655. *Triazines. Part I. The Synthesis of Melamines from Diguanides and Carbodi-imides.*

By Frederick Kurzer and Ernest D. Pitchfork.

The reaction between diguanides and carbodi-imides in dimethylformamide provides a new general route to melamines. The use of diguanide and its 1-mono- and 1,2-di-substituted analogues affords satisfactory yields of monosubstituted melamines, 2,4-disubstituted melamines, and 1,2,6-trisubstituted isomelamines, respectively. In each case, the reaction is thought to involve primary addition of the reactants, followed by the cyclisation of the resulting intermediate triguanide, with loss of amine, to the heterocyclic end-product.

Guanidine similarly reacts with carbodi-imides to yield, successively, 1,2-diaryldiguanides and 1,2,6-triarylisomelamines. Some properties of the new melamines are described.

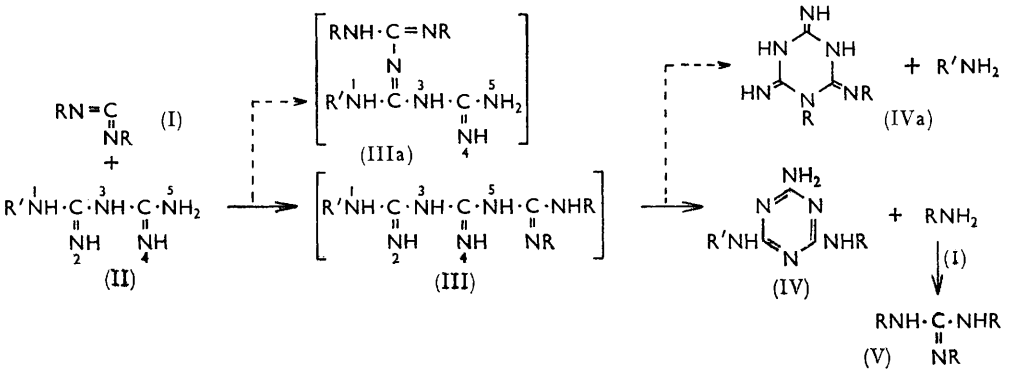
A number of new routes to five-membered heterocycles, particularly 1,2,4-triazoles,[1a-c] 1,3,4-thiadiazoles,[1b,c] and 1,2,4-thiadiazoles [1d,e] are now available from our studies of addition reactions between systems incorporating cumulative double bonds, such as carbodi-imides, isothiocyanate and isocyanate esters, and suitable compounds related to aminoguanidine.[2] The latter classes include aminoguanidine [1a-c] itself, thiosemicarbazide,[1c] semicarbazide,[1c] nitroguanidine,[1e] and diaminoguanidine.[3] The behaviour of diguanide and its derivatives has now been examined; this Paper describes their interaction with carbodi-imides.

In their reactions with carboxylic acid derivatives, aldehydes, ketones, and ureas, diguanides are a versatile source of amino-1,3,5-triazines,[4,5a-f] as are the closely related cyanoguanidines which have been particularly widely employed in the production of melamines, ammelines, and ammelides. The extensive literature has been surveyed by Smolin and Rapoport (ref. 5, ch. 3—6). The reaction between diguanides and carbodi-imides was thus expected to furnish variously substituted melamines. Cyanamide, in its di-imino-form, may be regarded as the parent compound of carbodi-imides; the interaction of cyanamide and diguanide would thus be the simplest example of the present group of reactions but has apparently not been studied. The patent literature [6,7] describes the manufacture of melamine by heating to 140—240° mixtures of guanidine or diguanide or their salts with cyanamide or dicyandiamide, but, since each of these compounds alone yields melamine under these conditions, the course of the reactions is not clear. The only relevant example appears to be the condensation of *p*-chlorophenylcyanamide and *p*-chlorophenyldiguanide to 2,4-di-(*p*-chlorophenyl)melamine.[8]

The action of carbodi-imides (I) on the parent compound, diguanide (II; R′ = H), in dimethylformamide at 100° afforded monosubstituted melamines (IV; R′ = H) smoothly, in good yields; the products were isolated as the crystalline toluene-*p*-sulphonates, from which the bases were liberated without difficulty. The reaction probably involves initial formation of the triguanide (III; R′ = H). Like comparable seven-membered linear carbon–nitrogen systems [4,5a-g,9] this cyclises spontaneously, with elimination of amine.

[1] Godfrey and Kurzer, *J.*, (*a*) 1960, 3437; (*b*) 1961, 5137; (*c*) 1962, 3561; (*d*) 1963, 4558; (*e*) 1963 4566.
[2] Kurzer and Godfrey, *Angew. Chem., Internat. Edn.*, 1963, **2**, 459.
[3] Kurzer and Douraghi-Zadeh, *J.*, 1964, in the press.
[4] Modest, in "Heterocyclic Compounds," ed. Elderfield, Wiley, New York and London, 1961, Vol. 7, pp. 627, 663.
[5] Smolin and Rapoport, "s-Triazines and Derivatives," Interscience, New York, 1959, (*a*) 225; (*b*) 226, 242; (*c*) 239; (*d*) 258; (*e*) 283; (*f*) 354; (*g*) 198; (*h*) 366; (*i*) 333, 337.
[6] Ciba, A.G., Swiss P. 209,503/1940; B.P. 527,697/1940; French P. 849,752/1940; G.P. 715,761/1941.
[7] Brookes (to American Cyanamid Co.), U.S.P. 2,287,597/1943.
[8] Gupta and Guha, *Current Sci.*, 1949, **18**, 294.
[9] Beyer, Bieling, and Pyl, *Z. Chem.*, 1962, **2**, 310.

The presence of the latter was demonstrated under suitable conditions. The action of two moles of diphenylcarbodi-imide on diguanide gave a mixture of phenylmelamine (IV; R = Ph, R′ = H) and *NN′N″*-triphenylguanidine (V; R = Ph) in approximately equimolar quantities. In this case, the triarylguanidine is thought to arise by the addition



of the eliminated aniline to the excess of carbodi-imide. This observation thus supports the suggested mechanism; it shows the cyclisation to be part of the actual reaction, and not a chance result of the working-up process, since *NN′*-diphenylurea (originating hydrolytically from the excess of diphenylcarbodi-imide) would otherwise be the secondary product instead of the triphenylguanidine.

The interaction of carbodi-imides (I) and 1-substituted diguanides (II) similarly afforded 2,4-disubstituted melamines (IV) in one stage. Thus, 1-phenyldiguanide (II; R′ = Ph) and diphenylcarbodi-imide (I; R = Ph) gave, under the usual conditions, 2,4-diphenylmelamine (IV; R = R′ = Ph) in 65% yield. The product was identical with authentic material synthesised from 2-amino-4,6-dichloro-1,3,5-triazine by the method of Kaiser *et al.*[10] The present synthesis is particularly useful when disubstituted melamines bearing dissimilar substituents are required. Thus, the reaction of di-*p*-tolyl- and dicyclohexyl-carbodi-imide with 1-phenyldiguanide gave 2-phenyl-4-*p*-tolyl- and 2-phenyl-4-cyclohexyl-melamine, respectively. The only other route to such derivatives appears to be the stepwise substitution of halogen in cyanuric halide by the appropriate amine.[5h]

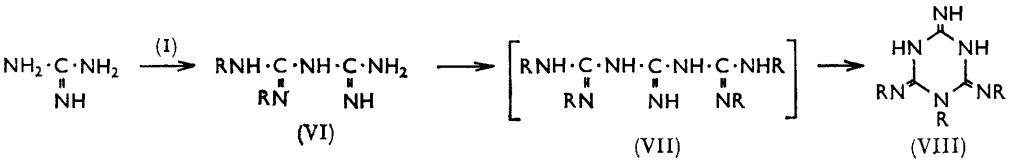
By the general mechanism suggested, the disubstituted melamines (IV) are regarded to arise by loss of one mole of amine from the intermediate addition compounds (III). Theoretically, carbodi-imides may be added at four possible positions [1, 2, 3, and 4(or 5)] in 1-substituted diguanides (II); only those intermediates arising from N(4 or 5)- or N(2)-addition (*i.e.*, III and IIIa) are capable of yielding melamines on cyclisation. Of these two alternatives, the formation of the former (III) is considered more likely, on the basis of observations made in the corresponding reactions involving isothiocyanates.[11] The nature of the final products shows that the intermediate triguanide (III) preferentially loses the amine-moiety of its carbodi-imide component (*i.e.*, RNH rather than R′NH). The alternative ring-closure (of III) to isomelamines (IVa) is probably precluded by the greater ease with which an imino-hydrogen rather than an aryl(or alkyl)amino-hydrogen (in III) participates in the elimination.

The behaviour of 1,2-disubstituted diguanides in this reaction followed the general pattern. 1,2-Diphenyldiguanide (VI; R = Ph), on treatment with a slight excess of diphenylcarbodi-imide in dimethylformamide at 100°, gave 1,2,6-triphenylisomelamine (VIII; R = Ph) in 60% yield. The high speed of this reaction was evident from the fact

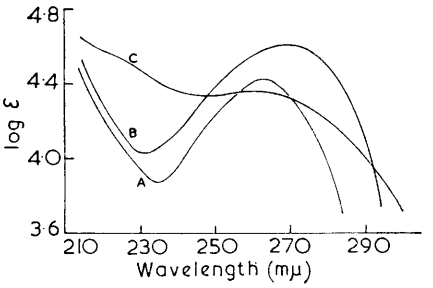
[10] Kaiser, Thurston, Dudley, Schäfer, Hechenbleickner, and Holm-Hansen, *J. Amer. Chem. Soc.*, **1951**, **73**, 2984.
[11] Kurzer and Pitchfork, unpublished results.

that part of the carbodi-imide was consumed by the aniline eliminated from the intermediate triguanide (VII), and reappeared as *NN'N''*-triphenylguanidine (V; R = Ph).

The same reaction also occurred when the 1,2-disubstituted diguanide was formed *in situ* from guanidine and carbodi-imide. Thus, guanidine, treated with 2·5 moles of



diphenylcarbodi-imide in dimethylformamide gave the trisubstituted melamine (VIII; R = Ph) in 60% yield; a considerable proportion of the guanidine (30—35%) was recovered. Under appropriate conditions, the intermediate (VI) of this two-stage process can be isolated; 1,2-diphenyldiguanide (VI; R = Ph) was the main product (54%) when equimolar proportions of guanidine and the carbodi-imide reacted in an acetone–sodium alkoxide medium. In dimethylformamide the reaction could not be confined to the first stage, triphenylisomelamine being again formed, though in lower yield, whilst about one-third of the carbodi-imide was used up in the production of *NN'N''*-triphenylguanidine; in this medium, cyclisation thus appears to proceed faster than the initial diguanide formation. Intermediate results were observed when guanidine and two moles of carbodi-imide reacted in acetone, (VI; R = Ph) and (VIII; R = Ph) being isolated in moderate yield side by side.



Ultraviolet absorption spectra.
(A) phenylmelamine.
(B) 2,4-diphenylmelamine.
(C) 1,2,6-triphenylisomelamine.

1,2,6-Triphenylisomelamine showed a striking tendency to form solvated crystals with water, ethanol, and acetone. It did not yield acetyl, benzoyl, or *p*-nitrobenzenesulphonyl derivatives under the usual conditions, its resistance to acylating agents being even more pronounced than that of the parent compound, melamine.[5i,12] Unlike melamine,[13] it also failed to give adducts with phenyl isothiocyanate or isocyanate.

Unlike its parent compound melamine, which shows only low-intensity absorption in the 280—340 mμ range,[14] phenylmelamine had a high-intensity peak at 264 mμ. This absorption is ascribed to conjugation of the aromatic substituent with the triazine nucleus. The absorption curve of 2,4-diphenylmelamine resembled that of the monosubstituted analogue, except for the slightly higher intensity and small bathochromic displacement (to 270 mμ) of the absorption maximum. The absorption curve of the 1,2,6-triphenyl homologue (VIII; R = Ph), however, differed completely, displaying a wide plateau (240—265 mμ). This reflects the structural distinctness of the isomelamine; the absence

[12] Bann and Miller, *Chem. Rev.*, 1958, **58**, 131, 148, 150.
[13] Hantzsch and Bauer, *Ber.*, 1905, **38**, 1010; Zerweck and Keller (to I.G. Farbenindustrie), U.S.P. 2,228,161/1941; D'Alelio (to General Electric Co.), U.S.P. 2,394,042/1946; Austerwell, B.P. 639,218/1950; *Chem. and Ind.*, 1952, 372.
[14] Hartley, Dobbie, and Landers, *J.*, 1901, **79**, 848; Dixon, Woodberry, and Costa, *J. Amer. Chem. Soc.*, 1947, **69**, 599; Costa, Hirt, and Sally, *J. Chem. Phys.*, 1950, **18**, 434; Klotz and Askounis, *J. Amer. Chem. Soc.*, 1947, **69**, 801.

of strong absorption peaks is ascribed to the smaller number of possible tautomeric forms of this triazine (VIII) owing to ring-substitution.

Experimental

Light petroleum had b. p. 60—80° unless otherwise stated. Dimethylformamide was redistilled and the water-containing forerun rejected. Ultraviolet measurements were made with a Unicam S.P. 500 spectrophotometer for 0·00005M-solutions in ethanol.

Monosubstituted Melamines

Diguanide Ditoluene-p-*sulphonate.*—Diguanide sulphate monohydrate (2·17 g., 0·01 mole) in water (20 ml.), treated with toluene-*p*-sulphonic acid monohydrate (4·18 g., 0·022 mole) in water (6 ml.), slowly deposited the *ditoluene*-p-*sulphonate*, m. p. 273—275° (decomp.) (from 50% aqueous ethanol) (63%) (Found: C, 42·8; H, 5·5; N, 16·0. $C_{16}H_{23}N_5O_6S_2$ requires C, 43·1; H, 5·2; N, 15·7%). The use of equimolar quantities of the reactants gave the ditoluene-*p*-sulphonate in diminished yield (52%).

Diguanide Dipicrate.—Diguanide sulphate monohydrate (0·54 g., 0·0025 mole) in water (8 ml.), treated with picric acid (1·15 g., 0·005 mole) in ethanol (10 ml.), slowly deposited the *dipicrate* (85%), silky needles, m. p. 230—232° (decomp.) (from 50% aqueous ethanol) (Found: C, 29·8; H, 2·5; N, 27·1. $C_{14}H_{13}N_{11}O_{14}$ requires C, 30·05; H, 2·3; N, 27·55%).

Phenylmelamine.—Freshly prepared diguanide [15] (3·0 g., 0·03 mole), in dimethylformamide (30 ml.) at room temperature, was treated with diphenylcarbodi-imide (4·85 g., 0·025 mole) and kept on a steam-bath for 1 hr.; the colour changed from green to deep blue to orange during about 10 min. The finally deep yellow liquid was stirred into a solution of toluene-*p*-sulphonic acid monohydrate (11·4 g., 0·06 mole) in water (120 ml.), and the solid collected after 12 hr. at 0° to give *phenylmelamine toluene*-p-*sulphonate* prisms (66—72%), m. p. 245—247° (decomp.) (from 90% ethanol) (Found: C, 51·15; H, 5·0; N, 22·6; S, 8·7. $C_{16}H_{18}N_6O_3S$ requires C, 51·3; H, 4·8; N, 22·5; S, 8·6%).

The foregoing toluene-*p*-sulphonate (1·12 g., 0·003 mole), on being warmed with 3N-ammonia (12 ml.), gave a clear solution which deposited white solid. This was collected at 0° and gave phenylmelamine (85%), m. p. 197—198° (decomp.) [from acetone–light petroleum (b. p. 40—60°)] (Found: C, 53·1; H, 4·4; N, 42·6. Calc. for $C_9H_{10}N_6$: C, 53·5; H, 4·95; N, 41·6%), identical (mixed m. p. and ultraviolet spectrum) with an authentic sample[10] [which had $\lambda_{min.}$ 234 mμ (log ε 3·89) $\lambda_{max.}$ (wide) 264 (4·42)].

A solution of the toluene-*p*-sulphonate (0·75 g., 0·002 mole) in warm 90% ethanol (12 ml.), treated with 0·05M-picric acid (0·0025 mole), gave the *picrate* (100%), m. p. 292—293° (decomp.) (from nitrobenzene) (Found: C, 42·0; H, 3·2; N, 28·6. $C_{15}H_{13}N_9O_7$ requires C, 41·8; H, 3·0; N, 29·2%).

Alternatively, the original reaction mixture was added to water (100 ml.) and 3N-sodium hydroxide (40 ml.), and set aside overnight (slight evolution of ammonia). The white granular solid was filtered off and gave phenylmelamine (65—75%), m. p. and mixed m. p. 195—197° (decomp.). The filtrate was treated with sodium hydroxide (10 g.) and slowly distilled. The distillate (80 ml.) was refluxed for 20 min. to remove the bulk of the dissolved ammonia and dimethylamine, originating from the dimethylformamide, and shaken with 40% aqueous sodium hydroxide (25 ml.) and benzoyl chloride (6 ml.), giving a precipitate of benzanilide (65%), m. p. and mixed m. p. 159—161° (from ethanol).

Attempts to isolate the possible intermediate triguanide (III; R = Ph, R′ = H) as its copper complex by the addition of copper sulphate to the original reaction mixture under various conditions were unsuccessful.

Action of Two Moles of Diphenylcarbodi-imide on Diguanide.—Diguanide (1·51 g., 0·015 mole) in dimethylformamide (15 ml.) was treated with diphenylcarbodi-imide (5·82 g., 0·03 mole) and kept at 100° for 1 hr., then stirred into 0·5M-sodium hydroxide (60 ml.). The precipitated gum solidified, and was collected at 0° (filtrate A) and rinsed with water. The air-dried white powder (6·5 g.) was boiled with ethanol (50 ml.) and a small insoluble residue (R) filtered off while hot. The product in the ethanolic filtrate was separated with some difficulty by fractional crystallisation from ethanol into phenylmelamine (40—45%), m. p. and mixed m. p.

[15] Slotta and Tschesche, *Ber.*, 1929, **62**, 1396; see also American Cyanamid Co., U.S.P. 2,330,376/1941.

201—202° (decomp.) (from acetone–light petroleum), and the more soluble *NN'N''*-triphenylguanidine, m. p. 142—144° (from ethanol) (lit.,[16] 143—144°) (Found: C, 79·1; H, 6·3. Calc. for $C_{19}H_{17}N_3$: C, 79·4; H, 5·9%).

The insoluble residue (R) (0·4—0·75 g.) was impure phenylmelamine (up to 12%; after purification). Filtrate A was acidified with concentrated hydrochloric acid and treated with 0·05M-picric acid (0·01 mole), to give phenylmelamine picrate (18%), m. p. and mixed m. p. 291—293° (decomp.) (from nitrobenzene).

N-p-*Tolylmelamine*.—A solution of diguanide (1·51 g., 0·015 mole) in dimethylformamide (15 ml.) was treated with di-*p*-tolylcarbodi-imide (2·78 g., 0·0125 mole) and kept on a steam-bath for 1 hr., then stirred into a solution of toluene-*p*-sulphonic acid (5·7 g., 0·03 mole) in water (50 ml.). The precipitated salt was collected at 0° and gave N-p-*tolylmelamine toluene*-p-*sulphonate*, platelets (75%), m. p. 275—276° (decomp.) (from 70% ethanol) (Found: C, 52·4; H, 4·8; S, 8·4. $C_{17}H_{20}N_6O_3S$ requires C, 52·6; H, 5·15; S, 8·25%).

A solution of the toluene-*p*-sulphonate (0·39 g., 0·001 mole) in 66% ethanol (12 ml.), treated with 0·05M-picric acid (0·002 mole), gave the *picrate* (~100%), m. p. 276—278° (decomp.) (from nitrobenzene) (Found: C, 43·2; H, 3·3. $C_{16}H_{15}N_9O_7$ requires C, 43·1; H, 3·4%).

The toluene-*p*-sulphonate (0·97 g., 0·0025 mole) dissolved on being warmed with 3N-ammonia (12 ml.). The deposited solid was collected at 0° and gave *N*-*p*-tolylmelamine (83%), m. p. 258—260° (decomp.) [from acetone–light petroleum (b. p. 40—60°) (1 : 2)] (lit.,[17] 265—266°) (Found: C, 55·65; H, 5·5; N, 38·8. Calc. for $C_{10}H_{12}N_6$: C, 55·6; H, 5·6; N, 38·9%).

N-p-*Bromophenylmelamine*.—Interaction of diguanide (0·015 mole) and di-*p*-bromophenylcarbodi-imide (4·4 g., 0·0125 mole) in dimethylformamide (20 ml.) at 100° for 1 hr. gave, after the usual treatment, N-p-*bromophenylmelamine toluene*-p-*sulphonate* (80%), m. p. 290—294° (decomp., after darkening at 260°) (from 66% ethanol) (Found: C, 42·9; H, 3·7; N, 17·8: S, 7·0. $C_{16}H_{17}BrN_6O_3S$ requires C, 42·4; H, 3·75; N, 18·55; S, 7·1%).

The *picrate* (*ca.* 100%) had m. p. 296—297° (decomp.) (from nitrobenzene–ethanol) (Found: C, 35·95; H, 2·6. $C_{15}H_{12}BrN_9O_7$ requires C, 35·3; H, 2·35%).

The toluene-*p*-sulphonate (1·35 g., 0·003 mole) was dissolved in 3N-ammonia (20 ml.) with warming. The deposited solid was collected at 0°, and gave N-p-*bromophenylmelamine*, prisms (65%), m. p. 243—245° (decomp.) [from ethanol–light petroleum (b. p. 40—60°)] (Found: C, 39·1; H, 3·1; N, 28·4; Br, 27·4. $C_9H_{11}BrN_6$ requires C, 38·4; H, 3·2; N, 29·9; Br, 28·45%).

N-*Cyclohexylmelamine*.—Interaction of diguanide (0·015 mole) and dicyclohexylcarbodi-imide (2·6 g., 0·0125 mole) in dimethylformamide gave the crude toluene-*p*-sulphonate which was boiled with water (60 ml.) and filtered hot. The filtrate deposited a solid which gave N-*cyclohexylmelamine toluene*-p-*sulphonate* (64%), m. p. 192—194° (decomp.) (from water) (Found: C, 49·9; H, 6·2; N, 22·2; S, 8·45. $C_{16}H_{24}N_6O_3S$ requires C, 50·5; H, 6·3; N, 22·1; S, 8·4%). The residue gave *NN'N''-tri*(*cyclohexyl*)*guanidine toluene*-p-*sulphonate* (14%), m. p. 188—189° (from ethanol–light petroleum) (Found: C, 65·2; H, 9·0; N, 9·2; S, 7·2. $C_{26}H_{43}N_3O_3S$ requires C, 65·4; H, 9·0; N, 8·8; S, 6·7%).

N-*Cyclohexylmelamine picrate* (75%), prepared in aqueous solution from the toluene-*p*-sulphonate, had m. p. 269—271° (decomp.) (from nitrobenzene) (Found: C, 41·6; H, 4·0. $C_{15}H_{19}N_9O_7$ requires C, 41·2; H, 4·35%).

The toluene-*p*-sulphonate (0·57 g., 0·0015 mole) was dissolved in 3N-ammonia (15 ml., 0·045 mole) by boiling, and the clear solution rapidly cooled. The separated material was collected at 0°, to give *N*-cyclohexylmelamine (72%) m. p. 144—146° (after sintering at 138°) [from acetone–light petroleum (1 : 1)] (lit.,[18] 136—138°) (Found: C, 49·6, 49·1; H, 7·7, 7·5; N, 38·8. Calc. for $C_9H_{16}N_6,\frac{1}{2}H_2O$: C, 49·8; H, 7·8; N, 38·7%).

2,4-*Disubstituted Melamines*

1-*Phenyldiguanide Dipicrate*.—A solution of the base (0·35 g., 0·002 mole) in water (3 ml.) was added to hot aqueous 0·15M-picric acid (0·004 mole) to give the *solvated dipicrate*, prisms (75%), m. p. 188—191° (decomp.) (from ethanol) (Found: C, 38·8, 38·4; H, 2·9, 3·1; N, 23·2.

[16] Merz and Weith, *Z. Chem.*, 1868, 604; Dixon, *J.*, 1899, **75**, 405; Lautz, *Z. phys. Chem.*, 1913, **84**, 621.

[17] Walker, l'Italien, Pearlman, and Banks, *J. Amer. Pharmaceut. Assoc.* (*Sci. Edn.*), 1950, **39**, 393.

[18] Okumura and Bando (to Tokushima Petroleum Co.), Jap. P. 9597/1962 (*Chem. Abs.*, 1963, **59**, 3940).

$C_{20}H_{17}N_{11}O_{14}.C_2H_5OH$ requires C, 38·8; H, 3·4; N, 22·6%). The m. p. of the monopicrate has been reported as 176—179°,[19] 184°,[20] and 246—247°,[21] that of the dipicrate as 212—213°.[21]

2,4-*Diphenylmelamine*.—A solution of 1-phenyldiguanide (1·95 g., 0·011 mole) in dimethylformamide (15 ml.) was treated with diphenylcarbodi-imide (1·94 g., 0·01 mole) and kept at 100° for 1 hr. (usual colour changes during the first 5 min.), then stirred into 0·5N-sodium hydroxide (60 ml.). The resulting precipitate was collected at 0°, washed with water, digested with warm ethanol (10—20 ml.), and collected at 0°, to give 2,4-diphenylmelamine, prisms (65%), m. p. 216—217° (from ethanol) (lit., 218—219°,[22] 219—220° [10]) (Found: C, 64·6; H, 5·1; N, 30·8. Calc. for $C_{15}H_{14}N_6$: C, 64·75; H, 5·0; N, 30·2%), identical (mixed m. p. and ultraviolet spectrum) with a sample synthesised by the method of Kaiser *et al.*;[10] this had $\lambda_{min.}$ 232 mμ (log ε 4·05); $\lambda_{max.}$ 270 (4·64).

The *picrate* (85%), obtained from equimolar quantities of the components in a large volume of boiling ethanol, had m. p. 280—281° (decomp.) (from nitrobenzene) (Found: C, 49·3; H, 3·3. $C_{21}H_{17}N_9O_7$ requires C, 49·7; H, 3·35%).

2-*Phenyl*-4-p-*tolylmelamine*.—Interaction of 1-phenyldiguanide (2·83 g., 0·016 mole) and di-*p*-tolylcarbodi-imide (3·33 g., 0·015 mole) in dimethylformamide (15 ml.) at 100° for 1 hr. and addition of the liquid to 0·5N-sodium hydroxide (60 ml.) gave a crude product which was dried (4·5 g.), boiled with ethanol (12 ml.), and filtered hot. The undissolved residue, and the first fraction which separated from the filtrate gave 2-*phenyl*-4-p-*tolylmelamine*, prisms (58%), m. p. 206—208° (decomp.) (from ethanol) (Found: C, 65·4; H, 5·5; N, 29·15. $C_{16}H_{16}N_6$ requires C, 65·75; H, 5·5; N, 28·8%), $\lambda_{min.}$ 232 mμ (log ε 4·07); $\lambda_{max.}$ 270 mμ (log ε 4·63). Its *picrate* (90%) had m. p. 256—257° (decomp.) (from nitrobenzene) (Found: C, 50·75; H, 3·5. $C_{22}H_{19}N_9O_7$ requires C, 50·7; H, 3·65%).

2-*Cyclohexyl*-4-*phenylmelamine*.—1-Phenyldiguanide (1·95 g., 0·011 mole) and dicyclohexylcarbodi-imide (2·05 g., 0·01 mole) in dimethylformamide (15 ml.) was kept at 100° for 1 hr., then stirred into 0·5N-sodium hydroxide (60 ml.). The aqueous layer was decanted from the highly viscid oil, which was rinsed with more water and covered with ethanol (10 ml.), when it gradually solidified and gave the *melamine*, needles (32%), m. p. 174—177° (decomp.) (from methanol) (Found: C, 63·4; H, 6·9; N, 29·8. $C_{15}H_{20}N_6$ requires C, 63·4; H, 7·0; N, 29·6%).

The aqueous layer was acidified with 3N-hydrochloric acid, treated with 0·05M-picric acid (0·005 mole), and the precipitate collected at 0°, to give the solvated phenyldiguanide dipicrate, prisms (30%), m. p. and mixed m. p. (see above) 188—190° (Found: C, 38·9; H, 2·85%.)

The *picrate* (~100%) had m. p. 280—281° (decomp.) (from nitrobenzene) (Found: C, 49·8; H, 4·6. $C_{21}H_{23}N_9O_7$ requires C, 49·1; H, 4·5%).

1,2,6-*Trisubstituted Isomelamines*

1,2-*Diphenyldiguanide*.—(*a*) The compound (20—25%) was obtained from *N*-amidino-*N'*-phenylthiourea by the method of Bamberger,[23] m. p. 168—170° (from ethanol) (lit.,[23] 167°).

(*b*) To the suspension obtained on introducing sodium (0·92 g., 0·04 g.-atom) into acetone (100 ml.), guanidine thiocyanate (4·72 g., 0·04 mole) was added. The resulting clear orange-red warm liquid was treated dropwise with diphenylcarbodi-imide (7·76 g., 0·04 mole), refluxed for 30 min., distilled to half-bulk under reduced pressure, and stirred into ice–water (200 ml.) containing 3N-sodium hydroxide (10 ml.). The aqueous phase was decanted from the precipitated oil, which was washed with water, dissolved in chloroform (30 ml.), heated with carbon–Kieselguhr, and filtered. The filtrate was diluted with light petroleum to incipient turbidity (30 ml.), and slowly gave 1,2-diphenyldiguanide, prisms (32—45%), m. p. 168—170° [from ethanol–light petroleum (1 : 1)] (Found: C, 66·2; H, 6·1. Calc. for $C_{14}H_{15}N_5$: C, 66·4; H, 5·9%).

The aqueous phase was acidified with concentrated hydrochloric acid, and treated with 0·05M-picric acid (0·01 mole), giving 1,2-diphenyldiguanide picrate (6—8%), m. p. and mixed m. p. (see below) 212—214° (decomp.) (from 66% ethanol).

The *picrate* (85%) formed felted needles, m. p. 212—214° (decomp.) (from ethanol) (Found:

[19] Cohn, *J. prakt. Chem.*, 1911, **84**, 396.
[20] Oxley and Short, *J.*, 1951, 1252.
[21] Kawano and Odo, *Yuki Gosei Kagaku Kyokai Shi*, 1962, **20**, 649 (*Chem. Abs.*, 1963, **59**, 3770).
[22] Matsui, Hagiwara, and Soeda, *Yuki Gosei Kagaku Kyokai Shi*, 1960, **18**, 184 (*Chem. Abs.*, 1960, **54**, 11,042).
[23] Bamberger, *Ber.*, 1880, **13**, 1581.

C, 50·6; H, 3·9; N, 22·7. $C_{20}H_{18}N_8O_7$ requires C, 49·8; H, 3·7; N, 23·2%). A dipicrate was not obtained, the use of a three-molar excess of picric acid in ethanol giving again the monopicrate quantitatively.

A solution of the diguanide (0·25 g., 0·001 mole) in boiling ethanol (4 ml.), treated with toluene-*p*-sulphonic acid monohydrate (0·19 g., 0·001 mole) in water (1 ml.), gave the *toluene-p-sulphonate*, lustrous needles (*ca.* 100%), m. p. 233—235° (decomp.) (from 50% ethanol) (Found: C, 59·0; H, 5·9; N, 17·2. $C_{21}H_{23}N_5O_3S$ requires C, 59·3; H, 5·4; N, 16·5%).

(*c*) The use of two moles of diphenylcarbodi-imide (15·5 g., 0·08 mole) in the foregoing experiment gave, on addition of the distilled-down reaction mixture to dilute sodium hydroxide, an oil, which was stirred with cold ethanol (20—30 ml.), and the resulting white solid collected after two days' storage at 0°. The ethanolic filtrate was treated with 0·2M-ethanolic picric acid (0·04 mole), and slowly diluted with water (200 ml.). The resulting precipitate was collected at 0° (20 g.) and afforded, on successive crystallisations from 85% ethanol and absolute ethanol, 1,2-diphenyldiguanide picrate (24%), m. p. and mixed m. p. 211—213° (decomp.). The white solid was 1,2,6-triphenylisomelamine (28%), m. p. 252—255° (decomp.) (from acetone–light petroleum), identical (mixed m. p. and ultraviolet spectrum) with the sample prepared below.

1,2,6-*Triphenylisomelamine*.—(*a*) A solution of guanidine thiocyanate (freshly powdered and dried at 70°) (1·18 g., 0·01 mole) in dimethylformamide (20 ml.) was treated with diphenylcarbodi-imide (3·88 g., 0·02 mole), kept at 100° for 30 min., then stirred into 0·3N-sodium hydroxide (100 ml.). The granular precipitate was collected at 0° (filtrate F), washed with water, air-dried (4 g.), and dissolved in acetone (60—80 ml.). The filtered solution was diluted with light petroleum and allowed to evaporate, to give *solvated* 1,2,6-*triphenylisomelamine* (total, 38—45%), m. p. 253—255° (rate-dependent decomp.) (Found: C, 69·5; H, 5·4; N, 21·4. $C_{21}H_{18}N_6$,Me_2CO requires C, 69·9; H, 5·8; N, 20·4%). This solvate, after being kept at 120° for 1 hr., gave 1,2,6-*triphenylisomelamine* as a white powder, m. p. 270—271° (rate-dependent, decomp.) (Found: C, 71·0; H, 5·0; N, 23·0. $C_{21}H_{18}N_6$ requires C, 71·2; H, 5·1; N, 23·7%). Crystallisation of this compound from absolute ethanol gave minute needles of the *solvate*, m. p. 265—267° (rate-dependent, decomp.) (Found: C, 69·5; H, 5·3; N, 21·3. $C_{21}H_{18}N_6$,C_2H_5OH requires C, 69·0; H, 6·0; N, 21·0%). Crystallisation from 95% ethanol gave the *monohydrate*, m. p. 252—254° (decomp.) (Found: C, 67·6; H, 5·2; N, 22·8. $C_{21}H_{18}N_6$,H_2O requires C, 67·7; H, 5·4; N, 22·6%). The identity of the four compounds was confirmed by their identical ultraviolet spectra, plateau 242–267 mμ, including $\lambda_{max.}$ 260 mμ (v. shallow) (log ε 4·36), $\lambda_{min.}$ 248 mμ (v. shallow) (log ε 4·34).

Filtrate F was acidified with concentrated hydrochloric acid and treated with 0·05M-picric acid (0·006 mole), giving guanidine monopicrate (48%), m. p. and mixed m. p. 318—320° (decomp.) (from 50% ethanol) (literature values [24] vary between 310 and 316°).

By increasing the proportion of diphenylcarbodi-imide to 2·5 moles per mole of guanidine, the yield of 1,2,6-triphenylisomelamine was raised to 54—60%, whilst that of the recovered guanidine (picrate) was reduced to 30—35%.

(*b*) Interaction of diphenylcarbodi-imide (0·02 mole) and guanidine thiocyanate (0·02 mole) in dimethylformamide [conditions and isolation as in (*a*)] gave a crude product which afforded 1,2,6-triphenylmelamine monohydrate (45—52%), m. p. 253—255° (decomp., rate-dependent) (from 95% ethanol); identical ultraviolet spectrum with that of a sample prepared in (*a*). Its picrate had m. p. and mixed m. p. (see below) 302—303° (decomp.) (from nitrobenzene–ethanol) (Found: C, 55·3; H, 3·7%).

The ethanolic mother-liquors gave, on spontaneous evaporation, a semi-solid residue, which was redissolved in ethanol (15 ml.), filtered, and treated with picric acid (2 g.) in hot ethanol (8 ml.). The crude product which separated slowly on storage gave *NN'N''*-triphenylguanidine picrate (33%), m. p. and mixed m. p.[25] 181—183° (decomp.) (from 80% ethanol) (Found: N, 16·9. Calc. for $C_{25}H_{20}N_6O_7$: N, 16·3%). The aqueous fraction gave guanidine picrate (up to 20%).

(*c*) A solution of 1,2-diphenyldiguanide (1·26 g., 0·005 mole) in dimethylformamide (15 ml.) was treated with diphenylcarbodi-imide (1·15 g. 0·006 mole), kept at 100° for 1 hr., then poured into 0·3N-sodium hydroxide (100 ml.). The oily product solidified on being stirred and cooled to 0°, affording solvated (acetone) 1,2,6-triphenylisomelamine (58%), m. p. and mixed m. p. with material from (*a*) 255—257° (from acetone–light petroleum).

[24] Beilstein's Handbuch, 4th edn., vol. 6, p. 279, and supplements.
[25] Dains, *J. Amer. Chem. Soc.*, 1900, **22**, 184.

The filtrates after the removal of the above isomelamine, were treated with picric acid (0·57 g., 0·0025 mole) in ethanol. The resulting *NN'N''*-triphenylguanidine picrate (60%) had m. p. and mixed m. p.[25] 181—183° (decomp.) (from 80% ethanol) (Found: C, 57·7; H, 4·3; N, 17·0. Calc. for $C_{25}H_{20}N_6O_7$: C, 58·1; H, 3·9; N, 16·3%).

1,2,6-*Triphenylisomelamine. Derivatives.*—The compound failed to yield an acetyl derivative on being heated under reflux for 2 hr. in acetic anhydride (20 ml. per g.), with or without addition of anhydrous sodium acetate. Treatment with an excess of benzoyl chloride in pyridine at 100° for 15 min. gave mostly intractable gums. It was substantially recovered after being heated with a small excess of *p*-nitrobenzenesulphonyl chloride in pyridine for 30 min.

A solution of the isomelamine (0·11 g., 0·0003 mole), or its acetone solvate (0·0003 mole), and picric acid (0·08 g., 0·00035 mole) in warm dimethylformamide (2 ml.) was diluted dropwise with water to incipient precipitation. Separation of the solid was completed by storage at 0°; solution in boiling nitrobenzene (2 ml.) and dilution with ethanol (2 ml.) gave 1,2,6-*triphenylisomelamine picrate*, needles (75%), m. p. 302—303° (decomp.) (Found: C, 55·6; H, 3·6. $C_{27}H_{21}N_9O_7$ requires C, 55·6; H, 3·6%).

The isomelamine (0·002 mole) was recovered (80%) after treatment at 100° in pyridine (12 ml.) with phenyl isothiocyanate or isocyanate (0·002 mole), for 2 and 0·5 hr., respectively.

1,2,6-*Tri*-p-*tolylisomelamine.*—A solution of guanidine thiocyanate (1·18 g., 0·01 mole) in dimethylformamide (25 ml.) was treated with di-*p*-tolylcarbodi-imide (4·44 g., 0·02 mole) and kept at 100° for 30 min., then stirred into water (100 ml.) containing 3N-sodium hydroxide (10 ml.). The precipitated resin solidified on being stirred, and was collected at 0°. It was extracted with boiling ethanol (10 ml.); the powdery residue yielded fine silky needles of 1,2,6-*tri*-p-*tolylmelamine* (64%), m. p. 298—300° (decomp.) (from 2-ethoxyethanol) (Found: C, 72·3; H, 5·6; N, 21·4. $C_{24}H_{24}N_6$ requires C, 72·7; H, 6·1; N, 21·2%). It had $\lambda_{min.}$ (shallow) 245 mμ (log ε 4·33); $\lambda_{max.}$ (very shallow, approaching a " plateau ") 255—270 mμ (log ε 4·36).

The *picrate* formed needles (~100%), m. p. 226—227° (decomp.) (from 80% ethanol) (Found: C, 57·7, H, 4·8. $C_{30}H_{27}N_9O_7$ requires C, 57·6; H, 4·3%).

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