383. *Complexes of Polynitro-compounds. Part III. Compounds of Polynitro-substances with Derivatives of Carbostyril, etc.*

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Monomethyl derivatives of carbostyril and of dibenzylaniline (cf. Part II, J., 1938, 8) and some other derivatives of the former have been examined with reference to their capacity to afford crystalline, termolecular (1 : 2) compounds with polynitro-substances, analogous to those provided by the parent compounds (Sudborough, J., 1916, **109**, 1346). Some exceptions were observed, including a crystalline 2 : 3 product from *s*-trinitrobenzene (X) and dibenzyl-*m*-toluidine (cf. the analogous compound between X and triphenylcarbinol, indicated by the m. p. curve; Kremann, Hohl, and Müller, *Monatsh.*, 1921, **42**, 199), but 13 substances gave 16 new examples of ternary complexes with X or with picric acid (Y).

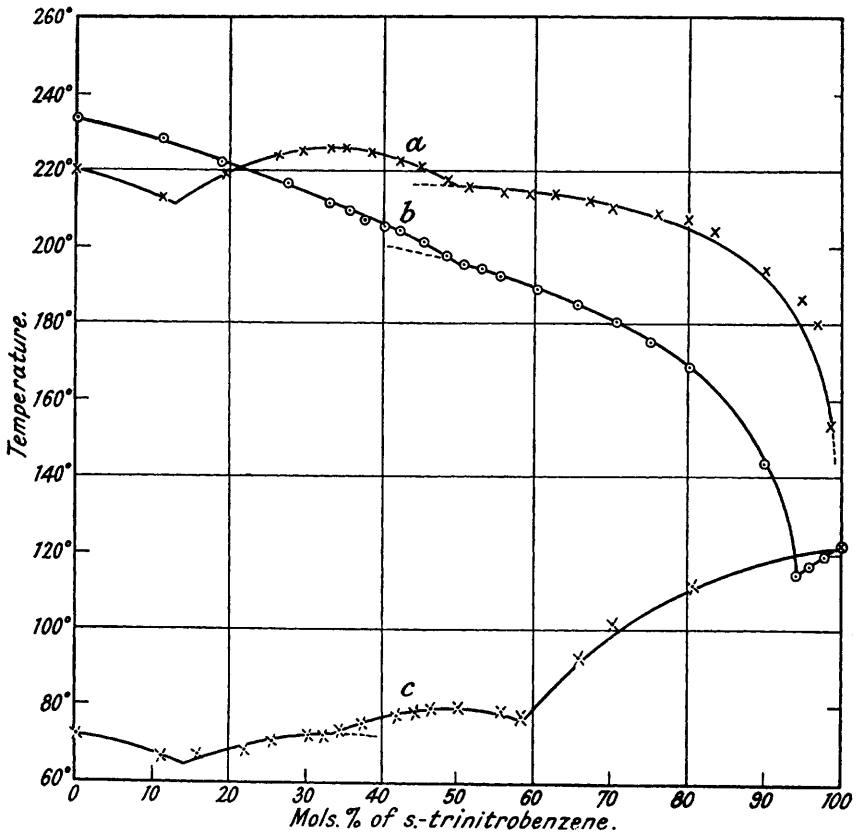
The Y compounds prepared included some " salt-like " types with carbostyrils (cf. Knorr, *Annalen*, 1886, **236**, 86) and with 2-quinolones (cf. Fischer, *Ber.*, 1899, **32**, 1305, but also Kaufmann and de Petherd, *Ber.*, 1917, **50**, 342) for which a " hydrogen bond " is suggested. A few picrates were obtained from thio-compounds and methyl picrate.

In contrast to 1-ketotetrahydrocarbazole (Part I, J., 1935, 977), carbostyril and dibenzylaniline, though readily giving homogeneous, crystalline, molecular compounds from alcohol with *s*-trinitrobenzene (X), did not do so with 1 : 2 : 4-trinitrobenzene, *m*- or *p*-dinitrobenzene, *s*-trinitrotoluene, 2 : 4- or 3 : 5-dinitrotoluene. Carbostyril, however, afforded a range of accessible derivatives which demonstrate in some instances (*e.g.*, in the table, XB_2, XL_2, XP'_2) persistence in ternary complex formation over a relatively wide constitutional range; and of the cases in which there is apparently an exceptional behaviour in that binary compounds are formed, some (XU, XU', XV) may not strictly be comparable with complexes containing a carbostyril derivative to which a resonant amido-character may be assigned (Arndt, Eistert, and Ender, *Ber.*, 1929, **62**, 50; Arndt and Eistert, *Ber.*, 1938, **71**, 2041). The remaining exceptions of this type, however, demonstrate that secondary influences affect the availability as solid phases of any alternatives present in appropriate solutions or melts; for instance, the effect of *p*-methylation on thiocarbostyril is to change the *s*-trinitrobenzene complex from ternary to binary, whereas it has the opposite effect on 1-ketotetrahydrocarbazole (cf. Part II), and in dibenzylaniline the type of complex is unaltered.

The most striking variation in the tendency for complex formation with *s*-trinitrobenzene is provided among the *C*-methylcarbostyrils by the unique failure in this respect of 6-methylcarbostyril; this appears to be constitutional (cf. the 4-isomeride; see figure) and is contrary to the usually helpful influence of such substituents in amines or hydrocarbons (Sudborough and Beard, J., 1910, **97**, 774; Moore, Shepherd, and Goodall, J., 1931, 1453; Davies and Hammick, J., 1938, 766; Hamilton and Hammick, *ibid.*, p. 1351): it may partly account for the absence or the relative instability of similar complexes from 6-methylcarbostyril derivatives. *N*-Methylation of carbostyrils, in contrast to *O*-methylation (cf. XU, where U is a liquid, and XV), appeared to reduce the probability of isolating homogeneous crystalline derivatives of *s*-trinitrobenzene; on the other hand, replacement of carbonyl oxygen by sulphur had generally, as in coumarin, a helpful effect except in one case (that of 1 : 6-*dimethyl*-2-*thioquinolone*), but it is not quite clear that these are constitutional effects rather than results of relative component solubilities (cf. Bamberger and Dimroth, *Annalen*, 1924, **438**, 67).

The picrates obtained from various quinolones and carbostyrils are, with one exception (*viz.*, YC_2), manifestly " salt-like " in character if compared with the *s*-trinitrobenzene complexes in colour and m. p. (Pfeiffer, " Organische Molekulverbindungen," Stuttgart, 1927, pp. 351, 357); and moreover they are here frequently of different (*i.e.*, 1 : 1) composition. Their similar ease of preparation and moderate solubility in alcohol suggest that the picrates of carbostyrils are not differentiated from 2-quinolone picrates as salts of " 2-hydroxyquinolines," unless perhaps in the case of carbostyril picrate itself, which is

plainly exceptional in its relatively low m. p. (cf. Arndt, Eistert, and Ender, *loc. cit.*) and its excessive solubility in water and ether (Henze, *Ber.*, 1936, **69**, 1568) and in the lower alcohols. Although an " amide picrate " formulation is equally applicable to both types, salts of anilides are relatively unstable (Topin, *Ann. Chim. Phys.*, 1895, **5**, 128, 130), and it is notable that dihydrocarbostyril is unable to afford an analogous product, although it is derived from an acid weaker than *cis*-cinnamic (Internat. Crit. Tables, 1929, **6**, 290—291) and it contains an amido-group less likely than that of carbostyril to exercise an internal basic function (Arndt and Eistert, *loc. cit.*, p. 2042). These picrates may therefore be " hydrogen bond " adducts, ·NR·C:O · · · · HOX, stabilised by resonance. If so, the anomalous behaviour of 3-methylcarbostyril towards picric acid would be of some theoretical



a. *System* 4-*methylcarbostyril*–s.-*trinitrobenzene.*
b. *System* 6-*methylcarbostyril*–s.-*trinitrobenzene.*
c. *System* 1-*methyl*-2-*quinolone*–s.-*trinitrobenzene.*

interest; and such a structure for the quinolone and carbostyril picrates would be consistent with the tendency of the 2-thio-quinolones and -carbostyrils to give molecular compounds with this acid (YA′, YD'_2, YP'_2) or none (1 : 6-dimethyl-2-thioquinolone; cf. Lassettre, *Chem. Rev.*, 1936, **20**, 259; Huggins, *J. Org. Chem.*, 1936—1937, **1**, 454). On the other hand, the picrate of 2-thiocoumarin (Ghosh, J., 1915, **107**, 1599) is, by the usual criteria, almost certainly a " salt " analogous to those of coumarin (Ghosh, *loc. cit.*) and 1-thiocoumarin.

Experimental.

Picrates assumed to be " salt-like " in structure are indicated hereafter by the use of Y as a suffix (*e.g.*, in the table : AY, but YC_2). The descriptions of XA_2 (Sudborough, *loc. cit.*) and UY (Kaufmann and de Petherd, *loc. cit.*) confirm those of the respective authors; analytical

data are provided for AY (Henze, *loc. cit.*), DY (Knorr, *loc. cit.*), and QY (Fischer, *loc. cit.*). The other compounds appear to be new except that our XD_2 coincides sharply in its properties with the similar complex, containing " hydroxylepidine," of Sudborough and Beard (J., 1911, **99**, 213) although their " hydroxyquinoline " is clearly 8-hydroxyquinoline.

The compounds were best prepared in the solvent indicated, absolute alcohol being used if practicable, and if possible the original solvent was used for recrystallisation of specimens for micro-analysis (for all of which the authors are indebted to Mr. J. M. L. Cameron) : alternative analytical figures were derived from separate preparations. The complex XP and that from Y and F′ could not be isolated in microscopically homogeneous condition. The absence from the tabulated list of an X or Y compound indicates failure to obtain it from appropriate solutions or melts. 1 : 6-Dimethyl-2-thioquinolone, which is reasonably soluble in the common solvents, gave coloured solutions with X and with Y, but no solid products; moreover, melts of the components showed signs of decomposition.

X = *s*-Trinitrobenzene. Y = Picric acid.

Polynitro-component.	Aromatic component.	Compound.	N, %. Found.	N, %. Calc.	Description.	M. p.	Solvent.
X	A. Carbostyril	XA_2	13·9	13·9	Sulphur-yellow needles	178°	EtOH
Y	"	AY	14·8	14·9	Yellow needles	132	Et_2O *
X	A′. Thiocarbostyril	XA′	15·3	15·0	Light brown plates	163—165	EtOH
Y	"	YA′	14·1	14·3	Crimson needles	145	"
X	B. Dihydrocarbostyril	XB_2	13·8	13·8	Yellow plates	137—138	"
X	C. 3-Methylcarbostyril	XC_2	13·1	13·2	Light yellow needles	incongruent	"
Y	"	YC_2	12·6 12·5	12·8	Golden-yellow prisms	"	"
X	D. 4-Methylcarbostyril	XD_2	13·05	13·2	Canary-yellow prisms	226—227	"
Y	"	DY	14·5	14·4	Light yellow needles	164—165	"
X	D′. 4-Methyl-2-thiocarbostyril	XD'_2	12·4	12·4	Brown-yellow prisms	190—192	$CHCl_3$ + X
Y	"	YD'_2	11·9	12·1	Orange-red plates	193—195	$CHCl_3$ + Y
X	E. 5-Methylcarbostyril	XE_2	13·1	13·2	Light yellow needles	222—223	EtOH
Y	"	EY	14·3	14·4	Yellow prisms	156—157	"
Y	F. 6-Methylcarbostyril	FY	14·5	14·4	Pale yellow needles	171—172	"
X	F′. 6-Methyl-2-thiocarbostyril	XF'_2	12·5	12·4	Orange prisms	159—161	$CHCl_3$ (conc. soln.)
Y	"	?	—	—	Scarlet prisms	140—142	$CHCl_3$ (1 : 1 conc. soln.)
X	G. 7-Methylcarbostyril	XG_2	13·3 13·4	13·2	Canary-yellow needles	203—204	EtOH
Y	"	GY	14·3	14·4	Light yellow needles	163	"
X	H. 8-Methylcarbostyril	XH_2	13·2 13·2	13·2	Golden-yellow needles	181	"
Y	"	HY	14·5	14·4	Light yellow needles	128—129	" (conc. soln.)
X	L. 4 : 6-Dimethylcarbostyril	XL_2	12·7	12·5	Golden-yellow prisms	incongruent	" " "
Y	"	LY	13·8	13·9	Canary-yellow needles	188	EtOH
X	M. 4 : 7-Dimethylcarbostyril	XM_2	12·3	12·5	Sulphur-yellow needles	213—214	"
Y	"	MY	13·9	13·9	Light yellow needles	189—191	"
X	N. 4 : 8-Dimethylcarbostyril	XN_2	12·5	12·5	Sulphur-yellow needles	199—200	"
Y	"	NY	13·7	13·9	Canary-yellow needles	192—194	"
X	P. 1-Methyl-2-quinolone	XP	—	—	Light yellow laminated plates	77—79	CCl_4 + P (cf. Fig.)
Y	"	PY	14·5	14·4	Yellow needles	128—129	EtOH
X	P′. 1-Methyl-2-thioquinolone	XP'_2	12·5	12·4	Orange needles	98—99	"
Y	"	YP'_2	12·3	12·1	Orange prisms	104	"
Y	Q. 1 : 6-Dimethyl-2-quinolone	QY	13·8	13·9	Canary-yellow needles	150	"
X	R. 1 : 7-Dimethyl-2-quinolone	XR	14·45	14·5	Pale yellow prisms	106—107	CCl_4 + R
Y	"	RY	14·0	13·9	Lemon-yellow prisms	132	EtOH
Y	S. 1 : 8-Dimethyl-2-quinolone	SY	13·9	13·9	Canary-yellow needles	134	"
X	U. 2-Methoxyquinoline	XU	15·1	15·05	Yellow plates	89—90	"
Y	"	UY	14·2	14·4	Yellow needles	170—171	"
X	U′. 2-Methylthioquinoline	XU′	14·5	14·4	Deep yellow needles	99—100	MeOH
Y	"	U′Y	13·9	13·9	Yellow plates	183—184	"
X	V. 2-Methoxy-6-methylquinoline	XV	14·5	14·5	Greenish-yellow prisms	72—73	EtOH (conc. soln.)
Y	"	VY	13·9	13·9	Greenish-yellow plates	181—182	EtOH

* This compound was also prepared from very concentrated solutions of its components in MeOH or EtOH.

The compound of picric acid and 2-methylthioquinoline (U′Y) was first obtained when thiocarbostyril and methyl picrate were dissolved together by warming in methyl alcohol; that it was not, despite its ease of preparation, a molecular compound was established by the following synthesis of an identical product. Methanethiol, from *S*-methylthiourea sulphate (17 g.; Arndt, *Ber.*, 1921, **54**, 2237), was bubbled through a solution of sodium (0·7 g.) in methyl alcohol (10 c.c.), 2-chloroquinoline (5 g.) in methyl alcohol (5 c.c.) added, and the whole boiled under reflux for 2 hours, and filtered. Picric acid (5 g.) was added in portions to the filtrate, precipitating first sodium picrate and then crude U′Y, which was readily purified by washing with cold water (yield, 1·5 g.) (Found : N, 14·0%) and gave crude 2-methylthioquinoline (Beilenson and Hamer, this vol., p. 147) on cautious treatment with an ice-cold dilute solution of sodium bicarbonate. Giua and Giua (*Gazzetta*, 1921, **51**, 313, 315; cf. Pfeiffer, *op. cit.*, p. 369) describe as molecular compounds the products obtained from heterocyclic bases and methyl picrate, etc.; that from quinoline and methyl picrate is identical with the product from quinoline methosulphate

and Y, and the others described are also, from their lengthy mode of preparation, most probably analogous salts.

2-*Methylthio*-6-*methylquinoline picrate*, prepared from F′ and methyl picrate by 1 hour's boiling in methyl alcohol, formed golden-yellow plates from methyl alcohol, m. p. 196—197° (Found: N, 13·2. $C_{11}H_{11}NS,C_6H_3O_7N_3$ requires N, 13·4%), which afforded 2-methylthio-6-methylquinoline (Fischer, *loc. cit.*, p. 1306) with aqueous sodium bicarbonate.

2-*Methylthio*-1-*methylquinolinium picrate*, prepared from P′ and methyl picrate by 10 mins.' boiling in methyl alcohol, formed deep yellow plates, m. p. 175° [Found: N, 13·5. $SMe{\cdot}C_9H_6NMe{\cdot}O{\cdot}C_6H_2(NO_2)_3$ requires N, 13·4%]. 1 : 6-Dimethyl-2-thioquinolone was, in similar circumstances and even after 2 hours' boiling, recovered unchanged.

Crystallisation of X from 6-methylquinoline gave the binary compound (Sudborough and Beard, J., 1910, **97**, 776, 795) as faintly yellow needles, m. p. 63—65° (Found, by trituration with dilute aqueous hydrochloric acid: $C_6H_3O_6N_3$, 59·5. Calc. for $C_6H_3O_6N_3,C_{10}H_9N$: $C_6H_3O_6N_3$, 59·8%). 8-Methylquinoline similarly afforded the analogous product (*idem*, *ibid.*) as faintly yellow needles, m. p. incongruent (Found: X, 59·3%. A correction was applied in these analyses for loss of dissolved X as determined by a blank experiment). Thus no evidence was obtained of relative complex-instability associated with 6-methylation in this case.

Except for D and its homologues (Ewins and King, J., 1913, **103**, 104) the most attractive synthesis of carbostyrils is that of Tschitschibabin (*Ber.*, 1923, **56**, 1879; Tschitschibabin and Kursanowa, *Chem. Abstr.*, 1931, **25**, 2727); but efforts to obtain A or F by this procedure were unsuccessful. Attempts to extend Camps's synthesis of A (*Arch. Pharm.*, 1899, **237**, 682) to the preparation of C from *o*-aminobenzaldehyde and propionic anhydride were also unsuccessful, the only product isolated being the aldehydo-autocondensate (Camps, *loc. cit.*).

Späth's synthesis (*Monatsh.*, 1919, **40**, 122) was adopted for F, G, and H, then the more recent procedure of Henze (*loc. cit.*, p. 1567) was successfully extended to F, C, and E. In the preliminary preparation of 5-methylquinoline the intermediate 8-carboxylic acid (Jakubowski, *Ber.*, 1910, **43**, 3028) was isolated in greatly improved (60%) yield when Chakravarti and Venkatasubban's modification of the Skraup synthesis (*J. Annamalai Univ.*, 1933, **2**, 236; *Chem. Abstr.*, 1934, **28**, 2008, gives an erroneous abstract) was applied to 3-amino-4-cyanotoluene.

The following compounds were, unless otherwise indicated, finally recrystallised from alcohol: 2-*chloro*-7-*methylquinoline*, colourless plates, m. p. 81° (Found: N, 8·0; Cl, 19·8. $C_{10}H_8NCl$ requires N, 7·9; Cl, 20·0%); *picrate*, canary-yellow plates, m. p. 113—114° (Found: N, 13·7. $C_{10}H_8NCl,C_6H_3O_7N_3$ requires N, 13·45%). 3-*Methylquinoline oxide hydrochloride*, colourless prisms, m. p. 192—194° (Found: N, 7·0. $C_{10}H_{10}ONCl$ requires N, 7·15%); *picrate* (which may be a molecular compound; cf. Henze, *loc. cit.*, and XC_2), greenish-yellow needles, m. p. incongruent (Found: N, 14·4. $C_6H_3O_7N_3,C_{10}H_9ON$ requires N, 14·4%). 6-*Methylquinoline oxide hydrochloride*, colourless needles, m. p. 172—173° (Found: N, 7·0%); *picrate*, pale yellow, felted needles, m. p. 174—175° (Found: N, 14·2%).

5-*Methylcarbostyril*, colourless plates, m. p. 222—223° (Found: N, 9·1. $C_{10}H_9ON$ requires N, 8·8%). 7-*Methylcarbostyril*, colourless plates, m. p. 192—193° (Found: N, 8·9%).

1 : 7-*Dimethyl*-2-*quinolone*, long, faintly yellow needles from light petroleum, m. p. 107—108° (Found: N, 8·15. $C_{11}H_{11}ON$ requires N, 8·1%). 1 : 6-*Dimethyl*-2-*thioquinolone*, obtained by Roos's method (*Ber.*, 1888, **21**, 620), small yellow needles, m. p. 137° (Found: N, 7·5. $C_{11}H_{11}NS$ requires N, 7·4%. Sodium nitroprusside test for sulphur, positive).

The complex of X and dibenzylaniline (Sudborough, *loc. cit.*) was re-examined and its 1 : 2-constitution confirmed (Found: N, 9·5. Calc. for $2C_{20}H_{19}N,C_6H_3O_6N_3$: N, 9·2%).

s-Trinitrobenzene with dibenzyl-*o*-toluidine gave relatively lightly coloured alcoholic solutions which precipitated only the constituents. Melts of these substances in 1 : 1, 1 : 2, or 2 : 3 proportions afforded viscous red liquids which, very slowly in the last two instances, disintegrated to colourless powders.

Dibenzyl-o-toluidine picrate gave, very slowly from alcohol, canary-yellow prisms, m. p. 120—121° (Found: N, 10·9. $C_{21}H_{21}N,C_6H_3O_7N_3$ requires N, 10·8%).

s-Trinitrobenzene with dibenzyl-*m*-toluidine, in concentrated alcoholic solution, precipitated on seeding a *compound* as ruby-red regular prisms, m. p. 71—72° (Found: N, 9·9, 9·8. $2C_6H_3O_6N_3,3C_{21}H_{21}N$ requires N, 9·8%), obtained in the first instance by inoculation of a solution with the analogous 1 : 2-derivative of dibenzylaniline; a solution containing the reactants in the ratio 2 : 3 thus gave successive crops of complex until reduced to dryness. On the other hand, a concentrated alcoholic solution of both components deposited no trace of complex during one month in a thermostat (20°), although on seeding it provided the coloured product almost at once. Melts of these components in the molar ratios 1 : 1 or 1 : 2 solidified

to colourless mixtures; 2 : 3 melts, cautiously cooled, afforded a mixture of red prisms and starting materials.

Dibenzyl-m-*toluidine picrate* gave, from alcohol, yellow prisms, m. p. 126—127° (Found: N, 10·9%).

Alcoholic 1 : 2-solutions of *s*-trinitrobenzene and dibenzyl-*p*-toluidine readily afforded a *complex* as ruby-red needles, m. p. 62—64° (Found: N, 8·9. $C_6H_3O_6N_3,2C_{21}H_{21}N$ requires N, 8·9%), which recrystallised unchanged from alcohol.

Dibenzyl-p-*toluidine picrate* afforded golden-yellow plates from alcohol, m. p. 174—175° (Found by trituration with dilute aqueous ammonia: $C_{21}H_{21}N$, 55·6, 55·8. $C_{21}H_{21}N,C_6H_3O_7N_3$ requires $C_{21}H_{21}N$, 55·6%. Micro-analyses of specimens from various preparations gave consistently high results for nitrogen).

Dibenzylaniline and the dibenzyltoluidines were readily obtained in 80% yield by Desai's process (*Chem. Abstr.*, 1925, **19**, 2645) from the appropriate amine (1 mol.), iodine (0·01 mol.), benzyl chloride (2 mols.; not 1 mol., Desai), and fused sodium acetate (2 mols.).

s-Trinitrobenzene with 1-thiocoumarin in concentrated benzene or alcoholic solution gave colourless solutions which precipitated only the components. It thus resembles coumarin (Sudborough and Beard, J., 1911, **99**, 216). 1-*Thiocoumarin picrate* gave yellow needles from alcohol, m. p. 148° (Found: N, 10·8. $C_9H_6OS,C_6H_3O_7N_3$ requires N, 10·7%). In the preparation of 1-thiocoumarin it was observed that *trans-o*-aminocinnamic acid gave a binary *complex* with X (cf. XA_2) as brick-red, microscopic needles from alcohol, m. p. 131° (Found: N, 14·8. $C_6H_3O_6N_3,C_9H_9O_2N$ requires N, 14·9%); and that *o*-dithiocinnamic acid was quantitatively reduced to the thiol by the method of Claasz (*Ber.*, 1912, **45**, 2427; cf. Chmelewsky and Friedländer, *ibid.*, 1913, **46**, 1906). The dithio-acid (1 g.) and anhydrous sodium acetate (0·7 g.) were dissolved in water (3 c.c.); glucose (0·6 g.) was added and the whole heated on the water-bath for exactly 10 mins. before acidification.

s-Trinitrobenzene with 2-thiocoumarin in alcohol readily afforded a binary *complex* (cf. ternary complex with coumarin from m. p. curve, Sudborough and Beard, *ibid.*; cf. XA_2 and XA′, but also XP and XP'_2) as light brown plates which darkened on exposure to air, m. p. 87° (Found: N, 11·2. $C_6H_3O_6N_3,C_9H_6OS$ requires N, 11·2%).

2 : 4 : 5-Trinitrotoluene with 4 : 4′-bisdimethylaminodiphenylmethane in alcoholic solution gave a binary *complex* (cf. the similar X-derivative; Romburgh, *Rec. Trav. chim.*, 1888, **7**, 228) as dark-red needles, m. p. 92—93° (Found: N, 14·6. $C_7H_5N_3O_6,C_{17}H_{22}N_2$ requires N, 14·55%). 2 : 4 : 6-Trinitrotoluene and *p*-dinitrobenzene did not afford crystalline derivatives.

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