OPTIMAL DESIGN OF BITUMENOUS IMPROVEMENT RESIDUE IN ROOFING AND BUILDING APPLICATIONS

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ABSTRACT

This work was based on the fact, that a lot of waste-environmental pollution's –can be re-used by fabrication in different economical techniques in addition to save the environment from their aggressive effects.

The wastes of polyethylene (Pipsi bottles) and black emulation waste (bwb) for petroleum (bitumen) from local street and Iraqi refineries were used in this work to prepare a matrix materials (bwb/As/PE, bwb /Sc/PE) that will suitably used as water proofing lining and wall insulation.

Different weight ratios of waste polymer (polyethylene) as (10,20,30,40,50) wt% / bwb is used to improve phsiyco-chemco-properties and different reinforcement local cheap ceramic materials such as asbestos fiber (As) (5,10,15,20,25) vol% and silicon carbide (Sc) (5,10,15,20,25) wt% to improve thermo-mechanical properties of black waste bitumen (bwb).

Their effects on both phsiyco-chemco and thermo-mechanical properties (chemical resistance, thermal stability, TG analysis, tensile strength) of both matrices systems (bwb/As/PE, and bwb/Sc/PE) produced

achieved optimum mixing ratio which gives best properties with less internal stresses had been showed

The result of testing shows that an optimum mixing ratio for sample 3 from both matrices systems (bwb/As/PE and bwb/Sc/PE) and with excellent pysiyco-chemco and thermo –mechanical properties for system bwb/As/PE system Aging for 7 days, 50°C in different chemical solutions (100% H_2O, 5% NaOH, and 5%H_2SO_4).

The results of TG test are: an excellent thermal stability and less loss in weight is for sample 3 reinforced by asbestos fiber ,where its loss only 5% of original weight at 500 °C compared to sample 3 reinforced by silicon carbide ,which its loss 20% of original weight at the same temperature .

The thermal conductivity for both samples reinforced by asbestos fiber and silicon carbide decreased with increasing reinforcement agent (asbestos ,and silicon carbide) with excellent results for asbestos sample at 0.009 w/m °C than other one of 0.5 w/m °C

For silicon carbide .

The mechanical properties tensile load resistance for asbestos sample (3) after aging it in different chemical solutions (100% H_2O, 5% NaOH, and 5%H_2SO_4) for 7 days at 50°C with rang 100-200 dyne/cm compared to that of silicon carbide sample (3) for range 60-78 dyne/cm respectively .

KEY WORDS

building ,optimal design ,asphalt membrane

NOTATIONS

e= loss of heat per m^2 .

IV = rate of energy supplied .

d= thickness of disk m .

r= radius of disk m .

ds= thickness of sample m .

T_1, T_2, T_3 = temperatures through of copper disk .

INTRODUCTION

The roofing industry confronted with constantly increasing economical constraints, is looking more than ever to optimize its products. This means that the manufactures of polymer modified roofing sheets aim to use lowest amount of polymer possible without jeopardizing membrane characteristics .

From the economical point of view it should be noted that the cost of modifying polymer is by far the highest the formulation component , the incidence of the cost of the polymer on the total mass will obviously depend on the formula used [1-4].

The addition of these polymers improve various characteristics of the bitumen , these compositions are coupled with lithic materials having a special morphology for the preparation of bituminous conglomerates or at times the addition of other material as reinforcement in the form of water proofing sheaths used in construction for floor lining[5-7].

The basic advantage of using recycled waste polymers that reduced the volume of the polymers to be disposed after use, thus contributing problems relating to environmental pollution, and they improve the applicative performance of bitumen's.

The polymer modified bitumen membranes have been used in the united state since 1975 and the modifying compound added flexibility and elasticity, also improved cohesive strength and toughness [8-10]

There is a wide range of researchers have been studied the modification of bitumen residues .There are other out standing variables such as geological location type of roofing system and more an infrared thermographic survey on modified bitumen membrane.

This technique has been applied for systematic evaluation of different bitumen in combination with different type of waste polymers such as polyethylene , polypropylene ,and polyester . All blends have been assessed on the major criteria (softing point, penetration viscosity, cold temperature flexibility before and after aging).

More than 80% of contractor continue to use modified bitumen according to RSI s 2002 state of the industry research and this roofing product has experienced the greatest increase in demand in 2002, 30.5% “single ply ”.

Enhance its physical properties reduction the number of roofing plies create durable membrane excellent fatigue resistance and good tensile strength also, reduce the labor requirement due to fewer number of plies [11] .

Also many authors have been studied various new and standard roofing system by therograms and methodologies employed to show techniques , and to complement the thermographic imaging survey[12].

This type of work is very newest in Iraq , there is no any knoha or research in this field of insulation for building and roofing to resist the thermal ,mechanical , and chemical loading for high building .

The aim of present work

This coke by-products from petroleum Iraqi refineries are waste endangering the environmental equilibrium due to heavy organic products.

Therefore this research contain an attempt to use this waste residue with another danger waste polyethylene (pipsi container) to improve the low performance of their characteristics such as thermo-chemico-mechanical properties of this by products by compatibilization and incorporation of polymers.

In the same time , the rehabilitation , the repair of the damaged hydro insulation of roofs and building foundation ,by the use of different reinforcement insulating agents (asbestos/fiber, and silicon carbide/particulate) then studying its thermo-chemico-mechanical properties .

EXPERIMENTAL

Materials

1. Waste bitumen ,the black waste residue from refinery Iraqi oil in Al-Durra refinery of middle spot of Baghdad that characterized by 40-50 grade. and 1.04 sp.gr of 75% heavy organic hydrocarbons[13].

2. Waste polyethylene particles bring it from the local street of Baghdad (waste pipsi container) separated and classified in to 2-15 mm grade size.
3. Commercial reinforcement material from local market such as asbestos fiber and silicon carbide (ceramic material).
4. sulfuric acid, sodium hydroxide, ammonia, and acidic acid laboratory material and high purity at 99.9% for each other.
5. Softener material by BDH. And promoter for this matrix such as polyvinyl formal (PVF) of high purity 82.0% 15/95 E , 5-6% PVA, 9.5-13% PVAc.

Procedure

1. Preparation of base emulsion phase (bwb/PE)

The polymer- modified bitumen were made according to the following Procedure :

100 gm of black waste bitumen was heated to 180° C with a silverson L4R high shear mixer and subsequently different ratio of waste polymer of polyethylene (10,20,30,40,50)gm/100gm bwb were added as shown in table (1) over several minute period.

Upon mixing , the temperature increased to between 200°C which was caused the mechanical energy input from the mixer .

Blending at this temperature was continued until homogeneous blend is obtained. The homogeneity of the blend was monitored by visual inspection of the consistency of the blend. homogeneity was achieved after 90 minute of mixing [14].

2. Preparation of matrix systems [bwb/AS/PE , bwb/Sc/PE]

2-1: preparation bwb/As/PE matrix system

The black waste emulsion of anionic slow set type were prepared for each matrix system (bwb/As/PE) , where heated black waste emulsion modified with polymer , then is placed over different volume ratios of fiber at (5,10,15,20,25) %vol. reinforcement fiber asbestoses local PVF binder 150°C is used to promote the cohesive force .

SERP colloid mill is applied to give a smooth modified bitumen membrane in a variety of thickness due to the type of test (chemical, thermal, and mechanical properties) ,then these matrices system prepared were cured at 60°C for 15 hours then soaked in water for 1 hr at 25°C in order to complete the matrix system of (bwb/As/PE) finally the smother of these moulds occurred in order to accurate the test readings stability for thermal chemical and mechanical test [15] ,the mixing ratio of prepared system are shown in table (2).

2-2 preparation of (bwb/Sc/PE) matrix system

A particulate different weight ratio of reinforcement ceramic materials (5,10,15,20,25)%wt. were added to a heated black waste emulsion at 75°C then these matrix system (bwb/Sc/PE) was placed in a molder of different dimensions and thicknesses due to type of test required (chemical thermal and mechanical properties) then a talc powder is placed at the bottom of each molder in order to easily pick up of specimen sample , then the produced modified bitumen membrane is cured of 60°C for 15 hrs then cooled to 25°C after soaked it in water then smoothen the surface of each specimen before any property measured [15] ,the mixing ratio of this system are shown below :

Chemco-thermo-mechanical properties of materials system (bwb/AsPE and bwb/Sc/PE)

1. **Chemical properties**

This test is achieved by the use of moisture solutions for 7 days at 50°C for both matrices system (bwb/As/PE)& (bwb/Sc/PE)of (2 x 2 x 0.25) cm dimension for each specimen [16, 17].

2. **Thermal properties** :

These properties is achieved by the testing of insulation sheet :

2-1 Thermogravimatric analysis (TG):

This type of property was achieved by the use of a home made thermogravimetry system to suit our study of weight loss for bulky samples of matrix material system (bwb/As/PE or bwb/Sc/PE) this thermogravimetric system was achieved under a nitrogen flow at 0.5 m^3/hr , the sample was placed in a stainless steel basket of (5 cm diameter and 20 mm length). The basket was hung to the bottom of semi micro balance (0.0000) gm by 100cm stainless steel wire as shown in Figure (1). The temperature was measured at a specified point along the reactor of test (center wall) during constant time interval each 10 min, where both temperature and weight loss where recorded in order to investigate the TG- analysis curve and stability for each matrix systems (bwb/As/PE & bwb/Sc/PE).

2-2 Thermal conductivity K (W/m. °C):

This type of test was achieved by the use of lee-disk method according to lee-disk instrument and specimen dimension o.d 3 cm and 0.5 cm thickness to measure the stability of temperatures T_1, T_2, T_3, then applied the two equations below:

$$IV = \pi r^2 e (T_1 + T_3) + 2 \pi r e [d_1 T_1 + ds (T_1 + T_2) + d_2 T_2 + d_3 T_3] .(1)$$

$$K[T_2 - T_1 / ds] = e [T_1 + 2/r (d_1 + 1/2 ds) T_1 + 1/r\ ds\ T_2] .(2)$$

3- Mechanical properties

These type of properties were a chivied by measuring a tensile strength .

Tensile strength

This type of test is a chivied due to (68-257) ASTM type and use of zwick-tester for both matrices systems (bwb/As/PE, bwb/Sc/PE) after aging for 7 days and 50°C in a different chemical solutions (100% H_2O, 5% H_2SO_4, 5% NaOH).

RESULT AND DISCUSSION

Procedure

According to procedure of the present working it could indicate that :

-Applying pressure over the matrix system perpetration to form a substantially contact between material and improve the bonding between them.

-select the suitable waste polymers that will give a compatible mixture and have the same microstructure such as polyethylene, polypropylene.

-the composition of additive modified polymers depend on performance applicative products.

-try a cheaper fillers to reinforcement such as asbestos to less the cost of prepared materials.

-use a cheaper sifting smoothing materials such as sand or talc to which serve as release agents and prevent adhesion of material while roll step.

Properties of (chemeco-thermo-mechanical) properties

Chemical properties

Figures (2,3) indicate that an increasing in weight accrued with increasing of time soaking solution (100% H_2O)for all samples additive and the results of three samples 3,4,5 of (15, 20, 25) for bwb/As/PE system shows that a less change in weight than two samples due to best physico-chemico properties of both additives recycled polyethylene and asbestos fiber [18, 19].

And the chemical resistance for second matrix system (bwb/Sc/PE) is always the same with preference for sample No.3 mixing ratio due to the segregation between two phases of mixture liquid – solid at increasing the weight of additive particulate agents [12].

Figure (4) indicate a comparison between two materials system (bwb/As/PE) & (bwb/Sc/PE) , a best chemical resistance for bwb/As/PE than other bwb/Sc/PE due to the good compatibility between two phases liquid bwb/PE-solid (As) and good chemical resistance of asbestos fiber [18, 19].

2-Thermal properties

2-1 TG-analysis:

Figure (5,6) shows that a TG-analysis for both systems to indicate an optimum mixing ratio of both matrices system bwb/As/PE and bwb/Sc/PE .a less losses in weight at increasing of temperature for three samples (3,4,5) (5%) loss than others (1,2) (20% wt.) loss for bwb/As/PE system due to high insulated property and good compatibility between two phases liquid (bwb/PE)-solid (As) at increasing fibrous agent [18].

But Figure (6) shows that similarity in loss of weight at increasing of temperature due to high insulated property and segregation between two phases liquid bwb/As-solid Sc with preference for samples (3) of less loosing in weight (15% wt.) [12].

Figure (7) indicated that a comparison between two matrices system bwb/As/PE and bwb/As/PE and bwb/Sc/PE .

The results are given a good thermal stability for fiber matrix system of bwb/AS/PE due to a good insulated property and compatibility between two phases [19].

2-2 Thermal conductivity K

Figure (8) indicated that a comparison of results between two matrices system fiber (bwb/As/PE) and particulate (bwb/Sc/PE), which is proved that the reality results for TG-analysis of good insulated property for (bwb/As/PE) and less thermal stability and high thermal conductivity for (bwb/Sc/PE) matrix system due to high thermal conductivity and segregation of particulate insulated agent [12].

3-Mechanical properties

Figure (9) indicate the effect of aging condition (100% H2O, for 7 days at 50 °C) on the tensile strength of two matrices system fiber (bwb/As/PE) and particulate (bwb/Sc/PE).

An increasing in tensile strength for (bwb/As/PE) system (125 dyne/cm) than other (bwb/Sc/PE) (75 dyne/cm) with increasing of asbestos additives due to good compatibility and chemical resistance for asbestos fiber and worse chemical resistance and segregation between two phases for silicon carbide particulate system [12].

Figure (10) indicated that the effect of both fiber (As) and particulate (Sc) with the aging properties (5%NaOH, at 50°C for 7 days) on the tensile strength the results proved that an optimum mixing ratio for both systems (bwb/As/PE) (90 dyne/cm) and (bwb/Sc/PE) (60 dyne/cm) for sample number 3 with constant and high tensile strength for (bwb/As/PE) and worse tensile strength for (bwb/Sc/PE) due to good compatibility and chemical resistance for asbestos and a segregation between two phases and worse chemical resistance silicon carbide [12].

Figure (11) indicate the effect of aging properties of (5% H_2SO_4, at 50°C for 7 days) for both matrices system (bwb/As/PE) (130 dyne/cm) and (bwb/Sc/PE) (80 dyne/cm) on the tensile strength property.

The results shows that best and high tensile strength with increasing the additives of asbestos due to good chemical resistance and compatibility of asbestos in addition of alkali nature of bitumen used [18].

But less values of tensile strength for (bwb/Sc/PE) than (bwb/As/PE) for sample 3 , then become worse mechanical property due to less chemical resistance and segregation of silicon carbide [12].

CONCLUSIONS

1. High mixing velocity is required to give a homogeneous mixture also gave a good comptability.

2. Using a roller to spread and homogeneous of reaction mixture with reinforcement materials.

3. Optimum mixing ratio for both matrices system for sample No. 3.

4. Good chemical thermal and mechanical properties for fiber matrix system (bwb/As/PE).

5. Alkali form of black waste bitumen use (bwb) from the aging condition for mechanical properties .

6. Simple method and economical aspect to recycling wastes of (bwb/PE) and gave a natural environment clamiate.

7. Improvement on the bitumen waste occurred by the use of waste (PE, waste pipsi container) and cheap commercial materials (As, Sc).

8. Gave a good bituminous membrane for insulated applications in walls and ceiling of high building (hydro-insulation of existing building).

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Table (1) the ratio of base mixture (bwb/PE)

Sample no.	bwb(gm)	PE(gm)
1	100	10
2	100	20
3	100	30
4	100	40
5	100	50

Table (2) the ratio of improvement mixtures fibrous form (bwb/AS/PE)

Sample no	bwb(gm)	PE(gm)	AS(% vol
1	100	10	5
2	100	20	10
3	100	30	15
4	100	40	20
5	100	50	25

Table(3) the ratio of improvement mixtures particulate form (bwb/Sc/PE) .

Sample no.	**bwb(gm)**	**PE(gm)**	**Sc(% wt.)**
1	100	10	5
2	100	20	10
3	100	30	15
4	100	40	20
5	100	50	25

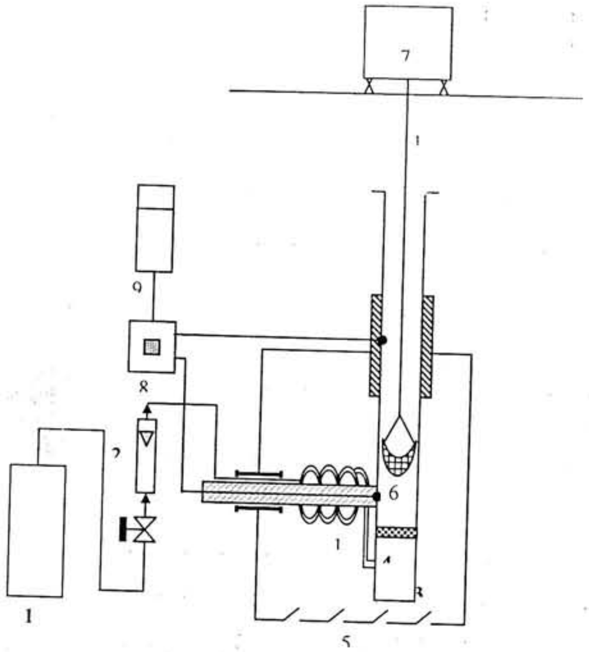


Figure (1) Experimental apparatus for TG-analysis
1- gas source with regulator .2- gas rotameter . 3- stainless steel reactor . 4- gas distributor . 5- electrical furnace . 6- stainless steel basket . 7- sensitive balance . 8- selector switch . 9- digital thermometer 10- stainless steel coil . 11- stainless steel wire .

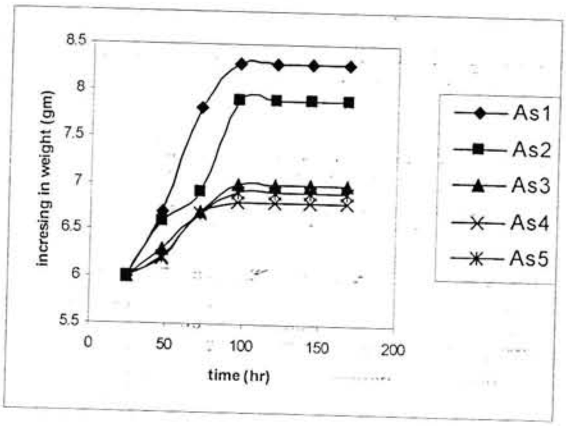


Figure (2) the chemical resistance for bwb/As/PE system at 50 °C for 7 days

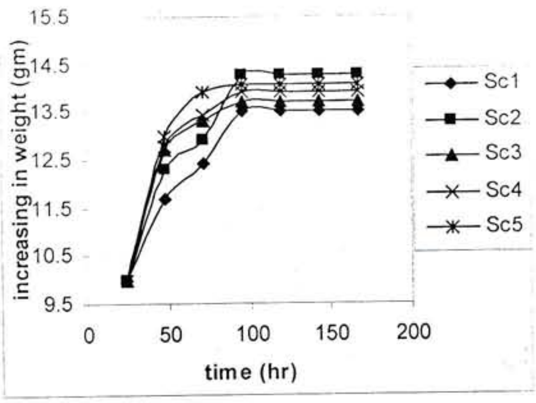
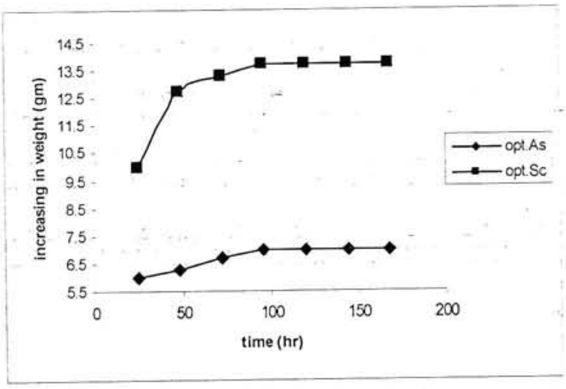


Figure (3) chemical resistance for bwb/Sc/PE system at 50 °C for 7 days .



Figure(4) comparison between two matrices system for chemical resistance .

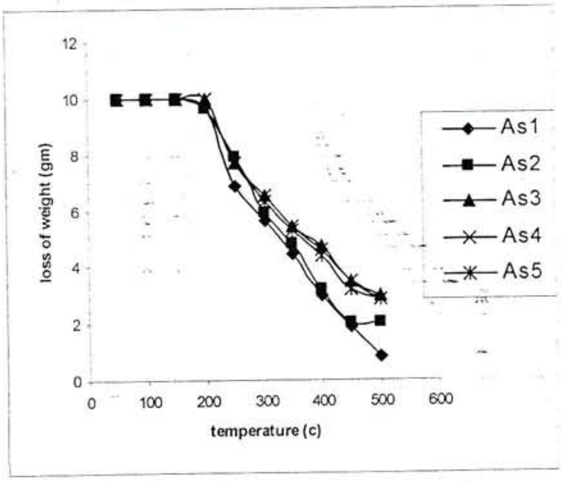


Figure (5) TG-analysis for bwb/As/PE system .

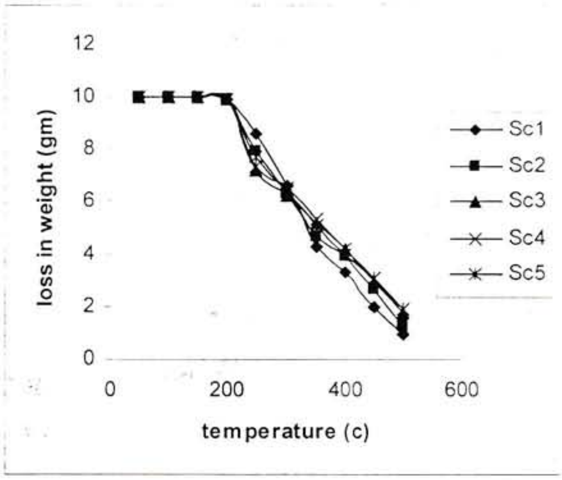


Figure (6) TG-analysis for bwb/Sc/PE system .

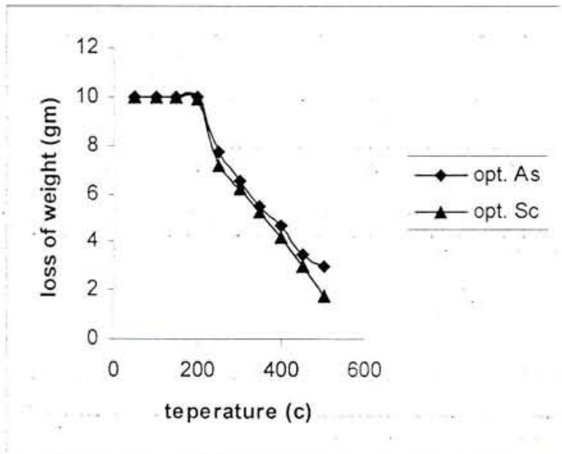


Figure (7) TG-analysis comparison between two matrices system .

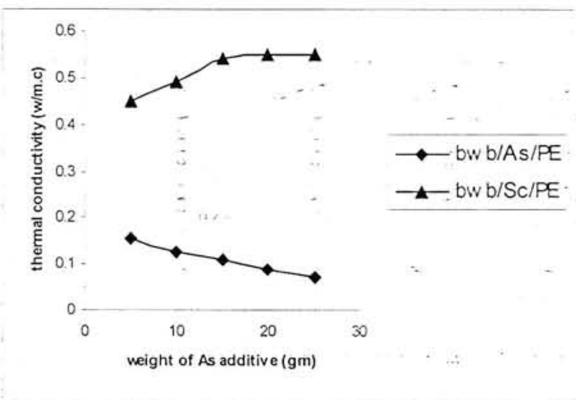


Figure (8) thermal conductivity comparison between two matrix systems .

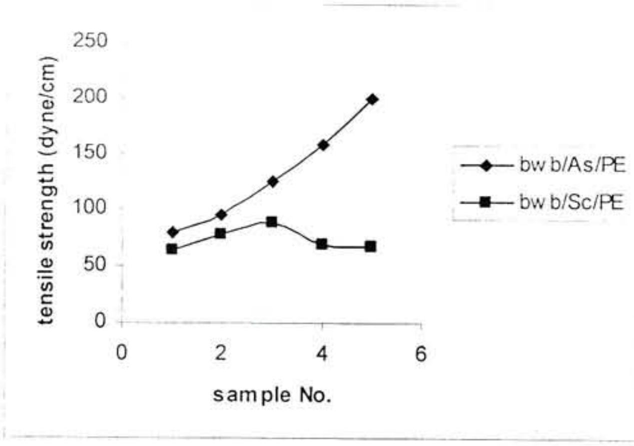


Figure (9) tensile strength aging for 7 days and 50 °C 100% H_2O

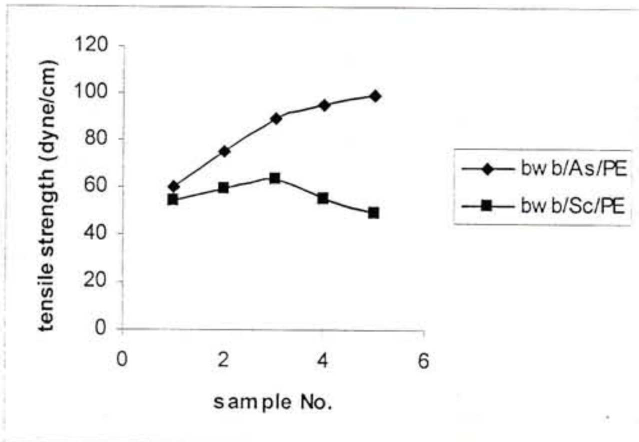


Figure (10) tensile strength aging for 7 days and 50 °C ,5% NaOH .

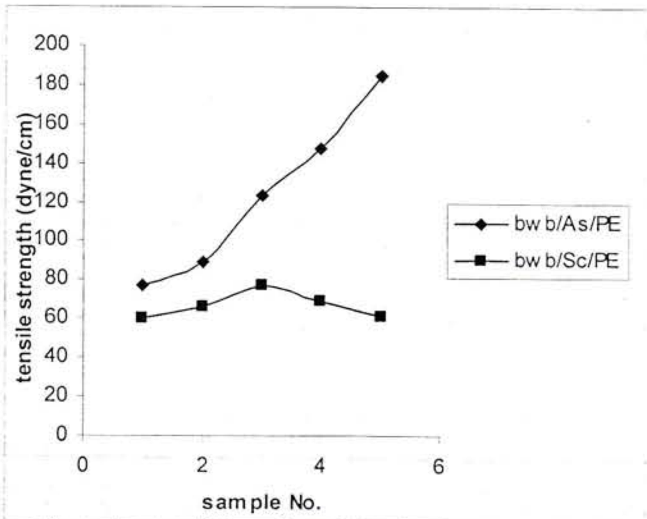


Figure (11) tensile strength aging for 7 days and 50 °C , 5% H_2SO_4

التصميم المثالي لمتبقي البتيومين المحسن وتطبيقه في السقوف والأبنية

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الخلاصة

إن البحث الحالي يستند على حقيقة واقعية ألا وهي تزايد النفايات الصلبة المسببة للتلوث وبشكل خاص نفايات النفط الخام والنفايات البوليمرية ، والتي بالإمكان إعادة تشكيلها باستخدام تقنيات اقتصادية مختلفة إضافة الى حماية البيئة من أي تأثيرات سلبية لاحقة .

إن هذه النفايات الصلبة (البوليمرية) قناني العبوات الغازية (البيبسي) (من النفط الخام) مادة الغير المتبقية (الاسفلت) .من البيئة المحلية او المصافي العراقية ثم أستخدامها في هذا البحث لتحضير مواد مركبة ذات أنظمة ثلاثية (اسفلت-ليف الاسبست-بولي اثلين)و(اسفلت-حبيبات كاربيد السليكون-بولي اثلين) وذلك لاستخدامها كروابط وعوازل للاسقف والجدران .

ثم استخدام نسب مختلفة من نفايات البولي اثلين وبنسب خلط (50,40,30,20,10) % نسبة وزنية لتحسين الخصائص الفيزو-كيميائية . اضافة الى تدعيم الخلطات المحسنة بمواد تقوية ليفية وحبيبية ومن مواد رخيصة ومتوفرة الاسبست وبنسب خلط (25,20,15,10,5) % نسبة حجمية وكاربيد السليكون (25,20,15,10,5)%نسبة وزنية لاجل تحسين الخصائص الميكانيكية - الحرارية للاسفلت المتبقي من مصافي الدورة .

وبعد اجراء الفحوصات (الفزيائية ،الكيميائية،الحرارية، والميكانيكية) تم التوصل الى الخلطة المثالية رقم 3 والمقواة بالياف الاسبست التي أعطت أفضل النتائج وبظروف تعتيق لمدة 7 ايام وبمختلف المحاليل الكيميائية (100% ماء ،5%حامض الكبريتيك ،5%هيدروكسيد الصوديوم).

وكانت نتائج الفقدان الوزني بالحرارة بتغير درجة الحرارة كما يلي : إن أفضل استقرارية حرارية واقل فقدان بالوزن كانت لنموذج 3 وتحديدا المقوى بالياف الاسبست حيث كان الفقدان بالوزن عند أعلى نقطة 500م 3غم وللنموذج المقوى بكاربيد السليكون عند نفس الدرجة 1.8 غم .

أما بالنسبة للتوصيلية الحرارية للنماذج المقواة بالألياف والحبيبات العازلـــة فكانـــت أفضل النتائج للنموذج المقوى بألياف الاسبست ،حيث تقل التوصيلية الحرارية بزيادة نسبة الألياف بين 0.009 واط لكل سم.درجة لنموذج الاسبست و 0.5 لنموذج كاربيد السليكون .

وكانت الخصائص الميكانيكية وتحديدا خاصية الشد للنماذج المقواة بالالياف والحبيبات بعد تعرضها للمحاليل الكيمياوية المختلفة (100% ماء ،5% حامض الكبريتيك ،5% هسدروكسيد الصوديوم) لمدة 7 ايام عند درجة حرارة 50°م كما يلي :

إن أفضل الخصائص الميكانيكية كانت للنموذج المقوى بألياف الاسبست حيث بلغـــت قيمة مقاومة الشد من 100–200 داين لكل سم مقارنة بالنماذج المقواة بالحبيبات حيث وصلت قيمة مقاومة الشد بين 60–78 داين لكل سم .

الكلمات الدالة

الأبنية ، التصميم المثالي ، الأغشية الإسفلتية المحسنة