

Synthesis and Characterisation of New Modified Anti-microbial Polyesteramide Resins by Partial Replacement with the Ingredient Source of The Polybasic Acid Based on Tetrabromophthalic Anhydride for Organic Surface Coatings

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NEW modified polyesteramide compositions were prepared and evaluated as antimicrobial vehicles for surface coating. The polyesteramide resins were obtained by means of a condensation polymerisation reaction between phthalic anhydride (PA) and N,N-bis-(2-hydroxyethyl) linseed oil fatty acid amide (HELA) as the ingredient source of the polyol used, and phthalic anhydride (PA), which was partially, replaced with tetrabromophthalic anhydride as the ingredient source of the dibasic acid. The structure of the resin was confirmed by acid value and FT-IR spectral studies. The modified polyesteramide vehicles of 40 ± 5 μm thickness were applied to the surface of glass panels by means of a brush. The coating performance of the resins was evaluated using international standard test methods and involved the measurement of physico-mechanical properties and chemical resistance. These tests revealed that, the modified polyesteramide based on tetrabromophthalic anhydride has been enhancing both physico-mechanical and chemical properties. Also, based on the results of the tests of biological activity for these resins, the resins were used as binders in primer formulations and evaluated as anti-microbial coatings. This was confirmed by storage in glass sample bottle for six month at ambient temperature and had their viscosity and there was no any bad odor and no any observed precipitated materials .

Keywords: Polyesteramide, Tetrabromophthalic anhydride, Surface coating, Antimicrobial coatings and Paints.

Polyesteramide resins (PEA) combine the advantages of both polyester and polyamide resins, such as high melting temperature, fast crystallization, good mechanical properties, good solvent resistance and low water absorption^(1,2). The presence of repeating units of ester (-COOR) and amide (-NHCOR) in the polymeric chain of polyesteramide improves the ease of application, thermal stability, chemical, water resistance, contributes to faster drying, and enhances hardness compared to normal alkyds⁽³⁻⁶⁾. Several polyesteramides have been synthesised, from conventional and non-conventional seed oils, to improve their drying ability and mechanical, corrosion protective efficiency⁽⁷⁻¹⁰⁾. The modification results in the formation of N,N-bis(2-hydroxyethyl) fatty acid amide (HEFA)

monomer, which plays a vital role in the synthesis of organic polymers, also finds application as a polymer cross-linker. Ahmed *et al.*⁽¹¹⁻¹⁴⁾ have successfully used it as a starting material for the development of polyetheramides, polyesteramides urethanes and polyamide urethanes, which find application as protective coating materials, and can be used as an effective antibacterial and biologically safe corrosion protective materials. New modified polyesteramide compositions were prepared and evaluated as anticorrosive varnish. The resin prepared by partial replacement of hydroxy ethyl fatty acid amide (HEFA) by polyethylene glycol (PEG), without affecting the resin constants. Primer formulations based on this resin showed good corrosion inhibiting properties⁽¹⁵⁾. Also, new anti-microbial paints and new anti-microbial modified polyesteramide compositions were prepared, and evaluated for surface coating and industrial applications. This modification, as expected, improved the film performance, durability and lead to substantial antimicrobial growth control⁽¹⁶⁻²³⁾. Actually, the investigation of new antimicrobial agents is important in this regards, bromine compounds have great importance in biological and industrial fields^(24,25). The aim of the present work was to characterise and evaluate new modified anti-microbial polyesteramide resins for use in protective coating formulations. These modified resins were prepared by partial replacement of phthalicanhydride(PA) with tetrabromophthalic anhydride(TBPA) as a new source of the polybasic source.

Experimental

Materials

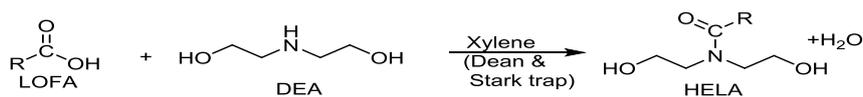
The used linseed oil fatty acid (LOFA) was supplied by Echantillon, Belgium, the phthalic anhydride (PA) by Avondate Laboratories, England and the diethanolamine (DEA) were obtained from Sdfine Indian. Sulphuric acid, anhydrous sodium carbonate, benzene, glacial acetic acid, ethyl acetate and tetrabromophthalic anhydride were obtained from El Nasr Pharmaceutical Company, Egypt. The xylene and mineral turpentine products were obtained from the Misr Petroleum Company, Egypt.

Methods and techniques

Synthesis of N, N-bis(2-hydroxyethyl)linseed oil fatty acid amide (HELA)

A mixture of freshly distilled diethanolamine (DEA) (11.55g, 0.11mol) and linseed oil fatty acid (28.0g, 0.1mol) was added to a 250 ml round-bottom flask fitted with a Dean and Stark trap. The mixture was allowed to reflux in the presence of 15% xylene until the theoretical amount of water (1.8ml, 0.1mol) was collected, indicating the complete formation of N,N-bis(2-hydroxyethyl) linseed oil fatty acid amide (HELA) as shown in Scheme 1.

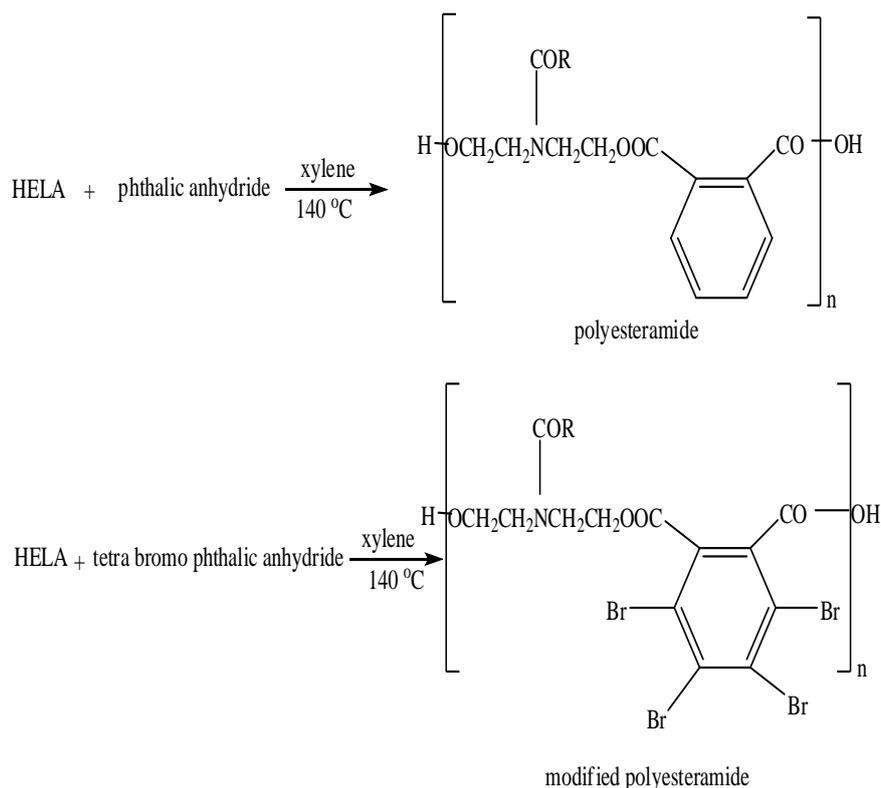
Preparation of modified polyester amide resin as shown by Scheme 1 and 2.



Scheme 1. Synthesis of N,N-bis (2-hydroxyethyl) linseed oil fatty acid amide (HELA).

Synthesis of polyesteramide and new modified anti-microbial polyesteramide resins

Polyesteramide resins were prepared through a condensation polymerisation reaction via a solvent process, in a one step reaction. A mixture of a calculated amount of hydroxyl ethyl linseed oil fatty acid amide (HELA), and phthalic anhydride (PA) replaced partially with tetrabromophthalic anhydride, as the ingredient source of the dibasic acid ingredient, was added to a 250 ml round-bottom flask fitted with a Dean and Stark trap, and refluxed in the presence of 10% xylene as shown in Scheme 2. The route of esterification was followed by observing the theoretical amount of water liberated. The resins were prepared, covering a wide range of oil lengths and hydroxyl content (0, 10, 20 and 30 % excess-OH). It should be noted that within each set of formulations, the total number of acid and hydroxyl equivalent for the various runs were kept constant⁽²⁶⁾. Resin characteristic constant and weight changes of the various formulations are illustrated in Tables 1 and 2. Alkyd calculations can be used to predict the completed formulation properties of the resin, the amount of reaction water liberated and the probable risk of gelation. The calculation of water evolved is also a useful tool for following the course of esterification reaction and to find the theoretical yield.



Scheme 2. Synthesis of polyesteramide /modified polyesteramide resin, R= alkyl chain of fatty acid.

TABLE 1. Resin constants for TBPA -modified polyesteramides.

Resin No.	Excess-OH (%)	Ingredients	E	F	e ₀	e _A	e _B	R	K	H ₂ O off (ml)
I_{a-d}	0	HELA	184	2	0.260	—	0.260	1.00	1.00	2.3
		TBPA	231.8	2	0.078	0.078	—			
		PA	74.1	2	0.181	0.181	—			
II_{a-d}	10	HELA	184	2	0.300	—	0.300	1.10	1.05	2.5
		TBPA	231.8	2	0.082	0.082	—			
		PA	74.1	2	0.191	0.191	—			
III_{a-d}	20	HELA	184	2	0.358	—	0.358	1.20	1.10	2.7
		TBPA	231.8	2	0.089	0.089	—			
		PA	74.1	2	0.208	0.208	—			
IV_{a-d}	30	HELA	184	2	0.44	—	0.44	1.30	1.15	3.1
		TBPA	231.8	2	0.10	0.10	—			
		PA	74.1	2	0.239	0.239	—			

HELA: Hydroxy Ethyl Linseed Amide; PA: Phthalic Anhydride; TBPA: Tetrabromophthalic Anhydride; E: Equivalent Weight; e_A: Number of acid equivalent; e_B: Number of hydroxyl equivalent; e₀: Total equivalent present at the start of the reaction; F: Functionality; Alkyl constant (m₀/e_A); R: Ratio of total-OH groups to total-COOH groups (e_B/e_A).

TABLE 2. List of hydroxyl equivalent of different runs .

Resin	HELA	TBPA
a	1.00	0.00
b	0.90	0.10
c	0.80	0.20
d	0.70	0.30

Measurements

The structure of the prepared tetrabromophthalicanhydride was confirmed by the melting point. The structure of the prepared N,N-bis (2-hydroxyethyl) linseed oil fatty acid amide (HELA) was confirmed by acid value (ASTM D 1639-96). Infrared spectra of the prepared polyesteramide resin was recorded in polymer/KBr pellets using (Shimadzu FT-IR 400) spectrometer, which was also undertaken for confirmation of the polyesteramide resin structure as shown in Fig. 1, and tabulated in Table 3. The colour (ASTM D 1544-04) of the prepared polyesteramide and the new modified anti-corrosive polyesteramides resins was undertaken using the (Gardner 1953 Standard Colour), whereas the viscosity (ASTM D 1545-07) was established by the use of (Gardner –Holdt) viscosity tubes..

Preparation of polyesteramide coatings

The solid content (ASTM D1644-01) of the modified and unmodified polyesteramide resins was adjusted by means of thinning with mineral turpentine to 50% solids for the 0, 10, 20 and 30% excess – OH samples. The resin samples were then filtered, and the driers combination added (Co, Zr and

Ca octoates, 0.04, 1.0 and 0.05% based on metal/solid resin, respectively). The resin material was then applied onto glass panels (ASTM D3891-02) and at room temperature by means of a brush.

Film casting and testing

Glass plates (100×150 mm) coated with the individual resins were utilised to measure the drying schedule, in terms of time of set-to-touch and dry - through times (ASTM D1640-03). In addition, the same coated glass plates were also used to measure the degree of gloss for individual resin coatings (ASTM 523-08). The measurements were undertaken using a gloss meter set at 20° angle. The chemical resistance (ASTM D 870-02, D 2792-04) of the dried resin coatings to different solvent media was undertaken on glass panels (25×75 mm). The coated steel strips were utilised to measure the coating film thickness (ASTM D 1005- 07), with this being undertaken using a Model 2100 Minitest microprocessor coating thickness gauge, manufactured by Electro – Physic, West Germany. The thickness of the coatings was found to be 40±5µm. The coated steel strips were also used to measure the mechanical resistance of the coated resin films, with testing undertaken on adhesion strength, by means of the cross-cut method (ASTM D 3359-02), flexibility (ASTM D 522-08), scratch hardness (ASTM D5178-98(2008)).

Microbiology assay

Test method of antimicrobial activity carried out according to ASTM, D5589-97 (Re-approved 2002).

1.a. Assay medium for antibacterial activity (g/l):

The nutrient agar medium was used for antibacterial assay. The medium has the following composition:

Pepton; 5.0, beef extract 3.0, NaCl 5.0 and agar 20. The PH of the medium was adjusted at 6.8-7.0 before sterilization.

1.b. Assay medium for anti-yeast activity (g/l):

Yeast extract-malt extract medium composed of: yeast extract 4.0, malt extract 10.0, cellulose (glucose) 4.0, and agar 20. The PH was adjusted at 7.3 before sterilization.

1.c. Assay medium for antifungal activity (g/l):

The Dox medium used for antifungal activity. This medium composed of :
Sucrose 20.0, NaNO₃ , 2.0, K₂HPO₄ 1.0, MgSO₄ . 7H₂O 0.5, KCl 0.5, FeSO₄. 5H₂O 0.001 and agar 20 . The PH was adjusted at 6-6.4 .

Organisms used

Bacteria employed in microbiological assay were *Micrococcus latus* NCTC 9341, *Staphylococcus aureus* NCTC 7447, *E.coli* Bppol, *Salmonella* . While

funguses were *Candida albicans* IMRU 366 g, *Aspergillus* flower, *Penicillium citricus* and *Suserium* .

Preparation of testing sample

The tested varnish was brushed on each side of a whatman filter paper (No. 30) and allowed to dry for 24 hr. The squares (1.25 in) coated filter paper was made then, sterilized by dipping in alcohol and placed centrally on the agar surface in the petri-dishes using a sterile for sepses.

Antimicrobial activity

(a) *The method used for bacteria and yeasts under investigation* : Twenty four hours old culture of each tested bacteria and forty eight hours old culture of each of the test yeasts were used. 5ml of sterile distilled water was added to culture tube, and mixed well by a vortex mixer . Five drops of the suspension was used to inoculate 100 ml. Nutrient agar medium (for test bacteria) or 100 ml yeast extract-malt extract medium (for test yeasts) at 45 °C. This was dispensed among Petri dishes in 20 ml portions. A coated filter paper discs (13mm) were aseptically put on the surface of the seeded plates with the different test organisms. The plates were left for 2 hr in a refrigerator for diffusion after which the plates were incubated at 30⁰C for 18 hr (for bacteria) or 48hr (for yeasts). The detection of clear zone around the paper disc is an indication of the antagonistic properties of the coated filter paper disc under study. For each test organism at least 4 discs were used for different concentration (0,10 ,20. and 30% excess-OH) of the varnish under investigation.

(b) *Method used for Fungi under investigation* : The spores and mycelia of each of the test fungi (48 hr old culture) were streaked on the surface of the plates of Dox. medium after pouring and solidification.

The method was preceded as previously described under item

The antimicrobial activity of the coated filter paper disc against a variety of microorganisms, including Gram-positive, Gram-negative, yeasts and fungi was investigated.

Results and Discussion

In recent years, there has been considerable interest in improving polyesteramide resins. A number of polyesteramides has been developed by the reaction of linseed oil fatty amide with dicarboxylic acids/anhydrides^(23,27,28). In the present work, the newly modified anti-corrosive polyesteramides resins were obtained by partial replacement of phthalic anhydride with tetrabromophthalic anhydride as the ingredient source of the polybasic acid. The reaction of LOFA with DEA to give HELA is demonstrated in Scheme 1, which was confirmed by acid value. The measured acid value was 6 to 10mg KOH/g, while the theoretical value is 0 mg KOH/g, the reaction of HELA and the source of dicarboxylic acid were followed and confirmed by acid value which ranged from 6 to 10mg KOH/g, whilst the theoretical value is 0 mg KOH/g as shown in Table 4, which indicated the complete formation of polyesteramide resins.

Spectral analysis of polyesteramide resin

Polyesteramide resins were prepared by the reaction of HELA with tetrabromophthalic anhydride or phthalic anhydride (PA) in the presence of xylene, as illustrated in Scheme 1. It contains both ester and amide linkages in the polymer backbone. This has been confirmed by both FT-IR spectral analyses, as shown in Fig.1. The key peaks of the IR spectra of polyesteramide are shown in Table 3, which indicates the presence of both ester and amide groups, confirming the formation of polyesteramide.

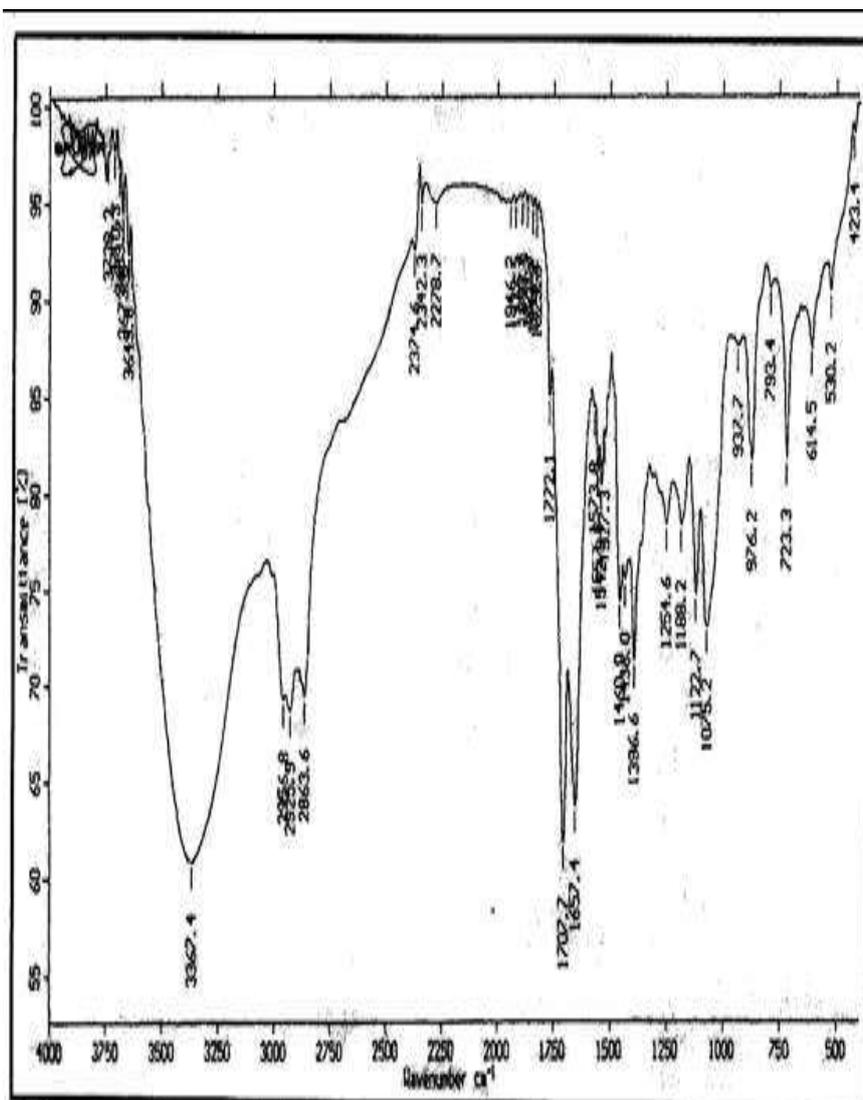


Fig.1. I.R. Spectrum of TBPA modified polyesteramide resin .

TABLE 3. FTIR spectra of modified polyesteramide resin.

Functional group	IR peak (cm ⁻¹)
OH broad band	3394
CH aliphatic	2863-2956
CON amide carbonyl	1657
CO ester carbonyl	1707
C-N	1460
Ring stretching vibration of aromatic nuclei	723

Physical-mechanical characterisation of the new modified anti-microbial polyesteramide resin

The effect of the tetrabromophthalic anhydride on the physical properties of the resin, *i.e.* colour, viscosity, air drying time was shown in Table 4. The effect on the chemical resistance and mechanical properties such as gloss, flexibility (bend), adhesion and scratch hardness was represented in Table 5. The results tabulated in Table 5 showed the polyesteramide and the new modified anti-microbial polyesteramide compositions, give a very clear transparent and homogenous appearance. The colour of resins was observed to be dark brown due to the presence of nitrogenous base, and the viscosity of resins increased with an increase in the percentage of both tetrabromophthalic anhydride and excess hydroxyl content. The drying time was observed to be proportional with both tetrabromophthalic anhydride and excess hydroxyl content. The mechanical characteristics of the various modified resins are tabulated in Table 5. The results indicated that the modified films showed outstanding performance, compared to unmodified films, the gloss results for the resins increased through modification, which may be attributed to the incorporation of dihydroxyl polyol containing a TBPA ring within the resin structure. The presence of the repeating units of ester (-COOR) in the polymeric chain of polyesteramide improved the ease of application. The flexibility test for the coated panel, carried out at the mandrel diameter of 6 mm, showed no evidence of cracks or de-laminating of the coating film. This high flexibility of the coating was attributed to the resin being composed of a polyester backbone. The cross-hatch test, carried out to determine the adhesion of the coating, clearly indicates that the modified coating has very good adhesion properties. Improvement of the mechanical properties appeared to be due to the combination of amide groups, which resulted in poly (amide), containing a TBPA within the resin structure.

TABLE 4. Varnishes characteristics data .

Resin No.	Excess-OH(%)	Replacement (% of TBPA)	Viscosity	Air Drying(HD) Time (hr)	Colour (Gardner)	Acid value mgKOH/g
I _a	0	0	F	4	15	10
I _b		10	H	3.45	16	8
I _c		20	J	3.30	17	6
I _d		30	M	3.30	17	8
II _a	10	0	G	4	18	10
II _b		10	I	3.30	16	10
II _c		20	L	3.15	18	6
II _d		30	N	3.30	18	8
III _a	20	0	H	3.30	15	7
III _b		10	I	3.15	17	9
III _c		20	N	3.0	17	6
III _d		30	P	3.30	18	9
IV _a	30	0	R	3.0	18	8
IV _b		10	T	2.45	18	10
IV _c		20	P	2.30	>18	7
IV _d		30	T	2.30	>18	6

TABLE 5. Effect of TBPA on mechanical and chemical properties of cured modified polyesteramide.

Resin NO	Gloss at 20°	Flexibility	Adhesion	Scratch hardness (1Kg)	Water Resistance Per(day)	Alkali ^{**} Resistance Per (day)	Acid [*] Resistance Per (day)	Solvent Resistance Per (day)
I _a	90	passed	3B	passed	25	2	17	passed
I _b	92	passed	4B	passed	25	4	18	passed
I _c	92	passed	4B	passed	28	4	20	passed
I _d	93	passed	5B	passed	29	5	22	passed
II _a	93	passed	5B	passed	25	3	18	passed
II _b	95	passed	5B	passed	27	4	20	passed
II _c	94	passed	5B	passed	29	5	21	passed
II _d	96	passed	5B	passed	28	6	23	passed
III _a	94	passed	5B	passed	26	3	20	passed
III _b	95	passed	5B	passed	27	5	22	passed
III _c	95	passed	5B	passed	29	6	24	passed
III _d	95	passed	5B	passed	30	5	21	passed
IV _a	96	passed	5B	passed	27	4	23	passed
IV _b	95	passed	5B	passed	29	6	24	passed
IV _c	96	passed	5B	passed	31	7	25	passed
IV _d	96	passed	5B	passed	31	8	26	passed

*Alkali concentration (Na₂CO₃) 5% by weight**Acid concentration (H₂SO₄) 10% by weight*Chemical resistance of the new modified anti-microbial polyesteramide resin*

The chemical resistance testing of the new modified anti-corrosive polyesteramide resins was undertaken on glass panels (25×75mm). The resin coated glass panels were sealed using paraffin wax on the edges of the panels. The samples were immersed to half their length in the various test solutions (water, 5% by weight anhydrous sodium carbonate, 10% by weight sulphuric

acid, and benzene/mineral turpentine solvent mixture (1:3 by volume). The panels were then removed from the solution, wiped carefully and allowed to dry at room temperature, prior to testing for any change. The obtained data was tabulated in Table 5. The data indicated that, an increase the levels of tetrabromophthalic anhydride lead to a substantial improvement in the films resistance towards water, acid and alkali resistance. This may well be attributable to the introduction of the TBPA compound within the resin structure. However, the tetrabromophthalic anhydride does not appear to affect the alkali and the solvent resistance properties, since all the examined films showed excellent performance within the experimental time of 30 days.

Antimicrobial activity tetrabromophthalic anhydride (TBPA) - modified polyesteramide resins

The results obtained from the antimicrobial activity were shown in Table 6 and Fig.2. The antimicrobial activity of the blanket sample (polyesteramide without replacement of TBPA) was evaluated by testing it against eight different micro-organisms such as Gram – negative bacteria (G-), Gram- positive (G+) bacteria and fungi. 20 and 30 % Ex-OH were found possess i) moderate antimicrobial activity against Gram- negative bacteria (G-) [*Escherichia coli*], showed higher sensitivity than *salmonella* ii) high antimicrobial activity against Gram- positive bacteria (G+) 30 % Ex-OH were very effective against *Micrococcus luteus* and *Staphylococcus aureus*], and iii) mild antimicrobial activity against fungi and yeast [*Aspergillus flower* and *Candida albicans*, *Penicillium citricus* and *Suserium* showed also the moderate antimicrobial activity. It can be observed that, the antimicrobial activity against the target micro-organisms increases with the increase of replacement of TBPA in the excise of -OH .

We believe that antimicrobial activity results contribute to circumvent the accumulation of organisms on the coating surfaces and contribute to the hazardous materials and ecological coating chemistry.

TABLE 6 . Biocides activity of TBPA modified polyesteramide .

Microorganisms	(0 % excess OH).	(10 % excess OH).	(20 % excess OH).	(30 % excess OH).
<i>Micrococcus luteus</i> ATCC 9341	+ve	++Ve	+++Ve	++++Ve
<i>Staphylococcus aureus</i> NCTC 7447	+Ve	++Ve	+++Ve	++++Ve
<i>Escherichia coli</i>	-ve	+Ve	+Ve	++Ve
<i>Salmonella</i>	-Ve	+ve	++Ve	+++V
<i>Candida albicana</i> IMRU 3669	-Ve	+Ve	++ve	++Ve
<i>Aspergillus flower</i>	-Ve	+Ve	++Ve	++Ve
<i>Penicillium citricus</i>	-Ve	+Ve	++Ve	+Ve
<i>Suserium</i>	-Ve	+Ve	++Ve	++Ve

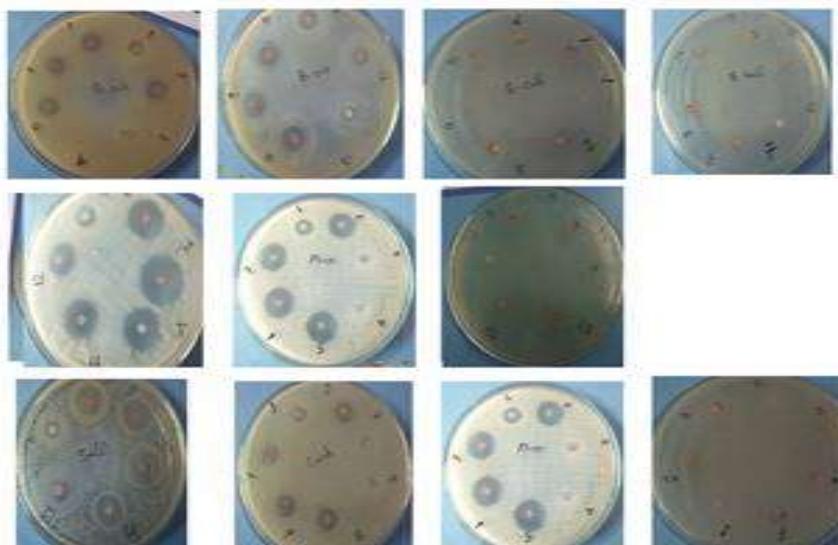


Fig.2. Biocides activity of TBPA modified polyesteramide .

Stability of paint formulation based on antimicrobial modified polyesteramide

All of the prepared paint formulation based on antimicrobial modified polyesteramide were stored in glass sample bottle for six month at ambient temperature, and had their viscosity and extent of precipitation observed at regular intervals. It was found that all of the paint formulation based on antimicrobial modified polyesteramide prepared had relatively constant viscosity and that no precipitation was found. The paint formulations based on TBPA modified polyesteramide were shown in the Table 7.

TABLE 7. Primer formulations of based on [TBPA] modified polyesteramide resin .

Ingredient (wt %)	Formulation no.															
	I _a	I _b	I _c	I _d	II _a	II _b	II _c	II _d	III _a	III _b	III _c	III _d	IV _a	IV _b	IV _c	IV _d
PEA	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
CaCO ₃	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37
Iron oxide red brown	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Zincphosphate	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Xylene	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Benton	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Methanol	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Zr-octoate	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Co octoate	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Anti skin	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Conclusion

We have successfully modified polyesteramide resin, by the partial replacement of phthalic anhydride (PA) as dibasic acid source by tetrabromophthalic anhydride. The modified resin showing enhanced physico-mechanical properties such as gloss, adhesion, scratch hardness. It is also observed that, the modified resin shows better film performance in terms of chemical resistance to water, acid and alkali. The antimicrobial activity of the modified TBPA resins, incorporated within primer formulations, also improved with increased levels of the modifier; this was confirmed by stability of paint formulations without any biocide additives and no any bacterial growth for one year. This improvement may be attributed to (i) the combination of amide groups, which results in poly (amide), which containing a TBPA compound within the resin structure; (ii) the presence of bromine atoms in the polymeric chain of the modified polyesteramide; and (iii) the high molecular weight of the modifier decreases the permeability of the coating to the different bacteria and fungi.

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تحضير وتوصيف راتنجات جديدة ومطورة للميكروبات من البولى استراميد وذلك باستبدال جزئى لمصدر عديد الكربوكسيل القائم على التترابروموفيثاليك انهيدريد لطلاءات السطوح العضوية

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تم تحضير وتقييم راتنجات جديدة ومطورة من البولى استر اميد كحوامل مضادة للميكروبات لطلاءات السطوح ، وتم الحصول على راتنجات البولى استر اميد عن طريق البلمرة بالتكاثف بين انهيدريد حامض الفيثاليك والذي يتم استبداله جزئيا بمركب رباعى برومو انهيدريد حامض الفيثاليك كمصدر لمجموعات الكربوكسيل فى عملية البلمرة وبين مركب هيدروكسى ايثيل اميد للحامض الدهنى لزيت بذرة الكتان كمصدر لمجموعات الهيدروكسيل فى عملية البلمرة بالتكاثف ، التركيب النهائى للبوليمر الناتج تم اثباته من خلال قياس درجة الرقم الحامضى للبوليمر الناتج وايضا من خلال دراسة الاشعة تحت الحمراء وتم تطبيق راتنجات البولى استر اميد كحوامل من خلال عملية الدهان بالفرشاة على شرائح زجاجية لسمك فيلم يصل الى ما بين 40 الى 45 ميكرون. وقد تم تقييم اداء طلاء الراتنجات باستخدام طرق الاختبار القياسية والتي تتضمن الخواص الفيزيائية والميكانيكية ومقاومة الكيماويات . هذه الاختبارات عززت ان استخدام راتنجات البولى استر اميد القائم على رباعى برومو انهيدريد حامض الفيثاليك يعزز كل من الخصائص الفيزيائية والميكانيكية للأفلام . تم عمل اختبار المقاومة لهذه الراتنجات المطورة لبعض البكتيريا موجبة وسالبة الجرام وأيضا بعض الفطريات واعطت نتائج مباشرة مما ادى الى استخدامها كحوامل فى تركيبات دهانات اولية تم تقييمها كدهانات مضادة للميكروبات وتم التأكد لذلك من خلال تخزين الدهان فى عبوات زجاجية لمدة ستة اشهر عند درجات حرارة الغرفة وتم التأكد من خلال ثبات درجات اللزوجة للراتنجات وايضا عدم وجود اى روائح كريهة وعدم وجود اى مواد مترسبة فى الدهان.