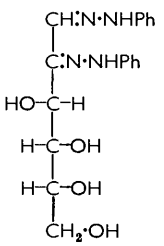
631. *The Scope and Mechanism of Carbohydrate Osotriazole Formation. Part II.* The Action of Oxidising Agents on Osazones and Osotriazoles.*

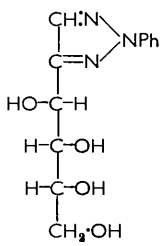
By H. El Khadem and Zaki M. El-Shafei.

Conversion of glucose arylosazones into osotriazoles by copper or iron salts, or by bromine water, is due to oxidation. Stronger oxidising agents yield 2-aryl-1 : 2 : 3-triazole-4-carboxylic acids.

Carbohydrate phenylosazones are converted into phenylosotriazoles and aniline when refluxed in aqueous copper sulphate.[1] Teuber and Jellinek [2] recently effected a similar change by nitrosodisulphonate. In the present work various inorganic salts were refluxed with aqueous suspensions of glucose phenylosazone (I): cupric chloride, nitrate, and acetate, ferric chloride, ferric sulphate, and potassium ferricyanide readily yielded glucose phenylosotriazole (II). The corresponding salts in lower states of valency and salts with no oxidising character were ineffective.

Other oxidising agents were also used; bromine water with glucose phenylosazone (I) in the cold yielded glucose *p*-bromophenylosotriazole, directly obtained also from glucose phenylosotriazole and bromine water. The fact that *p*-bromophenylosotriazoles are less soluble than the corresponding phenyl derivatives, together with the simplicity and good yields obtained, render this reaction of value for the identification of osazones and osotriazoles.


(I)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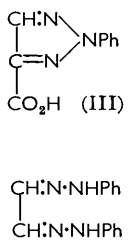
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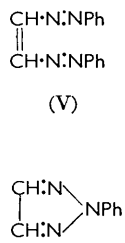
(V)

(IV)

(VI)

Bromine water seems to have a dual function; that of converting the osazones into the osotriazoles and of brominating them in the *para*-position. Aryl osazones in which the *para*-position was occupied, as in glucose *p*-tolylosazone and *p*-bromophenylosazone, were merely converted into the corresponding tolyl- and *p*-bromophenyl-osotriazole.

On treatment with strong oxidising agents such as neutral potassium permanganate, potassium dichromate, or 20% nitric acid glucose phenylosazone yielded in small amounts 2-phenyl-1 : 2 : 3-triazole-4-carboxylic acid (III) and benzoic acid; the latter was probably formed by degradation of the osazone before the triazole was formed, since glucose phenylosotriazole on similar treatment yielded 2-phenyl-1 : 2 : 3-triazole-4-carboxylic acid nearly quantitatively.

Potassium permanganate readily converted glucose *p*-tolylosotriazole into 2-*p*-carboxyphenyl-1 : 2 : 3-triazole-4-carboxylic acid, and glucose *p*-bromophenylosotriazole into 2-*p*-bromophenyl-1 : 2 : 3-triazole-4-carboxylic acid. The latter acid was also obtained by treating 2-phenyl-1 : 2 : 3-triazole-4-carboxylic acid with bromine water.

From the above it is clear that closure of the triazole ring is achieved through oxidation of the sugar osazone. In the case of simple osazones such as glyoxal phenylosazone (IV) it was shown by von Pechmann [3] that oxidation with potassium dichromate yielded a

* Part I, *J.*, 1953, 3452.

[1] Hann and Hudson, *J. Amer. Chem. Soc.*, 1944, **66**, 735; 1945, **67**, 939; 1946, **68**, 1766.
[2] Teuber and Jellinek, *Chem. Ber.*, 1952, **85**, 95.
[3] von Pechmann, *Ber.*, 1888, **21**, 2751.

stable red compound which was given a cyclic tetrazine structure, but later [4] ascribed structure (V). This was converted by boiling dilute acid or alkali into 2-phenyl-1 : 2 : 3-triazole (VI) and aniline. In the present work, it was found that refluxing glyoxal phenylosazone (IV) with aqueous cupric sulphate gave 2-phenyl-1 : 2 : 3-triazole (VI) and aniline; but at room temperature 1 : 2-bisphenylazoethylene (V) was obtained. This suggests that, when refluxed with cupric sulphate, the osazone is first oxidised to the intermediate (V), then decomposed to the triazole and aniline.

The ultraviolet absorption spectra of the triazoles are characterised by a single peak between 262 and 282 mμ (see Table).

	$\lambda_{max.}$ (mμ)	Log ε
Glyoxal phenylosotriazole	262	4·14
Glucose phenylosotriazole	268	4·33
Glucose *p*-bromophenylosotriazole	274	4·46
Glucose *p*-tolylosotriazole	268—272	4·39
2-Phenyltriazole-4-carboxylic acid	270	4·35
2-*p*-Carboxyphenyltriazole-4-carboxylic acid	282	4·53
2-*p*-Bromophenyltriazole-4-carboxylic acid	280	4·45

Experimental

Absorption spectra were determined for EtOH solutions with a Unicam S.P. 500 spectrophotometer. Microanalyses were by A. Bernhardt, Mülheim, W. Germany.

Glucose Phenylosotriazole (II) *from the Phenylosazone* (I) *by means of Cupric and Ferric Salts.*—Suspensions of glucose phenylosazone (2 g.) were refluxed with the salt until dissolved. The whole was filtered while hot and left overnight. The products were filtered off, washed with water and ethanol, and dried. Glucose phenylosotriazole crystallised from hot water and was identified by a mixed m. p. Yields were as follows: $CuSO_4$ 59% in 4 hr.; $CuCl_2$ 62% in 0·5 hr.; $Cu(NO_3)_2$ 55% in 3 hr.; $Cu(OAc)_2$ 53% in 2 hr.; $FeCl_3$ 29% in 1 hr.; $Fe_2(SO_4)_3$ 18% in 0·5 hr.; $K_3Fe(CN)_6$ 66% in 3 hr.

Glucose p-*Bromophenylosotriazole.*—(*a*) Glucose phenylosazone (2 g.), suspended in water (100 ml.), was treated in the cold with bromine (1 ml.), and the mixture kept overnight. The brown mass obtained was filtered off and washed with water and ethanol (yield 1·5 g.). It recrystallised from ethanol in needles, m. p. 225°, alone or mixed with glucose *p*-bromophenylosotriazole [5] (Found: C, 41·5; H, 4·2; N, 12·0; Br, 23·5. Calc. for $C_{12}H_{14}O_4N_3Br$: C, 41·9; H, 4·1; N, 12·2; Br, 23·3%).

(*b*) Glucose phenylosotriazole (2 g.), similarly treated, gave the same product, m. p. and mixed m. p. 225° (Found: C, 41·9; H, 4·1; N, 12·0; Br, 23·3%).

(c) Glucose *p*-bromophenylosazone (1 g.) in water (50 ml.) was treated with bromine (1 ml.) as above, giving glucose *p*-bromophenylosotriazole (0·4 g.), m. p. and mixed m. p. 225°.

Galactose p-*Bromophenylosotriazole.*—Galactose phenylosotriazole (0·5 g.) in water (50 ml.) was treated with bromine (0·5 ml.) as above, giving galactose *p*-bromophenylosotriazole (0·4 g.), m. p. 159°, not depressed by admixture with an authentic specimen [5] (Found: C, 41·6; H, 4·1; N, 12·3; Br, 23·4%).

Glucose p-*tolylosotriazole*, obtained (0·8 g.) from glucose *p*-tolylosazone (1 g.) in water (50 ml.) with bromine (1 ml.) as above and crystallised from water–ethanol, had m. p. 204° alone or mixed with authentic osotriazole [6] (Found: C, 55·8; H, 6·3; N, 15·1. Calc. for $C_{13}H_{17}O_4N_3$: C, 55·9; H, 6·1; N, 15·1%).

2-*Phenyl*-1 : 2 : 3-*triazole*-4-*carboxylic Acid* (III).—(*a*) A boiling solution of glucose phenylosotriazole (2 g.) in water (250 ml.) was treated with potassium permanganate (7 g.) in small portions. The hot mixture was filtered, treated with sodium hydrogen sulphite, and acidified with concentrated hydrochloric acid. The crystals (1·2 g.) that separated recrystallised from water–ethanol in needles, m. p. 191°, alone or mixed with 2-phenyl-1 : 2 : 3-triazole-4-carboxylic acid [7] (Found: C, 57·1; H, 3·7; N, 22·0. Calc. for $C_9H_7O_2N_3$: C, 57·1; H, 3·7; N, 22·2%).

[4] Stollé, *Ber.*, 1926, **59**, 1742.
[5] Hardegger, El Khadem, and Schreier, *Helv. Chim. Acta*, 1951, **34**, 253.
[6] Hardegger and El Khadem, *ibid.*, 1947, **30**, 1478.
[7] Hardegger and Schreier, *ibid.*, 1952, **35**, 232.

(*b*) A boiling suspension of glucose phenylosazone (10 g.) in water (500 ml.) was treated with potassium permanganate (60 g.) during 1 hr. The hot mixture was filtered, treated with sodium hydrogen sulphite, and acidified, and extracted with ether. The extract on evaporation gave a residue (1 g.) which sublimed at 10 mm. At 80°, benzoic acid sublimed (m. p. and mixed m. p. 121°). A fraction which sublimed at 150°, in colourless needles, m. p. 191°, was 2-phenyl-1 : 2 : 3-triazole-4-carboxylic acid.

(*c*) A suspension of glucose phenylosazone (10 g.) in water (250 ml.) was either heated for 1 hr. with potassium dichromate (60 g.) and 25 ml. of acetic acid or treated in the cold for 12 hr. with 70% nitric acid (100 ml.), then extracted with ether and treated as above, giving benzoic acid and 2-phenyl-1 : 2 : 3-triazole-4-carboxylic acid. The yield was however poor.

2-p-*Carboxyphenyl*-1 : 2 : 3-*triazole*-4-*carboxylic Acid*.—To a boiling solution of glucose *p*-tolylosotriazole (0·5 g.) in water (150 ml.), potassium permanganate (3 g.) was added gradually. The hot mixture was filtered, treated with sodium hydrogen sulphite, and acidified, giving crystals (0·2 g.) which recrystallised from ethanol in colourless needles, m. p. 344° (decomp.). 2-p-*Carboxyphenyl*-1 : 2 : 3-*triazole*-4-*carboxylic acid* is moderately soluble in hot ethanol and methanol and insoluble in water (Found: C, 51·3; H, 3·0; N, 17·9. $C_{10}H_7O_4N_3$ requires C, 51·5; H, 3·0; N, 18·0%).

2-p-*Bromophenyl*-1 : 2 : 3-*triazole*-4-*carboxylic Acid*.—(*a*) A boiling suspension of glucose *p*-bromophenylosotriazole (2·3 g.) in water (150 ml.) was treated with solid potassium permanganate (6 g.). The hot mixture was filtered, treated with sodium hydrogen sulphite, and acidified. The crystals (1 g.) recrystallised from water–ethanol in needles, m. p. 236°. 2-p-*Bromophenyl*-1 : 2 : 3-*triazole*-4-*carboxylic acid* is soluble in ethanol and methanol and insoluble in acetone and water (Found: C, 40·6; H, 2·3; N, 15·6; Br, 29·9. $C_9H_6O_2N_3Br$ requires C, 40·3; H, 2·2; N, 15·7; Br, 29·9%).

(*b*) A cold suspension of 2-phenyl-1 : 2 : 3-triazole-4-carboxylic acid (0·6 g.) in water (50 ml.) was treated with bromine (1 ml.) and left overnight. The almost colourless solid obtained was filtered off, washed with water (0·5 g.), and recrystallised from water–ethanol in colourless needles, m. p. 236° alone or mixed with 2-*p*-bromophenyl-1 : 2 : 3-triazole-4-carboxylic acid (Found: C, 40·5; H, 2·4; N, 15·5%).

2-*Phenyl*-1 : 2 : 3-*triazole* (VI) *from Glyoxal Phenylosazone* (IV) *and Copper Sulphate*.—Glyoxal phenylosazone (7 g.) was suspended in a solution of copper sulphate (7 g.) in water (350 ml.) and refluxed for 1·5 hr. The solution was then steam-distilled and the distillate (200 ml.) extracted with ether. The ethereal layer was washed with dilute hydrochloric acid to remove aniline, and dried (Na_2SO_4). The oily residual *triazole* after removal of the ether was purified by repeated distillation (80°/12 mm.) (Found: C, 66·5; H, 4·9; N, 28·7. $C_8H_7N_3$ requires C, 66·2; H, 4·8; N, 29·0%).

1 : 2-*Bisphenylazoethylene* (V) *from Glyoxal Phenylosazone* (IV) *and Copper Sulphate*.—Glyoxal phenylosazone (0·6 g.) was suspended in a solution of copper sulphate (0·6 g.) in water (100 ml.) and the mixture kept at room temperature for 30 days. The osazone gradually became reddish-brown (after one week). The suspension was filtered and the product recrystallised from ethanol in dark red plates, m. p. 150°, not depressed on admixture with 1 : 2-bisphenylazoethylene prepared by the action of potassium dichromate on glyoxal phenylosazone [3] (Found: C, 70·9; H, 4·8; N, 23·5. Calc. for $C_{14}H_{12}N_4$: C, 71·2; H, 5·1; N, 23·7%).

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