Studying the effect of a new polyamide as adhesive for wood-wood surfaces

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Abstract

In this research, a new copolyamid was prepared from reaction Aceglutamide with Formaldehyde by esterfication process, and used this copolymer as adhesive between wood – wood surface. Five different weight (0.2, 0.4 , 0.6, 0.8 & 1.0 gm) from the prepared copolymer respectively, were used as adhesive to prepared the specimens of wood / adhesive . Four standard test methods were used to measured the adhesion properties which are; *ASTM: D-790, ASTM: D- 695, ISO – 179* &*ASTM: D-638* .

The results obtained from these tests indicated that, the specimens of wood / adhesive containing 1.0 gm from the prepared copolymer have high values in all standard tests; Impact strength was 45 MPa, Compressive strength was 40 MPa, Flexural strength was 250 MPa and Tensile strength was 8150.41 MPa ; compared with the other specimens which contain on less weight from the prepared copolymer.

***Keyword*:** Adhesive ; Adhesion ; Amide Resin ; Chemical Modification ; Modified Copolymer ; Formaldehyde Resin ; Copolyamide ; Copolymer ; Copolymerization .

Introduction

Very large quantities of adhesives are being used in the aeronautical, ship building and poly wood industries[1], when maximum adhesion and bonding strength are required coupled with resistance to that, water and attack by moulds, fungi and bacteria [2] . There are two main types of adhesives [3] ; Those natural based adhesives, such as, Casein and Starch; Those based on synthetic resins, such as, Urea-formaldehyde, Phenol-formaldehyde, Melamine- formaldehyde, etc. , having good adhesive strength and considerable degree of elasticity and flexibility .

An adhesive is defined as a substance capable of holding materials together by surface attachment [4] . Each adhesively bonded joint is a system of two similar or dissimilar solid materials called substrates or adherents, joined by layer of another material called the adhesive [5] . Most of the modern adhesives are composed of various components, one of these components are base, this material from which the adhesive derives, its specific name like; Epoxy, Polyester, Polyurethane, etc.; It is usually a solid material that serves as the back-bone of the adhesive [6] . Because the function of an adhesive is to join two solids together, it must be able to make intimate contact with each surface and spread freely upon them, i.e. it must be capable of wetting the surfaces . The adhesive must, therefore, be applied in the liquid state and with sufficient pressure that it will flow into the small crevices of the solid surface[7] .

In this work, preparation of the new copolymer from Aceglutamide and Formaldehyde to formed a new amide resin, and studying some of the mechanical properties of this new resin as adhesive for wood-wood surface .

Experimental Part

1.Materials

a- Aceglutamide; trade name is (Acutil-S), in crystals form, imported from BDH Co.
b- Formaldehyde; 37% , imported from Fluka Co. .
c- Hexamethylenetetramine; as a hardener for the prepared resin, Purity 99.9% , imported from BDH Co. .
d- All chemicals were used to prepare of the copolymer imported from BDH Co. .

2. Preparation of the copolymer[8]

One mole Aceglutamide, was dissolved in 10 mole Ethanol absolute in 1Liter four-necked flask equipped with mechanical stirrer, reflux condenser and thermometer . Two moles Formaldehyde and 0.5N Sodium hydroxide solution, were added to the flask reaction and the temperature of solution was maintained at 110Cº and the PH of solution was adjusted from 7.0 – 7.5 . After 45 Min., stopped heating and cooled the reactants to 80Cº . 4N Acetic acid solution were added to the flask reaction and heating the reactants at 130Cº for one hours . The reactant was left to cool at room temperature . Table -1, obtained some of the physical measurements of the prepared copolymer, and Figure – 1, represent the chemical reaction to prepared Poly (Aceglutamide- co – formaldehyde) resin . Figure -2 , represent the FT-IR spectrum of the prepared copolymer, and showed the appearance of a strong sharp band at 3300 cm^{-1} for stretching (-NH) and strong broad band at 3500 cm^{-1} for stretching alcoholic (-OH) with stretching (H – bond) , and the spectrum also showed the aliphatic (C-H) at approximately 2860 cm^{-1} and the spectrum also showed a strong

sharp band at 1050 cm^{-1} and 1600 cm^{-1} for a stretching band (C-N) and (C=O) amide respectively .

3. Standard Tests

a- ASTM: D-790 [9] ***:***The measurement of flexural strength, by three point method .
b- ASTM: D- 695 [10] ***:*** The measurement of compression strength .
c- ISO – 179 [11] ***:*** Themeasurement of impact strength .
d- ASTM: D-638 [12] ***:*** The measurement of tensile strength .

4. Preparing of specimens

The dimensions of the specimens wood were cut according to standard tests were used in this work . Different weight (0.2, 0.4, 0.6, 0.8 & 1.0 gm) of the polymeric material respectively, were coated between the surface of specimens wood after added the hardener of resin to get cross linking copolymer and left the specimens to 24 hours to post dry (curing) . Three samples were prepared for each standard test.

Result and Discussion

As showed in Tables 2 to 4 and Figures 3 to 6, the mechanical behavior will be increasing with increased of the weight of the prepared copolymer which coated between surfaces of wood; the impact strength was 45 MPa , the compressive strength was 40 Mpa , the flexural strength was 250 Mpa and the tensile strength was 8150.41 Mpa for 1.0 gm from the prepared copolymer were used as adhesive; These values will be decreasing with decreases of the weight of the prepared copolymer . These results can be explained by formed of the strong linkages between the polar groups in the prepared copolymer and the CH_2OH groups in the lignin of wood . That linkages will be formed by five steps in an ideal wood / adhesive bond can be characteristic, which are; flow, transfer, penetration, wetting and hardening. During flow, adhesive applied to the wood surface merges into a uniform wet film . When two surfaces of wood to be adhered are brought together, the adhesive materials were transfers to both surfaces equally. The adhesive then penetrates in to the wood surfaces establishing complete contact between the adhesive and wood surfaces. During wetting, the adhesive develops an extensive and intimate molecular scale contact with wood surface. Wetting occurs to some extent during all the previous steps. Finally during hardening, the

adhesive film sets and develops cohesive strength; and the adhesive bonding process begins with interpenetrating of the copolymer in the cellulose fiber of the wood and then some types of bonds will be formed between the active site of the prepared copolymer and wood cellulose which are rich in CH_2OH groups; They are capable to formed ether linkages and hydrogen bonds with the polar groups of the prepared copolymer .

Conclusions

The influence of the (Aceglutamide – co – Formaldehyde) copolymer, shows high values of mechanical behavior as adhesive for wood – wood surfaces, compared with the values of the (Urea – Formaldehyde) and (Melamine – Formaldehyde) resins [13] , which used as adhesive for same surfaces; That interesting results can be due to the present of polar groups in the back-bone of the prepared copolymer, like (CO-NH) amid, (COOH) carboxylic acid and (CH_2OH) methylol groups; which linkages with the (CH_2OH) methylol groups in the back-bone of the wood cellulose; Those linkages was branched, and that got strong interpenetrating between the adhesive and wood surface .

Table – 1 : Some of the physical properties of the prepared resin .

Physical Properties	***Values***
Average Molecular Weight (Mw)	4380 gm/mole
Viscosity	108 cp.
Gel time	3 – 5 Min. at 25C^o
pH	7.8

Table – 2 : Impact Strength measurements .

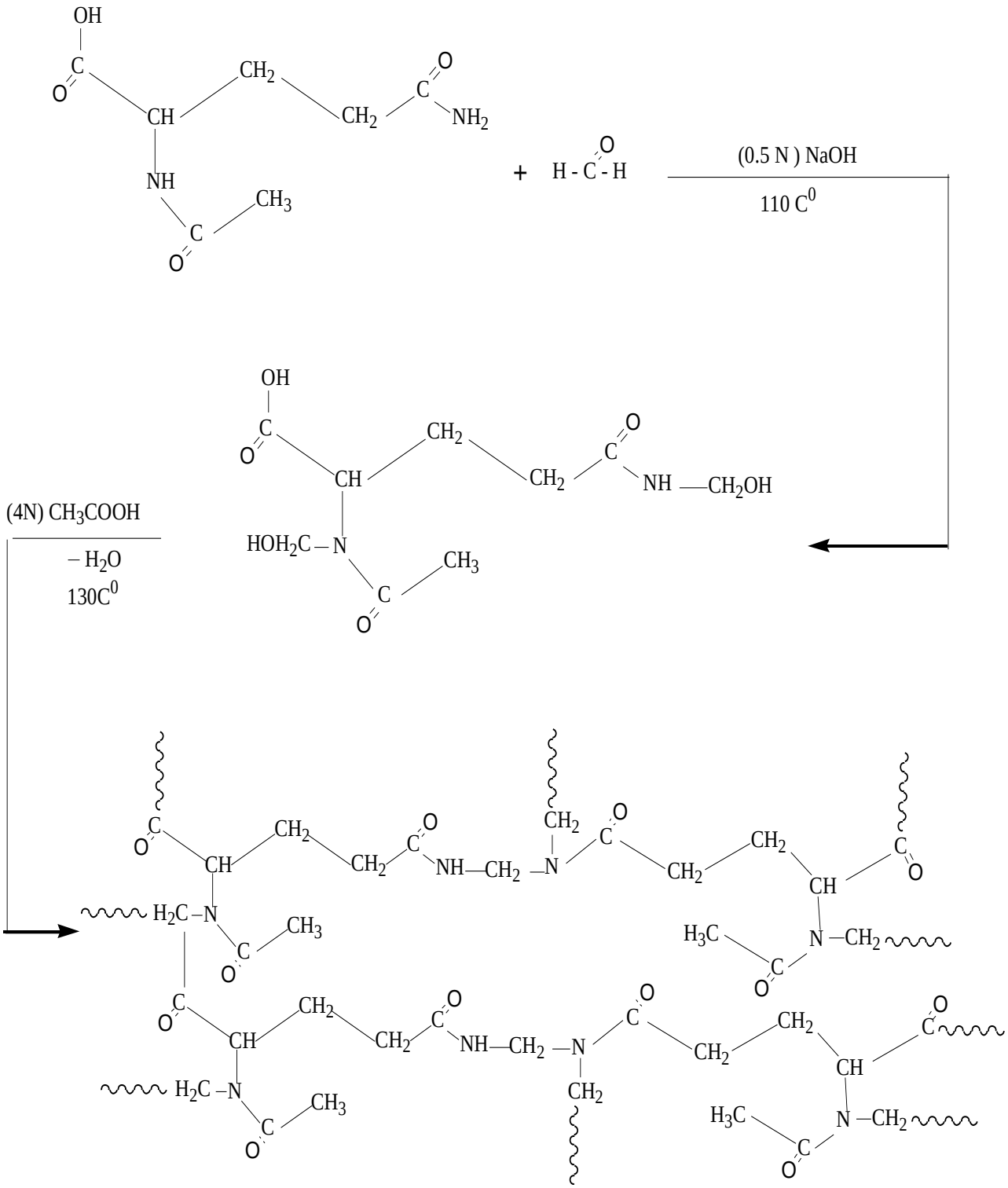
Weight of copolymer (gm)	***Cross Sectional Area (mm^2)***	***Impact Energy (Joule)***	***Impact Strength (Mpa)***
0.2	200	3.21	30.5
0.4	200	3.56	33.0
0.6	200	3.72	36.5
0.8	200	3.95	38
1.0	200	4.23	45

Table – 3 : Compressive strength measurements .

Weight of copolymer (gm)	***Cross Sectional Area (mm^2)***	***Force (N)***	***Compressive Strength (Mpa)***
0.2	200	2840	28.4
0.4	200	3110	31.1
0.6	200	3430	34.3
0.8	200	3750	37.5
1.0	200	4000	40

Table- 4 : Flexural and tensile strength measurements .

Weight of copolymer (gm)	***Flexural Strength (Mpa)***	***Tensile Strength (Mpa)***
0.2	163	7528.113
0.4	171	7696.462
0.6	198	7815.395
0.8	220	7982.06
1.0	250	8150.41



Poly(Aceglutamide-co- Formaldehyde) resin

Figure–1: The chemical reaction to prepared Poly (Aceglutamide- co – formaldehyde) resin .

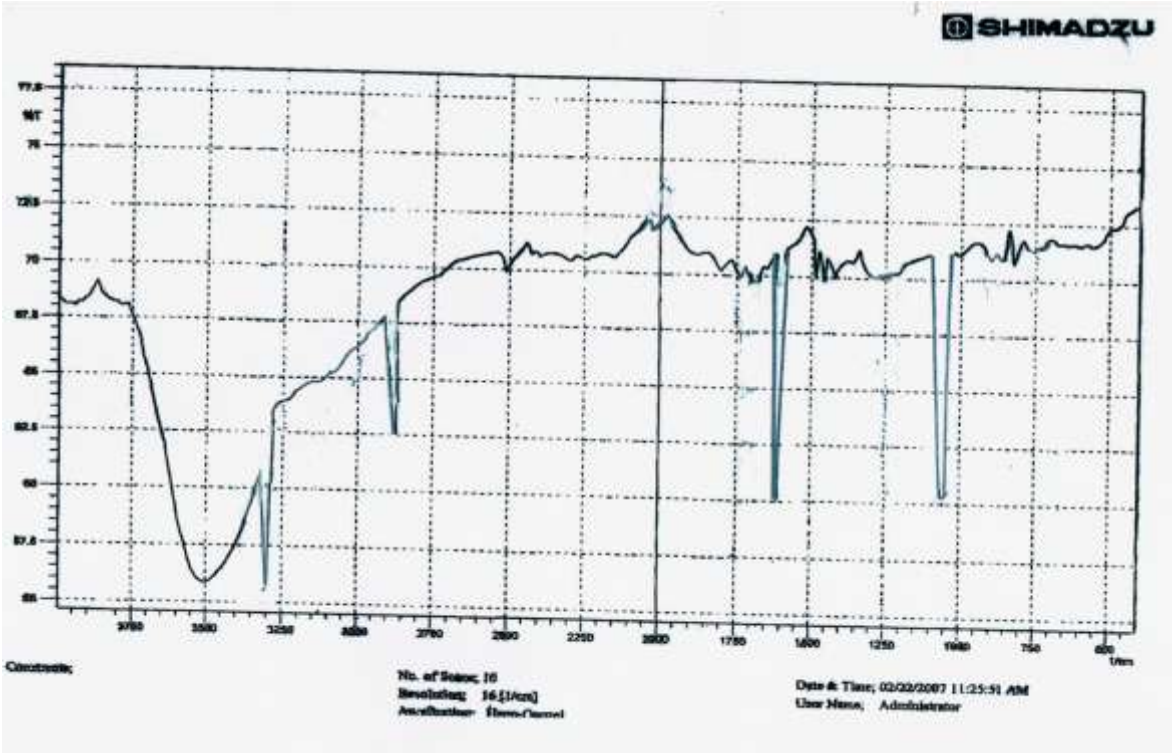


Figure -2: The FT – IR spectrum of the prepared polymer.

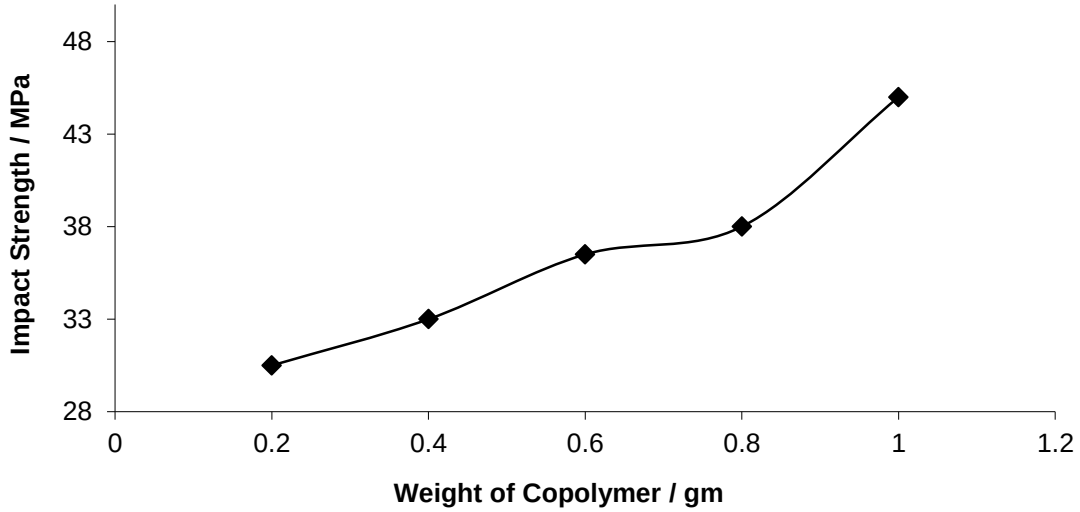


Figure – 3 : The influence of different weight of the copolymer on impact strength of specimens .

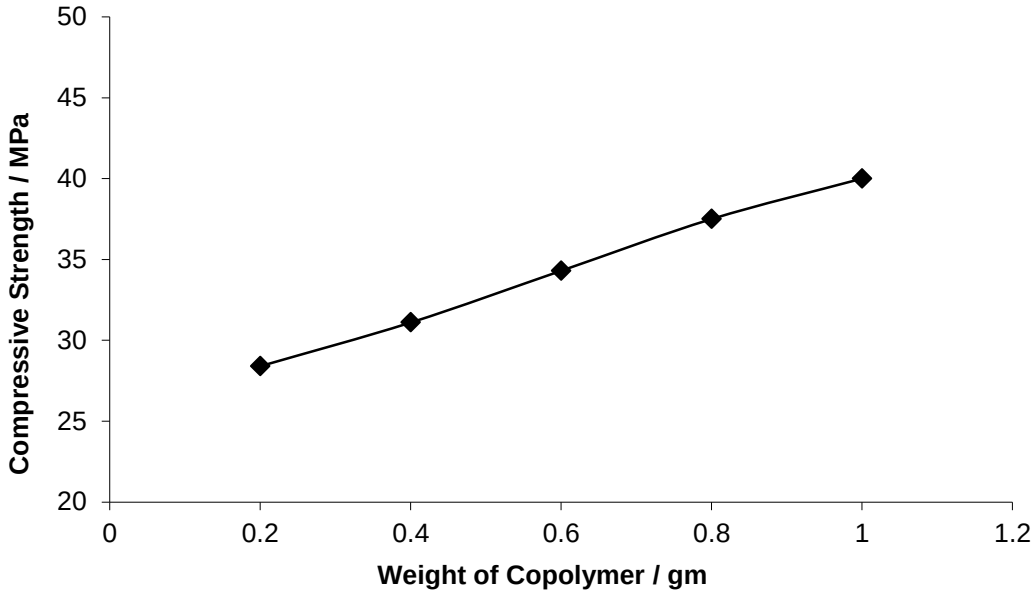


Figure - 4 : The influence of different weight of the copolymer on compressive strength of specimens .

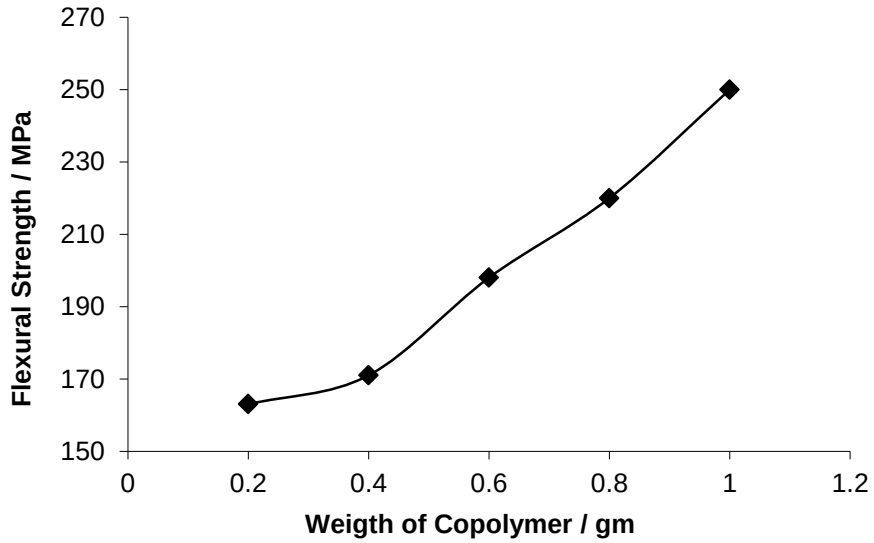


Figure – 5 : The influence of different weight of the copolymer on flexural strength of specimens .

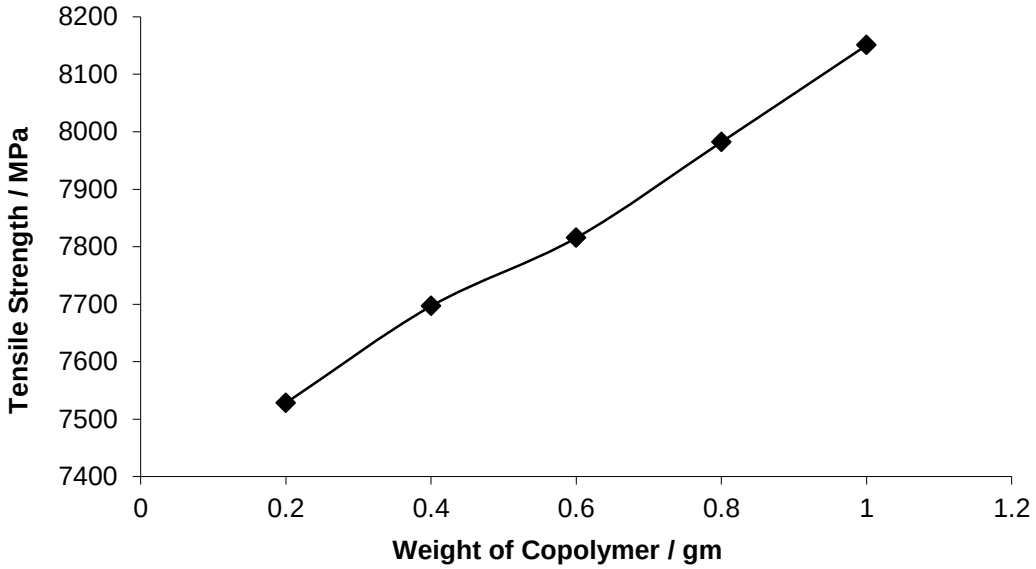


Figure - 6 : The influence of different weight of the copolymer on tensile strength of specimens .

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