Use of solid waste lignin in the reinforcement of UF-R system

Falak O. Abas
Head of solid waste department, Environmental Research Center, University of Technology
Raghad U. Abass
Assistant teacher /material engineering department/University of Technology
TarekH.M
Assistant teacher, Medicne Collage, University of Babylon

(NJC)

(Received on 4/2 /2006) (Accepted for publication on 19/ 8 /2006)

Abstract

Condensation polymerization at temperature 105ºC and PH range (7.5-8) was used for the reaction between urea and formaldehyde to produce polymeric adhesive.

Different mass ratio (12-30)g *RD/g UF of resorcinol are used as bonding catalyst (an adhesion promoter) for UF-lignin solid waste fibers system as curing binary system of adhesive for wood/wood laminate .

Mechanical properties such as impact strength, bending test have been measured .The result shows that all these properties are increased when percentage of bonding catalyst material is increased for adhesive-fiber system at different arrangement.

It was found that the improved sample **(R20c/UF) of resorcinol and woven roving arrangement for solid waste lignin which appear for both impact and bending test (11 J/cm , 0.7 mm) respectively .

*RD different resorcinol

**$R_{20\,c}$ sample (3) and woven roving, reinforcement

الخلاصة

تم استخدام البلمرة التكثيفية درجة الحرارة ١٠٥م ° و حامضيه (٧,٥-٨) وذلك لإتمام التفاعل بين اليوريا والفورمالديهايد وإنتاج اللاصق المعروف باليوريا فورمالديهايد.

تم استخدام نسب وزنية مختلفة لتدعيم اللصق وهو الريزورسينول (١٢-٣٠) غرام ورابط للاصق المحضر يوريا-فورمالديهايد مع نفايات الياف النخيل إضافة إلى عامل مساعد على عملية الإنضاج لنظام الملصق المتراكب لشرائح من الخشب فيما بينها.

ثم قياس الخواص الميكانيكية المهمة لتقيم نظام اللصق هذا بالخشب حسب تطبيقه (الأثاث) وهما قياس قوة الصدمة ومقاومة الانحناء وكانت نتائج الفحوصات الميكانيكية أعلاه لنظام اللصق المتراكب كالتالي:

تم تحسين الخواص الميكانيكية (مقاومة الانحناء وقوة الصدمة) بزيادة نسبة الإضافة لمدعم اللصق والإنضاج معا للنظام المتراكب للاصق fiber R-U-F وعند ترتيب مختلف لهذه الألياف وكانت أفضل نتائج لنسبة الخلط المحضرة R_{20}C-U-F للنظام المتراكب أما الترتيب الأقوى والأكبر متانة ومقاومة وانحناء هو

للترتيب المتشابك لهذه النفايات السليلوزية الخشبية والتي ظهرت جليا في كلا الفحصين كالتالي مقاومة الانحناء وقوة الصدمة على التوالي(٠,٧ ملم، ١١ جول/سم).

Introduction

Urea-formaldehyde resins with or without additives in the non-cross linked state or in the cross-linked state were used as Knobs ,handles ,bottle-caps table-ware , telephone sets , as increase-resistance of nylon and cotton fabric as cold-setting adhesives for wood , as additive to improve the wet strength of paper , as sizing resin ,as finishing agent for textile , in foam production in the mechanical treatment of cellulose , and as filler for high density polyethylene [1-3].

The first amino resin used commercially on textiles were the so-called Urea-formaldehyde resin , dimethylol urea , or its mixture with monomethylol urea , the amino resins react chemically with cellulose fibers to change their physical properties[4-7].

Industrial applications of various polymer mixes and continuous fibers have generated considerable work in the field of fracture toughness testing. Short fibers due to their random dispersion, account for the better resistance to fracture, the mechanics of such failures are also receiving the attention of researchers[4-7].

More recently, great interest has been aroused in adding resorcinol and Para-formaldehyde as adherent property which improve the adhesion strength. It was suggested that, the addition of silica along with additives result in some further increases in adhesion[8].

The stronger adhesives generally are those that are cross linked .They are applied as viscous liquid of high thickness, but they form network polymers by chemical reaction. According to bonding strength which measured by using tensile strength machine and the fact Kevlars aramide polyamide are more readily crystalline and oriented which provide strength and stiffness [9].

Some reinforcing materials are carbon, glass, mica, and aramide, these reinforcement's permits in plastics to be used at high temperatures and load with greater dimensional stability [10].

Other additives that are used with material as an adhesion promoter and have an effect on the adhesion [11] .

The aim of work:

Re-use of solid waste lignin by the use of cheep Iraqi commercial materials such as urea and formaldehyde , and improve the physical-mechanical properties such as impact and bending test for laminate sheets of wood which is used afterward in manufacturing of furniture as one of recycling method of solid waste biomass .

Experimental

Materials

1- Urea commercial (NH_2CONH_2), melting at 35ºC locally available .
2- Formaldehyde commercially type (37%) (CH_2O) of density 1-0.85 at 20ºC.
3- Resorcinol ($C_6H_4(OH)_2$) from Al-Kaakaa company, 99% melting at 111ºC ,and density 1.272 g/cm^3 .
4- Solid waste lignin from local Iraqi date palm, brown color, and different arrangement of fiber.

Procedure

1- preparation of urea-formaldehyde resins :
Formaldehyde (30 g), (20 g) of urea are charged with agitation in (1 L), three-necked flask equipped with a stirrer, reflux condenser and thermometer . The urea was dissolved while the

temperature of solution was maintained between 20 and 25ºC and the PH was adjusted with the range (7.5-8) using 5N formic acid and Sodium hydroxide. The reaction mixture was heated at refluxed , a maintaining the temperature between (90-100ºC) with a vigorous agitation until the reaction was completed for 2 hours .The sample was left to cool at room temperature before measurement PH and viscosity .The PH was controlled to be (7.5-8) and the viscosity was checked every (10 min) .

The final products (resin) was treated with hexamethylenetetramine (HMTA) (7 g) various mass ratio of adhesion-promoter resorcinol (12-30)g/urea formaldehyde to obtain solid cured product .

2- preparationof composite structures:

The steps in an ideal wood adhesion systems (flow, transfer, penetration, wetting, and hardening) have been developed by Marra [12].

during flow adhesive applied to the wood surface merges in to uniform wet film , two surfaces of wood laminate and different arrangement of solid waste lignin are brought together and pressurized (3-5) ton , when the adhesive transfers to both surfaces equally , then penetrates in to the wood and fiber surfaces establishing complete contact between the adhesive, wood and fiber surfaces . wetting occurs to some extent during all the previous steps , and the solid waste lignin are rich in CH_2OH and OH groups which are capable of forming ether linkages and hydrogen bonds with the polar groups of the adhesives as shown in figure (1) :

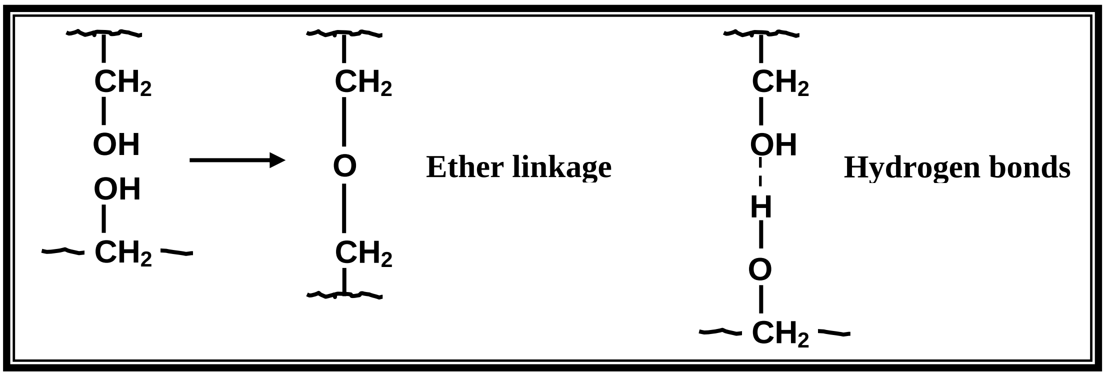

Figure (1)

Finally during hardening the adhesive film sets and develops cohesive strength and environmental resistance in the bond which curing at 150ºC for 1 hour to develop this cohesive strength [12].

3-determinationof physical-mechanical properties:

3-1 Impact test:

Charpy impact instrument was used for this test. And the samples were prepared according to (ISO-179) [13].

3-2 three point bending test:

Three point bending tester was used to determine the resistance to distortion. This test was carried out according to (ASTM-D-790) test [13].

3-3 Chemical resistance (Sweling degree):

This type of test was achieved by soaking all composite samples in both moisture (100% H_2O) and acidic solutions (10% H_2SO_4) for 7 days at 50 ºC to estimate the change in weight [12].

Results and Discussion

1- Preparation of urea formaldehyde resin:

1- The PH was adjusted in the range (7.5-8) by using 10% aqueous solution of sodium hydroxide.

2- The reaction temperature was kept between 90-100ºC.

3- To enhance the poly-condensation reaction in the final stages, the reaction continued under reduced pressure (0.013 atm).

2- preparation of composite structures :

1- The surface of wood laminate should be smooth and flat, wood adherents should be conditioned before bonding.

2- The type of the wood adhesive bond is largely depends on the viscosity and chemical nature of the adhesive, curing, condition and the preservative treatment given to the adherents.

3- physical-mechanical properties of composite structures :

3-1 impact test:

Figures (2, 3, and 4) shows the variation of mechanical properties with variation of binary system (RD/UF) composed with different arrangement of lignin solid waste.

from above results both adhesion promoter (RD) and lignin solid waste fibers are enhance the impact strength with preference for woven roving arrangement due to equally distribute of loading force on the sample .

and figure (5) shows the optimum selection of mass ratio additive of promoter adhesion material resorcinol (12-30)g where optimum additive mixing ratio is 20g R/UF , due to nature of resorcinol structure which is need high energy to break in an impact test [14].

3-2 three point bending test :

Figures (6, 7, 8) shows the different arrangement of lignin solid waste fibers at different mixing ratio of an adhesion promoter resorcinol (12-30) g.

Which proved that both lignin waste fibers and adhesion promoter resorcinol are enhanced the bending test and resistance to distortion with preference to woven roven arrangement due to resone indicated in the test above (impact test) [15, 16].

Figure (9) indicate that optimum selection of arrangement and additive of an adhesion promoter used (resorcinol) which indicate that the optimum arrangement is woven roven and the optimum mixing ratio of an adhesion promoter is 20 g R/g UF) .

3-3 Chemical resistance (Swelling degree):

All samples gave higher resistance to moisture and acidic solution (10% H_2SO_4) without change in weight

Conclusion:

1- All physical-mechanical properties of RD/UF system is enhanced by the use of lignin solid waste.

2- Re-use of solid waste lignin of date palm that be accumulated and cause an environmental pollution by deases and fires.
3- Reinforcement the in stability at high level of load which leads to the fracture mode of failure, in the case of brittle materials, which influence their capacity to resist crack propagation.

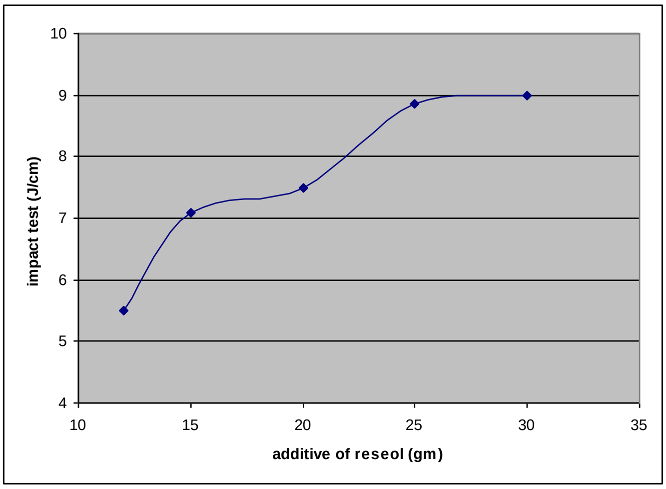

Figure (2) the effects of adhesion promoter resole on the impact test of UF/lignin solid waste system longitudinal arrangement.

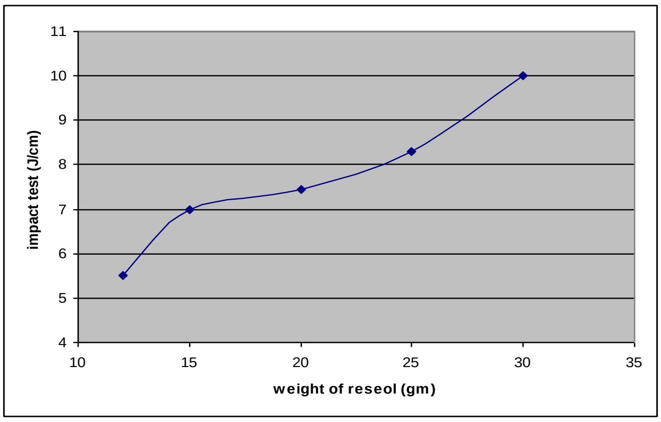

Figure (3) the effect of adhesion promoter resole on the impact test UF/lignin solid waste system width arrangement.

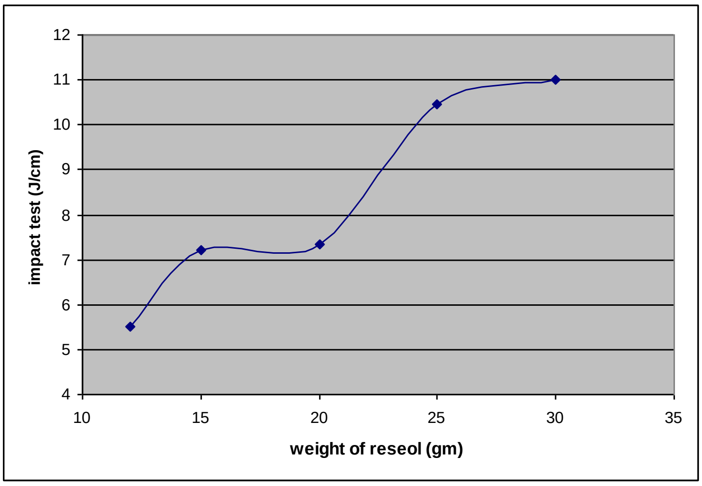

Figure (4) the effect of adhesion promoter reseol on the impact test of UF/lignin solid waste system woven roven arrangement

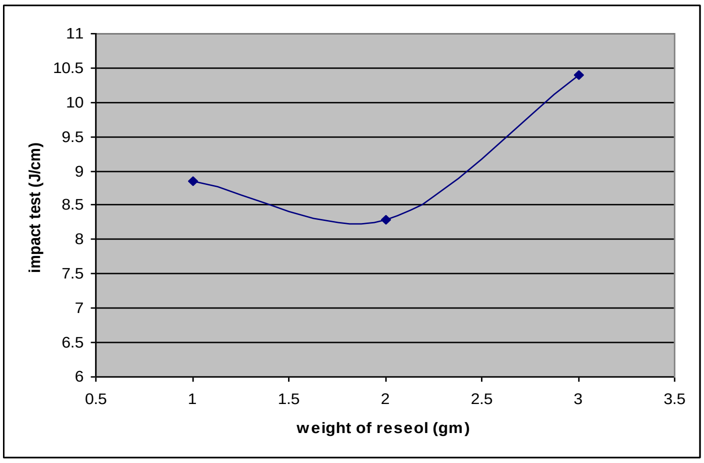

Figure (5) optimum additive of adhesion promoter for optimum arrangement UF/lignin solid waste system

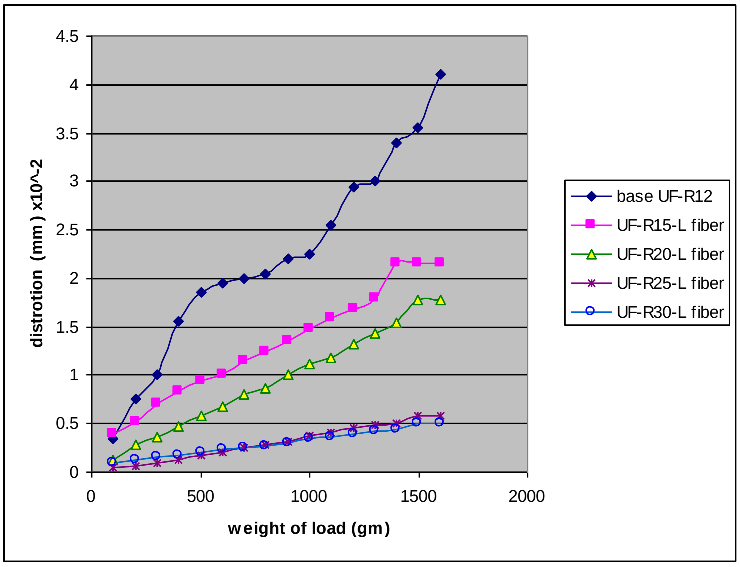

Figure (6) bending test for UF/lignin solid waste system longitudinal arrangement.

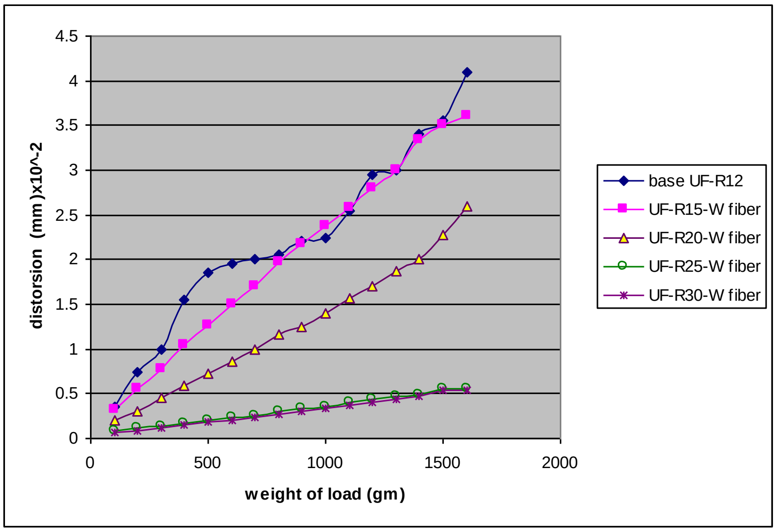

Figure (7) bending test for UF/lignin solid waste system width arrangement.

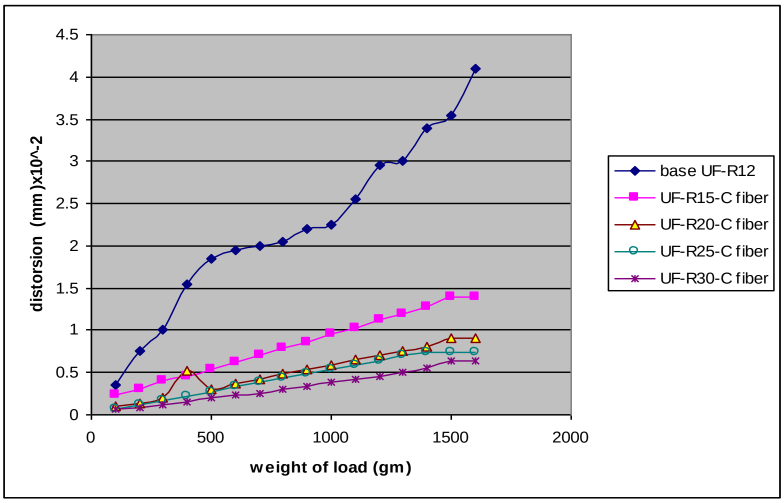

Figure (8) bending test for UF/lignin solid waste system for woven roven arrangement.

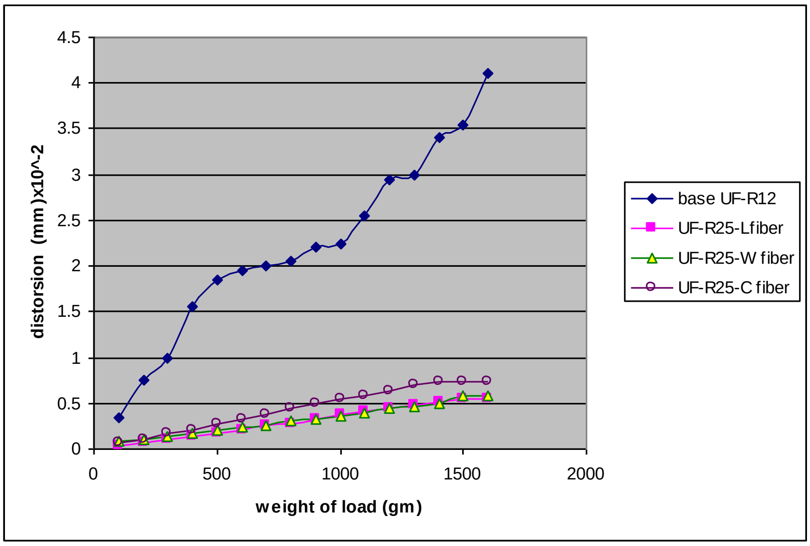

Figure (9) optimum selection arrangements for UF/lignin solid waste system for bending test.

References

1- RogersV. , G.C East, J.E.Mcintyre and P.Souwden ***J.Applied polymer science,*** 2000, **77,** 64.

2- Mansour O.I., B.Abdel-Hady, S.K. Ibrahim and M.Goda, ***Macromolecular Symposia***, 1999, **147**, 173.

3- Blizakor E.D., C.C.White and M.T.Chaw. ***J.of Applied Polymer Science***, 2000, **77**, 3202.

4- Gaggar S.K and L.J.Brontman, "strength and properties of random fiber polyester composite", ***Fiber Science and Technology***, 1976, **9**, 24, 205.

5- Hibbert A.P., and D.J.Hannant,"Toughness of fiber-cement composite", ***Composite***, 1982, 105.

6- Kameswara C.V., Anote on fracture toughness of multiphase materials, ***Eng.Fract.Mech.*** , 1983, **18**, 8.

7- Susznk Y., ***J .Material Science,*** 1993, **28**, 7, April.

8- Billemeyer F.N., "Text book of polymer science ", 2nd edition, p.998. John wiley & sons, New York, 1972.

9- Eckold G., "Design and Manufacture of composite structure", ***McGraw-Hill Inc.***, 2000, 1126, England.

10- Goel R.K., Gupta R.K.,"Industrial adhesive and gums ", 5th edition, vol1, p.555.1975.

11- Darwish, SN.Lawandy,

12- S.A.El-Shazaly, A.I.Abon-Kandil," polymer plastic and technology engineering, 39,793,806, 2000.

13- Marra A.A.,"Technology of wood bonding van nostrand reinhold", New York, chapter 3-6, and 8-10, 1993.

14-Chalfield H.W. "The science of surface coating ", Ernest Benn Ltd, London, 445, 1972.

15-Hull D., "An introduction to composite material ", 1st edition, p.996, Cambridge univer.press.1981.

16-Solomon R., and G.Honwink," Adhesion and adhesive ", 1977, **1**, 774.

17-Pand S.J.,Sharma D.K. "Fracture toughness of short glass fiber and glass particulate hybrid composite, ***Fiber science and technology***, 1984, **21**, 307.