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## SYNTHESIS AND REACTIONS OF L-ASCORBIC ACID ANALOG 4' (4-ETHOXY-CARBONYL-5-METHYLFURAN-2-YL) - 2̄,3̄-DIOXOBUTYRO-1̄, 4̄-LACTONE

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A furanyl analog of dehydro-L-ascorbic acid (12) was synthesized starting from D-glucose via its condensation with ethyl acetoacetate followed by periodate oxidation. Acyloin condensation of the obtained aldehyde (2) with glyoxal in presence of potassium cyanide afforded the imide (3) with aqueous acetic acid gave (8) which when treated with aryl or acylhydrazines afforded the pyrazolin derivatives (9,10) whereas with o-phenylenediamine gave a quinoxaline derivative (11). Acylation of (3) gave monoacyl derivatives (7), while with aryl and acylhydrazines gave the corresponding hydrazones (5,6). On the other hand, treatment of (3) with nitrous acid gave the title compound (12). Reaction of (12) with aryl or acylhydrazines gave the corresponding bis (hydrazones) (13,14), rearrangement of (13) gave the pyrazoline (15). Reaction of (12) with o-phenylenediamine gave the quinoxaline derivative (16). Reaction of (16) with aryl or acylhydrazines gave monohydrazones (17,18).

***Key words:*** Ascorbic acid analog, Tetronimide, Pyrazoline quinoxaline.

### Introduction

Several works have been done on *L*-ascorbic acid and its analogs owing to their important biochemical function as well as their wide biological activities [1-4].

### Experimental

All melting points were determined in open glass capillaries and are uncorrected. Infrared spectra were determined on Unicam SP 1025 infrared spectrophotometer using potassium bromide pellets, $^1$H NMR spectra were recorded with Varian EM 390, 90 MHz NMR spectrometer using tetramethylsilane as internal standard and microanalysis were performed in the Micro-analytical Laboratory, Faculty of Science, Cairo University, Egypt.

*4-Ethoxycarbonyl-2-(D-arabino-tetrahydroxybutyl)-5-methylfuran (1).* A well stirred mixture of anhydrous D-glucose (100 g) and anhydrous zinc chloride (50 g) was treated with ethyl acetoacetate (50 ml) and absolute ethanol (100 ml). The mixture was heated on a water bath for 3 hrs. and was then poured onto crushed ice (500 g), whereby the title compound was gradually obtained. It was filtered off, washed with water, dried, (yield 20%), and crystallized from dilute methanol in needles, m.p. 148° [5] (148-149°).

*4-Ethoxycarbonyl-2-formyl-5-methylfuran (2).* A suspension of 1 (2g) in distilled water (20 ml) was treated with a solution of sodium metaperiodate (4.4 g) in distilled water (20 ml) dropwise with continuous stirring for 1 hr. The aldehyde eventually separated out, was filtered off, washed with water, and dried (yield 77%). Compound 2 crystallized from ethanol in needles, m.p. 57° [5] (m.p. 50°).

*4-(4-Ethoxycarbonyl-5-methylfuran-2-yl)-2-hydroxytetronimide (3).* Glyoxal sodium bisulfite monohydrate (15 mmole) was added in one portion to a well stirred cold solution of potassium cyanide (26 mmole) in 40 ml of 2N sodium carbonate solution under nitrogen atmosphere. The resulting solution was treated with a solution of 4-ethoxycarbonyl-2-formyl-5-methylfuran (10 mmole) in 20 ml of dioxane. A yellow precipitate appeared after 10 mins and stirring was continued for another 30 mins. The nitrogen gas was then disconnected and the reaction mixture was acidified, stirring was maintained for 3 hrs. after which the tetronimide was separated, washed with water and recrystallized from methanol in needles, m.p. 161° (yield 95%).

Anal. Calc. for $C_{12}H_{13}O_6N$ : C, 53.9; H, 4.9; N, 5.2. Found: C, 53.6; H, 5.1; N, 5.2.

*4-(4-Ethoxycarbonyl-5-methylfuran-2-yl)-2-acetoxy-3-oxobutyrimino-lactone (7a).* A mixture of 3 (1 mmole) and (2ml) acetic anhydride was heated on a steam bath for 15 mins and then left at room temperature for 2 hrs. The reaction mixture was then poured on an ice cold saturated solution of sodium hydrogen carbonate and the product was filtered off, washed with water and recrystallized from benzene-methanol mixture in brown needles, m.p. 126° (yield 71%).

Anal. Calc. for $C_{14}H_{15}O_7N$: C, 54.4; H, 4.9, N, 4.5. Found : C, 54.7; H, 5.0; N, 4.1.

*4-(4-Ethoxycarbonyl-5-methylfuran-2-yl)-2-acetoxy-3-oxobutyrimino-lactone-3-phenylhydrazone (7c). Mehtod (A).* A mixture of the o-acetyl-drivative 7a (1mmole) and phenylhydrazine (1 mmole) in ehtanol (20 ml) was heated on a boiling water bath for 3 hrs. On concentration and cooling, the hydrazone separated out was crystallized from benzene-methanol mixture in deep brown needles, m.p. 55° (yield 62%).

Anal. Calc. for $C_{20}H_{21}O_6N_3$: C, 60.2; H, 5.3; N, 10.5. Found: C, 60.0; H, 5.5; N, 10.1.

*Method (B).* A mixture of the hydrazone 5 (R=H) (1 mmole) and acetic anhydride (2 ml) was refluxed for 15 mins. and then left at room temperature for 2 hrs and poured on an ice cold saturated solution of sodium hydrogen carbonate and the product was filtered off, washed with water and crystallized from benzene-methanol mixture in deep brown needles, m.p. 55° (yield 36%).

Anal. Calc. for $C_{20}H_{21}O_6N_3$: C, 60.2; H, 5.3; N, 10.5. Found: C, 60.0; H, 5.2; N, 10.1.

*4-(4-Ethoxycarbonyl-5-methylfuran-2-yl)-2-benzoyloxy-3-oxobutyriminolactone (7b).* A solution of the tetronimide 3 (1 mmole) in (6 ml) pyridine was warmed with benzoyl chloride (1 mmole) for 10 min. The reaction mixture was allowed to stand at room temperature for 5 hrs. It was then poured into an ice cold (25 ml) of dilute $H_2SO_4$ and the solid separated was filtered, mixed with saturated solution of sodium hydrogen carbonate, filtered, washed with water and recrystallized from benzene-methanol mixture in colourless needles, m.p. 198° (yield 49%).

Anal. Calc. for $C_{19}H_{17}O_7N$: C, 61.5; H, 4.6; N, 3.8. Found : C, 62.0; H, 5.0, N, 3.9.

*4-(Ethoxycarbonyl-5-methylfuran-2-yl)-2-hydroxy-3-oxobutyriminolactone-3-acylhydrazones (6).* These hydrazones were obtained by heating a solution of the tetronimide 3 (1 mmole) in (20 ml) ethanol containing one drop of glacial acetic acid with the desired acylhydrazine (1 mmole) on a water bath for 3 hrs. Concentration and cooling gave the hydrazones which crystallized from benzene-methanol mixture in needles (Table 1).

Table 1. 4-(4-Ethoxycarbonyl-5-Methylfuran-2-yl)-2-Hydroxy-3-Oxobutyriminolactone-3-Acylhydrazones (6).

| R | Yield (%) | M.P. °C | Molecular formula | Anal.% Calc. / Found C | H | N |
|---|---|---|---|---|---|---|
| H | 28 | 102 | $C_{19}H_{19}O_6N_3$ | 59.2 | 4.9 | 10.9 |
| | | | | 59.7 | 4.4 | 10.5 |
| $NO_2$ | 49 | 88 | $C_{19}H_{18}O_8N_4\frac{1}{2}H_2O$ | 51.9 | 4.3 | 12.8 |
| | | | | 51.7 | 4.3 | 13.0 |
| Cl | 45 | 196 | $C_{19}H_{18}O_6N_3Cl$ | 54.4 | 4.3 | 10.0 |
| | | | | 54.2 | 4.6 | 10.2 |

Table 2. 4-(4-Ethoxycarbonyl-5-Methylfuran-2-yl)-2-Hydroxy-3-Oxobutyrinimolactone-3-Arylhydrazones (5).

| R | Yield (%) | M.P. °C | Molecular formula | Anal.% Calc. / Found C | H | N |
|---|---|---|---|---|---|---|
| H | 42 | 90 | $C_{18}H_{19}O_5N_3$ | 60.5 | 5.3 | 11.8 |
| | | | | 60.7 | 5.0 | 11.3 |
| $NO_2$ | 45 | 198 | $C_{18}H_{18}O_7N_4$ | 53.7 | 4.5 | 13.9 |
| | | | | 53.5 | 4.7 | 14.0 |

*4-(4-Ethoxycarbonyl-5-methylfuran-2-yl)-2-hydroxy-3-oxobutyriminolactone-3-arylhydrazones (5).* A mixture of euqimolecular amounts of the tetronimide 3 (1 mmole) and the arylhydrazine (1 mmole) in (20 ml) ethanol containing one drop of glacial acetic acid was refluxed for 3 hrs. Concentration and cooling gave the desired hydrazones that was recrystallized from ethanol in brown-red needles (Table 2).

*α-Carboxamido-β(4-ethoxycarbonyl-5-methylfuran-2-yl)-glyoxal (8).* A mixture of compound 3 (1 mmole) was boiled with 1:1 water-acetic acid (20 ml) for 1 hr. On cooling, the intermediate dicarbonyl compound (8) separated out, filtered off, and recrystallized from pyridine in colourless needles, m.p. 230° (yield 60%).

Anal. Calc. for $C_{17}H_{18}O_6N_2 \cdot \frac{1}{2}H_2O$: C, 57.5; H, 5.4; N, 7.9. Found: C, 57.1; H, 5.4; N, 8.4.

*(4-Ethoxycarbonyl-5-methylfuran-2-yl)-(1-aryl-4-(arylhydrazono)-2-pyrazolin-5-one-3-yl) methanes (9).* A mixture of compound 3 (1 mmole) with 1:1 water-acetic acid (20 ml) was refluxed for 1 hr. To the reuslting solution excess of the arylhydrazine (0.01 mole) was added and boiling was continued for 90 mins. On cooling, the orange product that separated out, was filtered off, washed with ethanol and recrystallized from ethanol in needles (Table 3).

*(4-Ethoxycarbonyl-5-methylfuran-2-yl)-(1-acyl-4(acylhydrazono)-2-pyrazolin-5-one-3-yl) methanes (10).* A mixture of compound 3 (1 mmole) with 1:1 water-acetic acid (20 ml) was refluxed for 1 hr. To the resulting solution excess of the acylhydrazine (0.01 mole) was added and boiling was continued for 90 mins. On cooling, the product that separated

Table 3. (4-Ethoxycarbonyl-5-Methylfuran-2-yl)-1-aryl-4-(Arylhydrazono)-2-Pyrazolin-5-One-3-yl) Methanes (9).

| R | Yield (%) | M.P. °C | Molecular formula | Anal.% Calc. / Found C | H | N |
|---|---|---|---|---|---|---|
| H | 25 | 110 | $C_{24}H_{22}O_4N_4$ | 66.9 | 5.1 | 13.0 |
| | | | | 66.5 | 5.0 | 12.6 |
| $NO_2$ | 38 | 160 | $C_{24}H_{20}O_8N_6$ | 55.4 | 3.8 | 16.2 |
| | | | | 55.0 | 4.2 | 16.2 |

Table 4. (4-Ethoxycarbonyl-5-Methylfuran-2-yl)-1-Acyl-4-(Acylhydrazono-2-Pyrazolin-5-One-3-yl) Methanes (10).

| R | Yield (%) | M.P. °C | Molecular formula | Anal.% Calc. / Found C | H | N |
|---|---|---|---|---|---|---|
| H | 31 | 120 | $C_{26}H_{22}O_6N_4$ | 64.2 | 4.5 | 11.5 |
| | | | | 64.0 | 4.7 | 11.4 |
| Cl | 37 | 245 | $C_{26}H_{20}O_6N_4Cl_2$ | 56.3 | 3.6 | 10.1 |
| | | | | 56.7 | 3.1 | 10.4 |

out, was filtered off, washed with ethanol and recrystallized from ethanol in needles (Table 4).

*2-Carboxamido-3-(4-ethoxycarbonyl-5-methylfuran-2-yl)methylquinoxaline (11).* This quinoxaline derivative was obtained by refluxing a mixture of the tetronimide 3 (1 mmole) with 1:1 water-acetic acid (20 ml) for 1 hr, then adding to the resulting solution o-phenylenediamine (0.01 mole) and continued the boiling for another 90 mins. On concentration and cooling, the solid separated was filtered off, washed with ethanol and recrystallized from ethanol in brown needles, m.p. 115° (yield 36%).

Anal. Calc. for $C_{18}H_{17}O_4N_3$: C, 63.7; H, 5.0; N, 12.4. Found: C, 63.4; H, 5.2; N, 12.7.

*4-(4-Ethoxycarbonyl-5-methylfuran-2-yl)-2,3-dioxobutyro-1,4-lactone (12).* A suspension of 3 (0.02 mole) in (40 ml) acetone and (64 ml) 2M $H_2SO_4$ was cooled to 10°, and treated with (40 ml) of 10% of $NaNO_2$ solution. The mixture was warmed to expel the $N_2$ gas and left to cool. The product was filtered off, washed with water and recrystallized from water in yellow needles, m.p. 69° (yield 23%).

TABLE 5. 4-(4-ETHOXYCARBONYL-5-METHYLFURAN-2-YL)-BUTYRO-1,4-LACTONE-2,3-BIS(ACYLHYDRAZONES) (14).

| R | Yield (%) | M.P. °C | Molecular formula | Anal.% Calc. / Found C | H | N |
|---|---|---|---|---|---|---|
| H | 14 | 220 | $C_{26}H_{22}O_7N_4$ | 62.2 | 4.4 | 11.2 |
| | | | | 62.6 | 4.0 | 10.8 |
| $CH_3$ | 30 | 236 | $C_{28}H_{26}O_7N_4$ | 63.4 | 4.9 | 10.6 |
| | | | | 63.0 | 5.0 | 11.1 |
| Cl | 37 | 223 | $C_{26}H_{20}O_7N_4Cl_2$ | 54.7 | 3.5 | 9.8 |
| | | | | 54.5 | 3.0 | 9.6 |
| Br | 27 | 245 | $C_{26}H_{20}O_7N_4Br_2$ | 47.3 | 3.0 | 8.5 |
| | | | | 47.1 | 3.5 | 8.1 |
| $NO_2$ | 32 | 168 | $C_{26}H_{20}O_{11}N_6$ | 52.7 | 3.4 | 14.2 |
| | | | | 52.8 | 3.0 | 14.1 |
| 3,5-$(NO_2)_2$ | 24 | 59 | $C_{26}H_{18}O_{15}N_8$ | 45.7 | 2.6 | 16.4 |
| | | | | 45.5 | 3.1 | 16.7 |
| $NH_2$ | 41 | 88 | $C_{26}H_{24}O_7N_6$ | 58.6 | 4.5 | 15.8 |
| | | | | 59.1 | 4.8 | 15.5 |

TABLE 6. 4-(4-ETHOXYCARBONYL-5-METHYLFURAN-2-YL)-BUTYRO-1,4-LACTONE-2,3-BIS (ARYLHYDRAZONES) (13).

| R | Yield (%) | M.P. °C | Molecular formula | Anal.% Calc. / Found C | H | N |
|---|---|---|---|---|---|---|
| H | 31 | - | $C_{24}H_{22}O_5N_4$ | 64.6 | 4.9 | 12.6 |
| | | | | 64.3 | 5.1 | 12.5 |
| $NO_2$ | 19 | 136 | $C_{24}H_{20}O_9N_6$ | 53.7 | 3.7 | 15.7 |
| | | | | 53.2 | 3.9 | 15.6 |
| $2,4(NO_2)_2$ | 64 | 200 | $C_{24}H_{18}O_{13}N_8$ | 46.0 | 2.9 | 17.9 |
| | | | | 46.4 | 3.3 | 18.3 |

Anal. Calc. for $C_{12}H_{10}O_7$: C, 54.1; H, 3.8. Found: C, 53.8; H, 3.3.

*4-(4-Ethoxycarbonyl-5-methylfuran-2-yl)-butyro-1,4-lactone-2,3-bis(acylhydrazones) (14).* These compounds were obtained by heating a solution of 4-(4-ethoxycarbonyl-5-methylfuran-2-yl)-2,3-dioxobutyro-1,4-lactone (12) (1 mmole) in (25 ml) dilute ethanol 1:1 (containing a few drops of glacial acetic acid) with an ethanolic solution containing (2 mmole) of the desired acylhydrazine on a water bath for 3 hrs. Concentration and cooling of the reaction mixture gave the bis (acylhydrazones) which crystallized from ethanol in needles (Table5).

*4-(4-Ethoxycarbonyl-5-methylfuran-2-yl) butyro-1, 4-lactone-2,3-bis-(arylhydrazones)(13).* A solution of 12 (1 mmole) in (25 ml) dilute ethanol 1:1, containing a few drops of glacial acetic acid, was heated with (2 mmole) of the desired arylhydrazine on a water bath for 3 hrs. Upon concentration, cooling, the bis(arylhydrazones) that separated out, were filtered off, washed with dilute ethanol and crystallized from ethanol in needles (Table 6).

*1-Phenyl-(4-ethoxycarbonyl-5-methylfuran-2-yl)-3-hydroxymethylpyrazole-4,5-dione-4-phenylhydrazone (15).* These derivatives were obtained by heating the bis(hydrazones) 13, (R=H) (1 mmole) with 20% aqueous sodium hydroxide solution (10 ml) on a boiling water bath for 10 mins. On cooling and acidifying with glacial acetic acid, the desired product separated out and was purified by recrystallization from dilute ethanol in brown needles, m.p. 230° (yield 20%).

*1-Hydroxy-1-(4-ethoxycarbonyl-5-methylfuran-2-yl)-2-(2-quinoxalinone-3-yl)ethane (16).* A solution of 12 (1 mmole)

TABLE 7. 1-HYDROXY-1-(4-ETHOXYCARBONYL-5-METHYLFURAN-2-YL)--2-(ARYLHYDRAZONES)-2-(2-QUINOXALINONE-3-YL)ETHANES (17).

| R | Yield (%) | M.P. °C | Molecular formula | Anal.% Calc. / Found C | H | N |
|---|---|---|---|---|---|---|
| H | 41 | 120 | $C_{24}H_{22}O_5N_4$ | 64.6 | 4.9 | 12.6 |
| | | | | 64.2 | 5.2 | 13.0 |
| $NO_2$ | 30 | 139 | $C_{24}H_{21}O_7N_5$ | 58.7 | 4.3 | 14.3 |
| | | | | 58.5 | 4.5 | 14.0 |

TABLE 8. 1-HYDROXY-1-(4-ETHOXYCARBONYL-5-METHYLFURAN-2-YL)--2-(ACYLHYDRAZONES)-2-(2-QUINOXALINONE-3-YL) ETHANES (18).

| R | Yield (%) | M.P. °C | Molecular formula | Anal.% Calc. / Found C | H | N |
|---|---|---|---|---|---|---|
| $NO_2$ | 44 | 78 | $C_{25}H_{21}O_8N_5.2H_2O$ | 54.1 | 4.5 | 12.6 |
| | | | | 53.7 | 5.0 | 12.1 |
| Cl | 25 | 135 | $C_{25}H_{21}O_6N_4Cl$ | 59.0 | 4.1 | 11.0 |
| | | | | 59.4 | 4.5 | 10.9 |

in (10 ml) ethanol containing two drops of glacial acetic acid was refluxed for 3 hrs with o-phenylenediamine (1 mmole). Concentration, cooling gave the quinoxaline derivative was filtered off, washed with ethanol and recrystallized from ethanol in brown needles, m.p. 240° (yield 29%).

Anal. Calc. for $C_{18}H_{16}O_6N_2$: C, 60.7; H, 4.5; N, 7.9. Found: C, 60.3; H, 4.7; N, 8.3.

*1-Hydroxy-1-(4-ethoxycarbonyl-5-methylfuran-2-yl)-2-(arylhydrazones)-2-(2-quinoxalinone-3-yl)ethanes (17).* A solution of compound 12 (1 mmole) in ethanol (10 ml) was treated with a solution of o-phenylenediamine (1 mmole) in ethanol (5 ml) and (20 ml) water and the mixture refluxed for 2 hrs. To the resulting solution was added a solution of the arylhydrazine (1 mmole) in ethanol (5 ml) and the mixture was refluxed for 2 hrs. After concentration, cooling, the solid deposited was filtered off and recrystallized from ethanol in needles (Table 7).

*1-Hydroxy-1-(4-ethoxycarbonyl-5-methylfuran-2-yl)-2-(acylhydrazones)-2-(2-quinoxalinone-3-yl) ethanes (18).* A solution of compound 12 (1 mmole) in ethanol (10 ml) was treated with a solution of o-phenylenediamine (1 mmole) in ethanol (5 ml) and (20 ml) of water and the mixture refluxed for 2 hrs. To the resulting solution was added a solution of the acylhydrazine (1 mmole) in ethanol (5 ml) and the mixture was refluxed for 2 hrs. After concentration, cooling, the solid deposited was filtered off and recrystallized from ethanol in needles (Table 8).

## Results and Discussion

It was shown that *D*-glucose reacts with ethyl acetoacetate to give 4-ethoxycarbonyl-2-(*D-arabino*-tetrahydroxybutyl)-5-methylfuran (1) in high yield [5]. Periodate oxidation of (1) gave aldehyde (2) [6] which reacted with glyoxal sodium bisulphite and potassium cyanide in alkaline medium under nitrogen atmosphere [7-9] to give 4-(4-ethoxycarbonyl-5-methylfuran-2-yl)-2-hydroxytetronimide (3) in 95% yield by a mechanism as that proposed in the literature [7]. The $^1$H NMR spectrum of this tetronimide (3) in deuterochloroform showed the methyl of the ester group at 1.4 as triplet, singlet at 2.7 due to the methyl protons at position 5 of the furan ring, quartet at 4.3 for the $CH_2$ of the ester group, singlet at 5.8 due to the proton of the OH group, singlet at 7.3 for the proton of position 3 of the furan ring, singlet at 7.6 for the proton of position 4 of the tetronimide ring and singlet at 7.9 ppm arising from the NH proton. In addition, its infrared absorption spectrum showed the expected bands at 1720 cm$^{-1}$ for the carbonyl absorption, 3100 and 3440 cm$^{-1}$ for the NH and OH, the groups -C=C-C=N and -C-O-C- at 1660 and 1250 cm$^{-1}$.

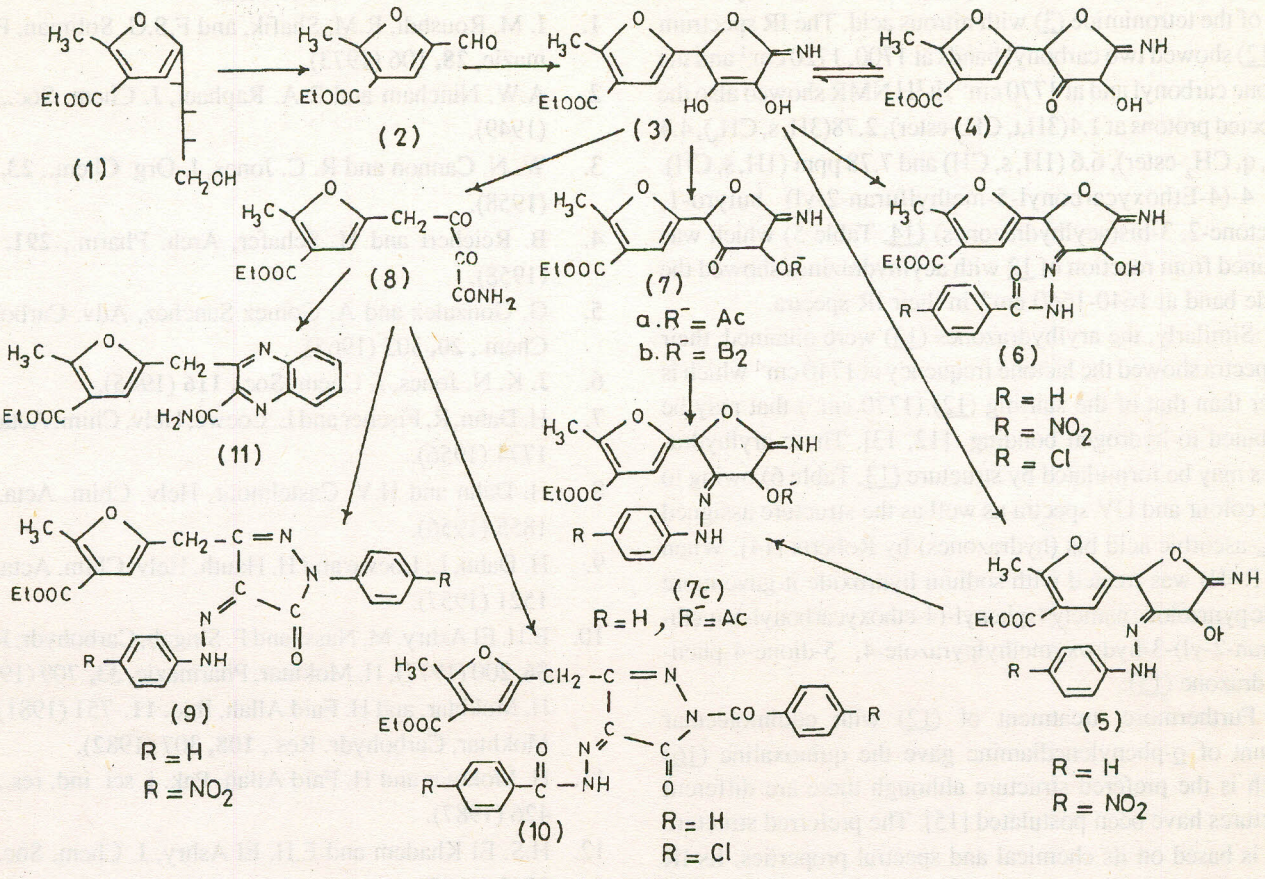
Reaction of the tetronimide (3) with aryl and acylhydrazines afforded the corresponding aryl and acylhydrazones (5,6) respectively (Tables 1, 2). The acylhydrazones (6) characterized by the amide band at 1650-1700 cm$^{-1}$ while the arylhydrazones showed the C=N band at 1600 cm$^{-1}$ in addition to the other bands in the molecule.

The formation of these hydrazones indicated the presence of the keto form in the starting imide (3). On the other hand, the enol form gave the acyl derivatives (7) on treatment with acetic anhydride or benzoyl chloride. These acyl derivatives are characterized by a band at 1730-1760 cm$^{-1}$ due to the acyl group in their infrared spectra. Treatment of (7a) with phenylhydrazine afforded the phenylhydrazone (7c) which was obtained from acetylation of the phenylhydrazone (5, R=H). This compound was characterized by bands at 1730 due to the acetyl group and C=N at 1610 cm$^{-1}$.

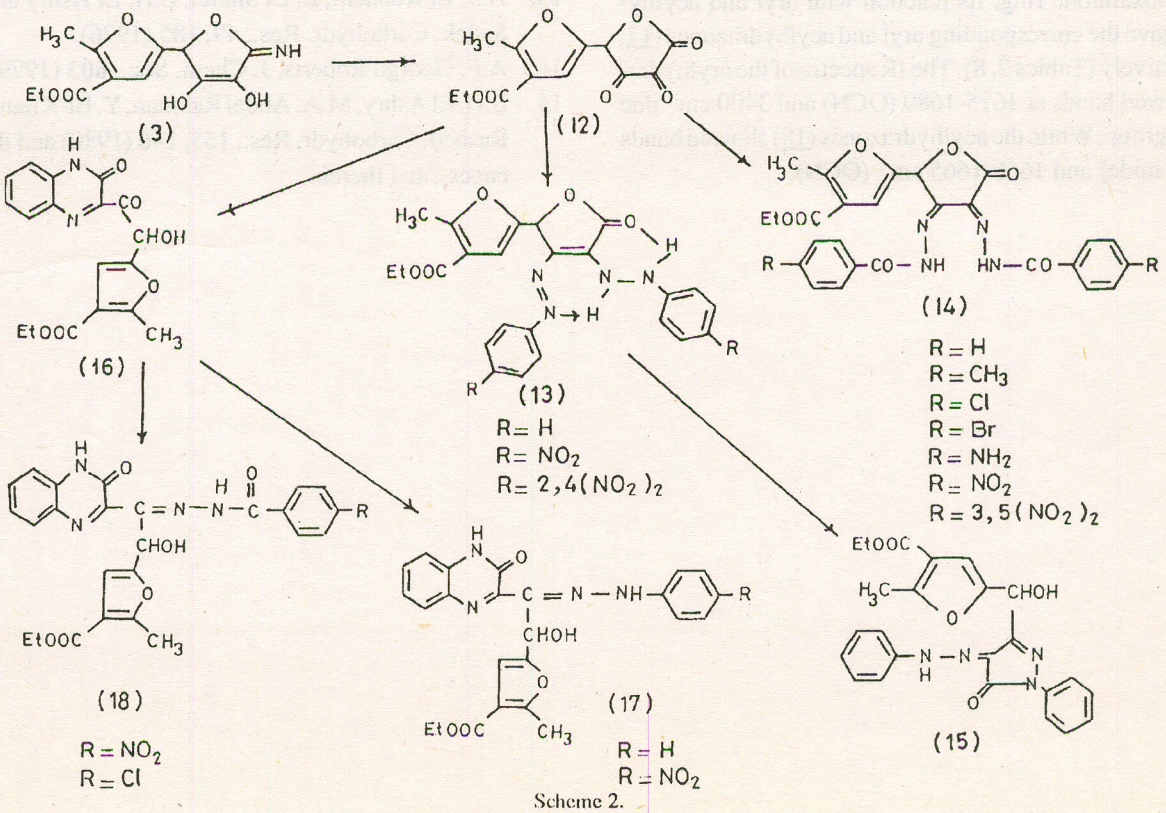
When the tetronimide (3) was heated with dilute acetic acid, colourless product was obtained that crystallized from pyridine which was assigned structure (8) that proposed by other authors [10,11] though it was not isolated in the course of their synthesis of other L-ascorbic acid analogs. This structure was supported by elemental analyses and infrared spectrum as well as its conversion to orange coloured products when treated with excess arylhydrazines. These products were shown to be (4-ethoxycarbonyl-5-methylfuran-2-yl)-(1-aryl-4(arylhydrazono)-2-pyrazolin-5-one-3-yl)methanes (9, Table 3). These products were obtained from (8) through the bis(hydrazones) then cyclization followed by loss of ammonia [11]. These pyrazolinones (9) are characterized by the (OCN) absorption at 1680-1695 cm$^{-1}$ and the NH at 3100-3400 cm$^{-1}$. The $^1$H NMR spectrum of (4-ethoxycarbonyl-5-methylfuran-2-yl)-(1-phenyl-4-(phenylhydrazono)-2-pyrazolin-5-one-3-yl) methane in deuterochloroform showed the methyl of the ester group at 1.2 as triplet, singlet at 2.4 due to the methyl protons at position 5 of the furan ring, singlet at 3.9 due to the -$CH_2$- protons, quartet at 4.3 for the $CH_2$ of the ester group, singlet at 6.3 for the protons of position 3 of the furan ring, singlet at 13.42 for the NH proton and multiplet at 7.05-7.85 ppm arising from the aromatic protons.

When (8) was treated with acylhydrazines under the same conditions as the arylhydrazines it gave (4-ethoxycarbonyl-5-methylfuran-2-yl)-(1-acyl-4(acylhydrazono)-2-pyrazolin-5-one-3-yl) methanes (10, Table 4). These compounds are characterized by the keto group at 1680-1700 cm$^{-1}$ and the amide band at 1650-1660 cm$^{-1}$ in their IR spectra.

On the other hand, treatment of the tetronimide (3) with excess o-phenylenediamine in aqueous acetic acid gave 2-carboxamido-3-(4-ethoxycarbonyl-5-methylfuran-2-yl)-methylquinoxaline (11), through the intermediate (8) which was characterized by IR absorption spectrum at 1700 due to (C=O ester), 1670 due to (OCN) and a band at 1615 cm$^{-1}$ due to (C=N).




Scheme 1.




Scheme 2.

The L-ascorbic acid analog (12) was obtained by oxidation of the tetronimide (3) with nitrous acid. The IR spectrum of (12) showed two carbonyl bands at 1700, 1720 $cm^{-1}$ and the lactone carbonyl and at 1770 $cm^{-1}$, it $^1H$ NMR showed also the expected protons at 1.4(3H,t, $CH_3$-ester), 2.78(3H, s, $CH_3$), 4.4 (2H, q, $CH_2$-ester), 6.6 (1H, s, CH) and 7.78 ppm (1H, s, CH).

4-(4-Ethoxycarbonyl-5-methylfuran-2-yl) butyro-1, 4-lactone-2, 3-bis(acylhydrazones) (14, Table 5) which was obtained from reaction of 12 with acylhydrazines showed the amide band at 1640-1660 $cm^{-1}$ in their IR spectra.

Similarly, the arylhydrazones (13) were obtained, their IR spectra showed the lactone frequency at 1740 $cm^{-1}$ which is lower than that of the starting (12) (1770 $cm^{-1}$) that may be attributed to hydrogen bonding [12, 13]. These arylhydrazones may be formulated by structure (13, Table 6) owing to their colour and UV spectra as well as the structure assigned for L-ascorbic acid bis (hydrazones) by Roberts [14]. When (13, R=H) was treated with sodium hydroxide it gave more stable pyrazolone namely 1-phenyl-(4-ethoxycarbonyl-5-methylfuran-2-yl)-3-hydroxymethylpyrazole-4, 5-dione-4-phenylhydrazone (15).

Furthermore, treatment of (12) with equimolecular amount of o-phenylenediamine gave the quinoxaline (16) which is the prefered structure although there are different structures have been postulated [15]. The preferred structure (16) is based on its chemical and spectral properties. Its IR spectrum showed the expected (OCN) group at 1680 $cm^{-1}$ of the 2-quinoxalinone ring. Its reaction with aryl and acylhydrazines gave the corresponding aryl and acylhydrazones (17, 18) respectively (Tables 7, 8). The IR spectra of the arylhydrazones showed bands at 1675-1680 (OCN) and 3400 $cm^{-1}$ due to the OH group. While the acylhydrazones (18) showed bands at 1680 (1mide) and 1660-1665 $cm^{-1}$ (OCN).

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