النماذج المحضرة ابدت مقاومة عالية للماء . ان النتائج الافضل المستحصلة كانت للنموذج ( 5 ) باستعمال ( 4.8 ) غم من اليوريا .
ويم استخدام اوزان مختلفة من الريزور سينول مع النموذج المذكور كمادة تقوية لتحضير نماذج من النظام الثلاثي للترابط ( الريزور سينول ، الهكسامثلين تترامين ، السليكا ) والذي يصلح لتقسية اللاصق بين سطحين من الخشب .
تم اجراء اختبارات الخصائص الميكانيكية والتي تمثلت بالاختبارات الآتية (الصدمة ، الانضغاط و الانحناء) . كما نوقشت نتائج جميع الاختبارات.

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