

Synthesis and Characterization of Thiazole Derivatives and Evaluating their Performance as Additives in Polyurethane Coating

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IN the last few decades, a lot of work has been done on thiazole derivatives due to their versatile utility associated with them. Thiazole derivatives have been reported to exhibit biological activity and are widely used as pharmaceuticals. In this research, a series of thiazole derivatives were prepared, the structures of the products were established by elemental analysis, FTIR, ¹H NMR and mass spectroscopy. The prepared thiazole derivatives A, B and C, were incorporated physically into polyurethane coating as an additive. Experimental coatings were manufactured on a laboratory scale and applied by brush on steel and wood panels. The coated films were screened against Gram-negative bacteria, Gram-positive bacteria and fungi to evaluate the antimicrobial activity of the prepared thiazole derivatives. A flame retardant property of the prepared thiazole derivative compounds was evaluated by measuring the limiting oxygen index (LOI) of the coated films. The mechanical properties of these coated films were also examined to evaluate the drawbacks of the thiazole derivative additive. The obtained results showed that, the physical incorporation of thiazole derivative have led to improve the antimicrobial, flame retardancy and mechanical properties of polyurethane coating.

Keywords: Thiazole, Antimicrobial coating, Flame retardant coating and Polyurethane coating.

Polyurethanes are an important class of polymers that have wide application in a number of different industrial sectors such as coatings, foams, adhesives, sealants and elastomers ⁽¹⁾. In 1947 the birth of polyurethanes (PUs) occurred in Germany when Bayer laboratories explored their use as fibre-forming polymers ⁽²⁾. Polyurethane topcoats, recommended for paint systems commonly utilized for corrosion protection of steel structures used in highly corrosive atmospheres (C5 category) ⁽³⁾. Polymers such as polyurethane and polyester are susceptible to

microbial attack, when they are exposed to the atmosphere or used as an adhesive or a coating material⁽⁴⁻⁶⁾. Micro-organisms have been found to cause blistering damage of coating materials under various service conditions⁽⁷⁻⁹⁾. New antimicrobial additives based on pyrimidine derivative incorporated physically into polyurethane varnish for surface coating and into printing ink paste were prepared and evaluated⁽¹⁰⁾. Also, arylhydrazone ligand and its metal complexes and their potential application as flame retardant and antimicrobial additives in polyurethane for surface coating were prepared and evaluated⁽¹¹⁾. New antimicrobial additives based on pyrazole and triazole derivatives incorporated physically into polyurethane varnish for surface coating and into printing ink paste were prepared and evaluated⁽¹²⁾. Thiazole derivatives are some of the oldest and most commonly known class of nitrogen and sulphur containing compounds. Compounds containing thiazole rings are a familiar group of heterocyclic compounds possessing chemotherapeutic properties. Thiazole is a parent material for various chemical compounds, including sulphur drugs, dyes and chemical reaction accelerators. Some thiazole derivatives are used as bactericidal and antimicrobial additives for paints^(13,14) and fungicidal agents⁽¹⁵⁾. Synthesis and characterization of coumarin thiazole derivative 2-(2-amino-1,3-thiazol-4-yl)-3*H*-benzo[*f*]chromen-3-one with anti-microbial activity and its potential application in antimicrobial polyurethane coating were reported⁽¹⁶⁾. The chemistry of thiazole derivatives continues to draw the attention of synthetic organic chemists due to their varied biological activities⁽¹⁷⁻¹⁸⁾. The thiazole nucleus is an integral part of all the available penicillin, which have revolutionized the therapy of bacterial diseases. Thiazoles have a continuing interest due to its variable biological activities, which have found many applications in the treatment of many diseases and as antimicrobial additives in organic coatings^(19,20). Thiazole derivatives also belong to organic heterocyclic compounds, which are added at small concentrations as corrosion inhibitors^(21,22). Thiazole derivatives are considered non-cytotoxic substances, with the potential to replace other toxic organic inhibitors used for the corrosion protection of metals. Demand for flame retardant polyurethane paints is extremely strong within the surface coatings industry. Several attempts to increase the thermal stability of polyurethanes by means of introducing thermally stable groups have been reported⁽²³⁻²⁶⁾. Flame retardants may be incorporated into polymeric materials either as additives or as reactive materials. Additive-type flame retardants, which are widely used, are generally incorporated into polymers by physical means^(27, 28). Synthesis and characterisation of the flame retardant properties and corrosion resistance of Schiff's base compounds incorporated into organic coating were reported⁽²⁹⁾. New modified reactive flame-retardant alkyd resin based on tetrabromophthalic anhydride as varnish for surface coatings were prepared and evaluated⁽³⁰⁾. Also, new flame retardant additives based on cyclodiphosph (V)azane of sulfaguanidine, 1,3-di- [N/-2-pyrimidinyl-sulfanilamide] - 2, 2, 2,4, 4, 4- hexachlorocyclodiphosph (V) azane and 1,3-di-[N/-2-pyrimidinylsulfanilamide]-2, 4-di[aminoacetic acid]-2, 4-dichlorocyclodiphosph (V)azane incorporated into polyurethane varnish were prepared and evaluated⁽³¹⁾. This obviously provides the most economical and expeditious way of promoting flame retardancy for commercial polymers. In view of the above-mentioned

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facts, this study reports the synthesis, characterization and evaluation of thiazole derivative compound and studies their potential application as an antimicrobial and flame retardant additive in surface coating. These compounds were anticipated to improve the biological activities and the flame resistance of polyurethane coating. The mechanical properties were also studied to evaluate any drawbacks associated with the additive.

Experimental

Materials

All the chemicals used during the project were sourced either locally, or from international companies.

Methods and techniques

The prepared thiazole derivatives A, B and C were prepared using the method of Koelsch⁽³²⁾

Synthesis of 3-(2-(Phenylamino)thiazol-4-yl)-2H-chromen-2-one (compound A)

A mixture of 3-(2-bromoacetyl)-2H-chromen-2-one (2; 0.01 mol, 2.67 g) and 1-phenylthiourea (0.01 mol, 1.52 g) was dissolved in 30 ml absolute ethanol. The reaction mixture was then refluxed for 2 hr. A precipitate formed on cooling, which was collected by means of filtration, washed with ethanol and dried under vacuum. The solid obtained was then recrystallized with an ethanol/benzene solvent mixture.

Synthesis of 3-(2-Hydrazinylthiazol-4-yl)-2H-chromen-2-one (compound B)

A mixture of 3-(2-bromoacetyl)-2H-chromen-2-one (2; 0.01 mol, 2.67 g) and hydrazine carbothioamide (0.01 mol, 1.08 g) was dissolved in 30 ml absolute ethanol. The reaction mixture was then refluxed for 2 hr. A precipitate formed on cooling, which was collected by means of filtration, washed with ethanol and dried under vacuum. The solid obtained was then recrystallized with an ethanol/benzene solvent mixture.

Synthesis of 3-(2-(2-(4-Fluorobenzylidene)hydrazinyl)thiazol-4-yl)-2H-chromen-2-one (compound C)

Procedure A: A mixture of 3-(2-bromoacetyl)-2H-chromen-2-one (2; 0.01 mol, 2.67 g) and 2-(4-fluorobenzylidene)hydrazine carbothioamide (0.01 mol, 1.97 g) in ethanol (30 ml) was refluxed for 4 hr. The obtained product that formed was collected by filtration and recrystallized from ethanol.

Procedure B: A mixture of 3-(2-hydrazinylthiazol-4-yl)-2H-chromen-2-one (6; 0.01 mol, 2.58 g) and 4-fluorobenzaldehyde (0.01 mol, 1.24 g) was dissolved in 30 ml of absolute ethanol in the presence of piperidine as a catalyst. The reaction mixture was then refluxed for 5 hr. A precipitate formed on cooling, which was collected by means of filtration, washed with ethanol and dried under vacuum. The solid obtained was then recrystallized with an ethanol solvent mixture, resulting in yellow coloured crystals.

Characterization techniques

The IR spectra were recorded in Mac FT-IR spectrometer (KBr technique); the ^1H NMR spectra (DMSO- d_6) were measured with a Varian Mercury-300 NMR spectrometer at Micro-analytical Centre, Cairo University. Mass spectroscopy was measured at the Regional Centre for Mycology and Biotechnology, Al-Azhar University.

Coating composition and film preparation

The coating compositions were prepared by means of incorporating thiazole derivatives A, B and C, in the ratio of 0.5, 1.0 and 1.5 %, into polyurethane varnish. The composition of polyurethane varnish is tabulated in Table 1. The coating compositions were applied to steel, glass and wood panels by means of a brush. All efforts were made to maintain a uniform film thickness of 50 +/- 5 μm for evaluating the physical and mechanical properties.

TABLE 1. Composition of the studied polyurethane varnish.

Component	wt %
Refined sunflower oil	33.42
Glycerol	0.039
Litharge (lead oxide catalyst)	00.03
Pentaerythritol	04.61
Turpentine	47.30
Barium octoate drier	00.26
Toluene diisocyanate	11.37
Mixed drier	02.11
UV absorber	00.26
Anti-skinning agent	00.32
Fire retardant additives	00.30 to 01.30

Properties: viscosity: G-I (Gardner), colour: 3 (Gardner), solid content: 53 \pm 2%

Antimicrobial screening

The antimicrobial activity of the synthesized thiazole derivatives A, B and C was tested against six different micro-organisms namely, Gram-negative bacteria such as *P. aeruginosa*, *E. coli* and Gram-positive bacteria such as *S. pneumonia*, *B. subtilis* and fungi such as *A. fumigates*, *G. candidum*. The test was performed using the diffusion agar technique at the Regional Centre for Mycology and Biotechnology, Al- Azhar University.

Paper disc diffusion method for determination of anti-microbial activity

The paper discs are soaked with a select antibiotic, or chemical, and then placed on a lawn of bacteria in a petri- dish. The zones of inhibition are measured around where the disc was placed, to determine whether the bacterium was resistant, or susceptible, to the particular antibiotic, or chemical, chosen. The sterilized medium (autoclaved at 120°C for 30 min) was incubated at 40-50°C (1 ml/100 ml of medium) with the suspension (10⁵ CFU ml⁻¹) of the micro-organism matched to McFarland barium sulphate standard and poured into a petri-dish, to

give a depth of 3-4 mm. The paper impregnated with the test compounds (mg/ml-1) was placed on the solidified medium. The plates were pre-incubated for 1 hr at room temperature and incubated at 37 °C for 24 and 48 hr for anti-bacterial and anti-fungal activity, respectively. Cefepime (mg/disc) was used as a standard for anti-bacterial and anti-fungal activity.

Flame retardant testing method

The performance of polyurethane varnish, with incorporated thiazole derivatives A, B and C additives, was evaluated in a limited oxygen index (LOI) chamber. LOI values were determined by standardized tests such as ISO 4589-1: 1996 and ASTM D: 2863-97. Test panels were prepared using a combustible material (wood specimen). It was important that the panels were free of any surface contamination, or imperfections, prior to the coating application. Hand tool cleaning (sand paper) was carefully used to treat the faces and edges of the panels. Final dry film thickness (DFT) was 100 +/- 5µm. In all cases, the film application was applied by means of brushing. Following 10 days of air drying, the panels under study were heated at 50-60°C for 2 hr to eliminate any remaining solvent.

Physical and mechanical testing of films

The steel panels were prepared according to ASTM D: 609-95, the dry film thickness was measured according to ASTM D: 1005-95, the degree of gloss was measured according to ASTM 523-08, the film hardness was measured according to ASTM Method D: 3363-92a, adhesion cross hatch was measured according to ASTM Method D: 3359-95a and the flexibility was measured according to ASTM Method D: 522-93a.

Results and Discussion

Synthesis of thiazole derivatives A, B and C

Thiazole derivatives A, B and C were prepared and purified as illustrated in the Experimental section. The chemical structure of the prepared compounds A, B and C is represented in Scheme 1. Elemental analysis, reaction yield and physical properties such as melting point and product colour were measured and listed in Table 2.

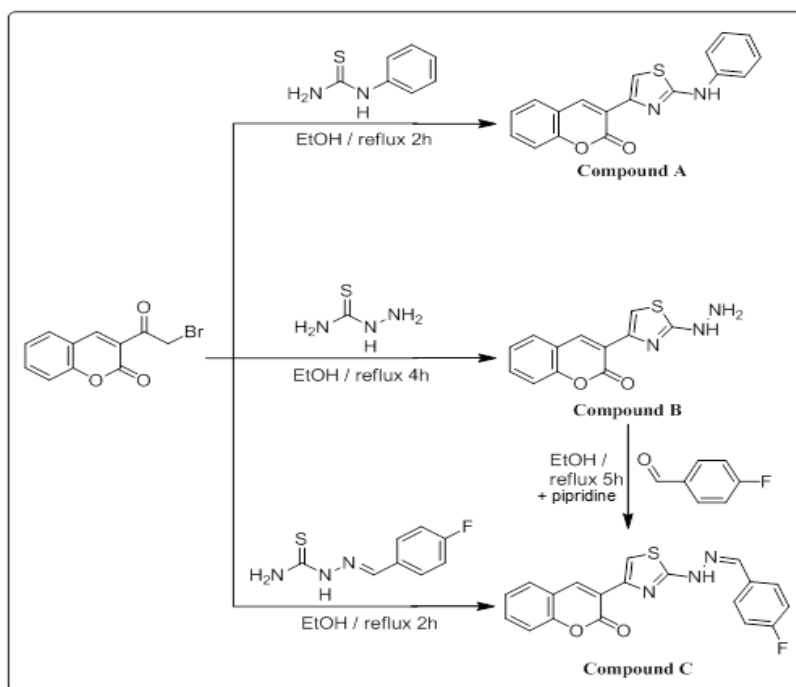
Spectral analysis of the prepared thiazole derivatives A, B and C

IR, ¹H NMR and mass spectra for the prepared thiazole derivatives A, B and C are summarized as follow:

Spectral analysis of 3-(2-(Phenylamino)thiazol-4-yl)-2H-chromen-2-one (compound A)

IR (KBr, cm⁻¹): ν_{\max} = 3139 (NH), 3096 (CH aromatic), 1710 (C=O), 1611 (C=N), 1568 (C=C). ¹H NMR (DMSO-*d*₆): δ = 6.58-7.97 (m, 10H, Ar-H + H₅-thiazole), 8.69 (s, 1H, H₄-Chromene), 10.32 (s, 1H, NH, Discharged with D₂O). MS *m/z* (%): 322.10 [M⁺+2] (7.81), 321.11 [M⁺+1] (24.68), 320.11 [M⁺]

(100.00), 319.09 (56.05), 305.06 (5.66), 291.08 (5.66), 275.09 (4.60), 150.05 (7.63), 145.04 (6.43), 102.06 (10.70), 77.05 (9.89), 51.05 (4.63).



Scheme 1. Synthesis of the prepared thiazole derivatives A, B and C.

TABLE 2. Physico-chemical properties of the prepared thiazole derivatives A, B and C.

Compound C	Compound B	Compound A	Characteristics	
$C_{19}H_{12}FN_3O_2S$	$C_{12}H_9N_3O_2S$	$C_{18}H_{12}N_2O_2S$	Formula	
162 -165	235- 237	243 -245	Melting point ($^{\circ}C$)	
65	78	77	Yield (%)	
Yellow	Brown	Yellowish -green	Colour	
62.46	55.59	67.48	Calc. found	Elemental analysis (%)
62.28	55.64	67.27	Calc. found	
3.31	3.5	3.78	Calc. found	
3.17	3.39	3.49	Calc. found	
11.5	16.21	8.74	Calc. found	
11.36	16.04	8.8	Calc. found	
8.78	12.37	10.01	Calc. found	
8.62	12.19	9.94	Calc. found	
365.38	259.28	320.36	Calc. found	Mass
365.08	261.03	322.1	Calc. found	

Spectral analysis of 3-(2-Hydrazinylthiazol-4-yl)-2H-chromen-2-one (compound B)

IR (KBr, cm^{-1}): ν_{max} = 3751, 3432 (NH₂, NH), 1713 (C=O), 1606 (C=N), 1554 (C=C). ¹H NMR (DMSO-*d*₆): δ = 3.61 (br, 2H, NH₂, Discharged with D₂O), 6.95-8.48 (m, 9H, Ar-H + Thiazol H Coumarin H +NH). MS *m/z* (%): 261.03 [M⁺+2] (21.79), 259.04 [M⁺] (32.83), 224.08 (100.00), 229.07 (25.80), 228.08 (40.79), 216.09 (41.81), 212.12 (17.40), 201.09 (21.46), 187.10 (14.98), 174.05 (27.61), 171.08 (53.86), 143.09 (41.39), 115.10 (30.33), 102.09 (89.40), 63.06 (49.73), 50.06 (22.08).

Spectral analysis of 3-(2-(2-(4-Fluorobenzylidene)hydrazinyl)thiazol-4-yl)-2H-chromen-2-one (compound C)

IR (KBr, cm^{-1}): ν_{max} = 3423 (NH), 3148 (CH aromatic), 1722 (C=O), 1610 (C=N), 1507 (C=C), 1157 (C-F). ¹H NMR (DMSO-*d*₆): δ = 4.02 (br, 1H, NH), 7.20-8.89 (m, 12H, Ar-H + thiazole H + coumarin H +Methine H). MS *m/z* (%): 365.08 [M⁺] (9.71), 245.07 (14.34), 244.06 (100.00), 216.06 (9.93), 211.06 (18.19), 174.04 (9.45), 172.03 (31.58), 155.08 (2.66).

Evaluation of film properties

Evaluation of the antimicrobial activity of thiazole derivatives A, B and C as a biocide additive

Biological species start to adhere to the coating surface under various service conditions and this can eventually lead to damage of coatings. Biocide additives are commonly used to prevent, or slow down, the growth of organisms on the coating surface. In paint manufacture, there are two types of biocide additives, one is used for wet-state protection to prevent bacteria and fungi from spoiling the paint during storage, and the second is used to prevent fungi and algae from growing on the coated surface. Thiazoles are chemically stable being capable of imparting anti-microbial activity properties when incorporated into polymers and their composites. The anti-microbial activity of the blank and blended polyurethane varnish formulations was evaluated by subjecting them to Gram-negative bacteria, Gram-positive bacteria and fungi. The results obtained from the anti-microbial activity shown in Table 3 showed that, the incorporation of thiazole derivatives A, B and C, by physical means, into polyurethane coating in the levels mentioned in the experimental section, results in excellent anti-microbial activity when compared alongside a blank polyurethane control sample. It also observed that the anti-microbial activity against the target microorganisms increases with the increase in the biocide additive level. The antimicrobial activity of the prepared thiazole derivative compounds was in order C > B > A.

Compound C was found to possess i) high anti-microbial activity against Gram-positive bacteria (*B. subtilis* shows a higher sensitivity than *S. pneumoniae*), ii) moderate anti-microbial activity against Gram-negative bacteria (*E. coli* shows a higher sensitivity than *P. aeruginosa*) and iii) mild anti-microbial activity against fungi (*G. candidum* shows a higher sensitivity than *A.*

fumigatus). The anti-microbial activity of polyurethane coating was improved with the addition of thiazole derivatives. Thiazole or 1,3-thiazole is a heterocyclic compound which has a five-membered ring containing three carbon, one sulphur and one nitrogen atom is found in many potent biologically active compounds. The thiazole ring, also shows remarkable activity against bacteria due to the presence of (=N-C-S) moiety and due its aromaticity. Finally, 2-amino thiazole derivatives are reported to exhibit significant biological activity. The belief is the anti-microbial activity results contribute to circumvent the accumulation of organisms on the coating surface and contribute to the hazardous materials and ecological coating chemistry.

TABLE 3. Anti-microbial activity of polyurethane varnish incorporated thiazole derivatives A, B and C.

Fungi		Bacteria				%	Formulation
		Gram-negative		Gram-positive			
<i>G. candidum</i>	<i>A. fumigatus</i>	<i>E. coli</i>	<i>P. aeruginosa</i>	<i>B. subtilis</i>	<i>S. pneumoniae</i>		
29	24	21	17	32	24	-	Blank polyurethane
29	24	22	17	32	26	0.5	Blank polyurethane & Compound A
32	25	24	21	35	30	1.0	
35	27	27	24	38	33	1.5	
28	23	22	18	33	28	0.5	Blank polyurethane & Compound B
31	27	25	22	37	33	1.0	
34	30	28	25	41	36	1.5	
28	23	22	18	33	27	0.5	Blank polyurethane & Compound C
32	26	26	23	37	31	1.0	
35	31	28	26	42	36	1.5	

Mean zone of inhibition in mm.

Evaluation of the flame retardant activity of thiazole derivatives A, B and C

Flame retardant properties of the polyurethane varnish blended with thiazole derivatives A, B and C were evaluated by means of the limiting oxygen index (LOI) test. The LOI is defined as the minimum concentration of oxygen, expressed as a percentage that will support combustion of a polymer. It is measured by passing a mixture of oxygen and nitrogen over a burning specimen, and reducing the oxygen level until a critical level is reached. A high oxygen concentration requirement indicates better flame retardancy of the specimen. This method is suitable as a semi-qualitative indicator of the effectiveness of the flame retardant during the research and development phase of the work. This is due to the fact that the equipment is relatively inexpensive and the size_of the test sample required is small. It is

clear that the incorporation of thiazole derivatives A, B and C, physically added into polyurethane varnish in the ratios mentioned in the Experimental section, results in excellent flame retardancy when compared alongside a blank polyurethane sample. The results obtained from the LOI test are shown in Table 4 and Fig. 1&2. It can be observed that the LOI value of polyurethane varnish without an additive compound is 20 and the maximum LOI with additive compound C is 48. Normal atmospheric air (*i.e.* the air that we breathe in) is approximately 21% oxygen, so a material with an LOI of less than 21% would burn easily in air. In comparison, a material with a LOI value of greater than 21% but less than 28% would be considered to be 'slow burning'. However, a self-extinguishing material is one that would stop burning after the removal of the fire or ignition source. The increased amount of thiazole derivatives A, B and C additives increases the LOI value of the polyurethane varnish formulation. This is due to the incorporation of the thiazole ring into the network of the thermoset polyurethane varnish, which increases the flame retardancy of the polymer. This is due to the flame retardant synergy of the sulphur and nitrogen content. An interesting point associated with the results is that the LOI curves for the three thiazole compounds A, B and C are more or less linear. This is as a result of the fact that they are high molecular weight compounds containing sulphur and nitrogen, and therefore provide superior flame retardant properties compared to low molecular weight flame retardants. A further interesting point is that the LOI values of compound C is the highest, whilst compound A is the lowest.

TABLE 4. The flame retardant activity of polyurethane varnish incorporated thiazole derivatives A, B and C.

Formulation	%	Limiting oxygen index (LOI)
Blank polyurethane	-	20
Blank polyurethane & Compound A	0.5	25
	1.0	32
	1.5	37
Blank polyurethane & Compound B	0.5	28
	1.0	38
	1.5	44
Blank polyurethane & Compound C	0.5	39
	1.0	43
	1.5	48

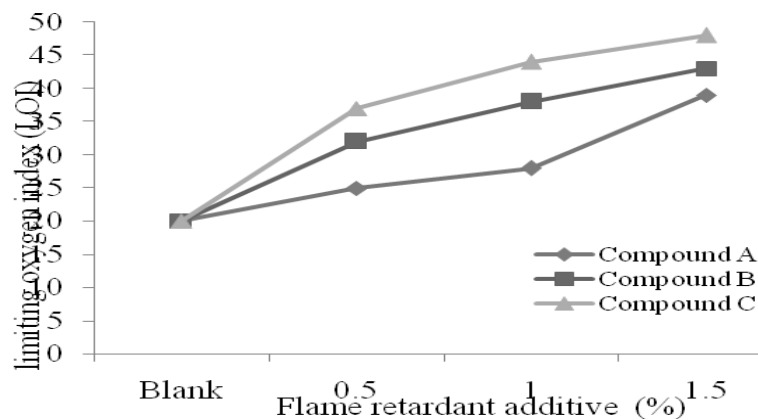


Fig.1. Flame retardant properties of polyurethane varnish incorporated thiazole derivatives A, B and C.

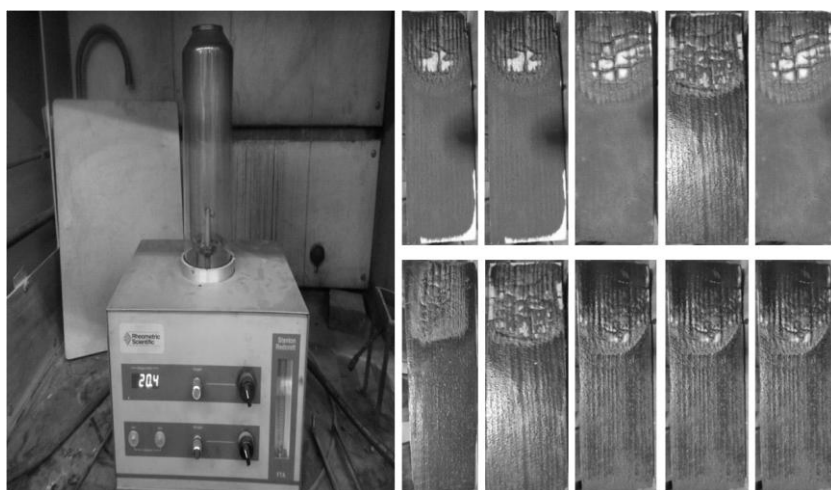


Fig. 2. LOI cabinet and coated wood tested samples.

Evaluation of the physical and mechanical properties of polyurethane varnish incorporated thiazole derivatives A, B and C

The effects of adding thiazole derivatives A, B and C to the polyurethane varnish, in respect of the physical and mechanical properties, were evaluated as per the standard test methods. This was done to ascertain any negative aspects that might arise due to the presence of the additives. The gloss, scratch hardness, cross hatch adhesion and flexibility were all measured. The resulting data are shown in Table 5.

TABLE 5. Physical and mechanical characteristics of polyurethane coating incorporated compound thiazole derivatives A, B and C.

Formulation	%	Gloss at 60 °C	(Kg)Hardness	Adhesion	Flexibility
Blank polyurethane	-	70	1.5	5B	Pass
Blank polyurethane & Compound A	0.5	86	1.7	5B	Pass
	1.0	89	1.8	5B	Pass
Blank polyurethane & Compound B	1.5	90	1.9	5B	Pass
	0.5	70	1.6	5B	Pass
	1.0	80	1.7	5B	Pass
Blank polyurethane & Compound C	1.5	85	1.8	5B	Pass
	0.5	88	1.6	5B	Pass
	1.0	95	1.8	5B	Pass
	1.5	98	1.9	5B	Pass

Gloss: This was measured using a Sheen UK glossmeter. On observing the films using a 60° angle, it could be seen that the thiazole derivatives A, B and C additives actually increased the gloss levels. This is obviously a positive result which may be attributed to the introduction of aromatic rings, present in the additive structure. A further interesting point is that the gloss values of compound C is the highest, whilst compound B is the lowest.

Scratch hardness test: This was determined by using a Sheen UK hardness tester. The scratch hardness is observed to vary between 1.5-1.9 Kg and it is clear from the data that as we increase the thiazole derivatives A, B and C additive, the scratch hardness of the film increases.

Cross-hatch adhesion test: This was measured by using a Sheen UK crosscut adhesion tester. For this test method a lattice with six cuts in each direction was made in the film (the cuts were spaced at 1 mm). Pressure-sensitive tape was then applied over the lattice and subsequently removed. All the coating film demonstrated good cross-hatch adhesion. The thiazole derivatives A, B and C additive did not change the adhesion properties of the polyurethane varnish formula.

Flexibility (bend) test: Flexibility was determined by using a ¼ inch Mandrel bend tester from Sheen UK, in such a way that the surface of the panel was directed outside. The films for all the coating compositions passed the ¼ inch Mandrel bend test. The varnish was considered satisfactory if no cracking marks, or dislodging, is observed following the bending procedure. Based on this qualitative measurement, it can be stated that all the films showed reasonably good flexibility.

Conclusions

In this study thiazole derivatives A, B and C were synthesized, characterized and added physically as a biocide additive to polyurethane varnish. It also evaluated as a flame retardant additive. The antimicrobial activity of the polyurethane coating incorporated these additive was screened against Gram-negative bacteria, Gram-positive bacteria and fungi. The flame retardancy of these compounds was characterized by the limiting oxygen index (LOI) test of the coated films, the physical and mechanical properties were examined to a scertain any drawbacks. The antimicrobial activity, against the target micro-organisms, increases with an increase in the levels of the biocide additive. Compound C possesses the highest antimicrobial activity and compound A possesses the lowest activity. The antimicrobial activity is attributed to the incorporation of compounds containing thiazole ring which is present in a group of heterocyclic compounds and possessing remarkable activity against bacteria, also, the introduction of 2-amino thiazole derivative, which is reported to exhibit significant biological activity. The incorporation of thiazole derivatives A, B and C as additives into the polyurethane varnish results in slight enhancement of the physical and mechanical properties.

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تحضير وتوصيف مشتقات الثيازول وتقييم أدائها كإضافات لطلائح البولي يوريثان

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في العقود القليلة الماضية، تم إنجاز الكثير من الأبحاث على مشتقات الثيازول وذلك بسبب الاستخدامات العديدة المرتبطة بها. واتصفت مشتقات الثيازول بنشاطها البيولوجى الملحوظ واستخدامها على نطاق واسع فى مجال الأدوية، وفي هذا البحث تم تحضير العديد من مشتقات الثيازول وتأكيد تركيبها عن طريق تحليل العناصر والأشعة تحت الحمراء والرنين النووي المغناطيسي للبروتون وكذا مطياف الكتلة. وقد تم استخدام مشتقات الثيازول المحضرة (أ) و (ب) و (ج) كإضافات لطلائح البولي يوريثان. وقد تم تصنيع أفلام من الطلائح التجريبية على نطاق مخبرى وتم الطلاء بواسطة الفرشاة على ألواح من الصلب والخشب. وتم اختبار أفلام الطلائح على الألواح ضد البكتيريا سالبة الجرام وموجبة الجرام وضد الفطريات لتقييم النشاط البيولوجى لمشتقات الثيازول المحضرة والمضافة على الطلائح. وتم قياس مقاومة الحريق لأفلام الألواح المطلية والمضاف إليها مشتقات الثيازول المحضرة عن طريق قياس مؤشر الحد من الأكسجين. كذا تم فحص واختبار الخصائص الميكانيكية للأفلام المطلية لتقييم أى عيب ملحوظ نتيجة إضافة مشتقات الثيازول لطلائح البولي يوريثان. وأظهرت النتائج أن عملية إضافة مشتقات الثيازول لطلائح البولي يوريثان أدت إلى تحسين خصائص تلك الطلائح من ناحية المقاومة للميكروبات ومقاومة الحريق والخصائص الميكانيكية لها.