

Reactions of *gem*-Tetra-, -Tri-, and -Diamines with Carbon Acids

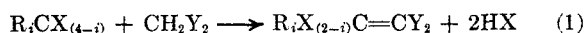
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Tetrakis(dimethylamino)methane, tris(dimethylamino)methane, and vinylidenebisdimethylamine were allowed to react with a number of carbon acids. Condensations were observed for carbon acids as weak as xanthene. A mechanism is suggested.

Condensations of carbon acids with *gem*-di- and -tri- amines, *gem*-di- and -trialkoxo compounds, as well as mixed *gem*-amine-alkoxy compounds have been reported by Meerwein¹ and by Bredereck.^{2,3} These reactions can be summarized by eq 1 in which X equals dialkylamino



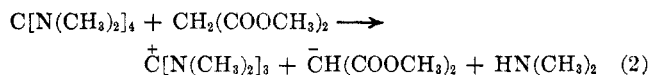
or alkoxy, Y equals groups such as CN or COOCH₃ and *i* equals 1 or 2.

It was of interest to us to expand this work in two directions. First, to examine similar condensations of tetrakis(dimethylamino)methane, C[N(CH₃)₂]₄, a compound only recently reported.⁴ And second, to explore the reactions of *gem*-multiamines with carbon acids six to ten orders of magnitude weaker than those used in previous reports.

Results and Discussion

Tetrakis(dimethylamino)methane, tris(dimethylamino)methane, and vinylidenebisdimethylamine were allowed to react with carbon acids, arbitrarily divided for the purpose of this discussion into strong (*p*K_a = 12–14) and weak (*p*K_a = 25–29).

The condensation of tris(dimethylamino)methane with the "strong" carbon acid methylcyanoacetate is reported³ to yield methyl 2-cyano-3-dimethylaminoacrylate, (CH₃)₂NCH=C(CN)COOCH₃. We repeated this experiment⁵ when we observed the corresponding reaction of tetrakis(dimethylamino)methane to be different. The tetraamine reacts rapidly with dimethyl malonate⁶ to give not the expected [bis(dimethylamino)methylene]malonic acid dimethyl ester, [(CH₃)₂N]₂C=C(COOCH₃)₂, but the hexamethylguanidinium salt, which does not appear to react further (see eq 2).



More vigorous conditions might, of course, bring about the conversion. In retrospect this may not appear to be a surprising result since guanidinium ions are known to be very stable, but it does provide evidence supporting the mechanistic hypothesis that amino carbonium ions are reaction intermediates. Further, it provides a method for the preparation and storage of malonate type anions.

(1) H. Meerwein, W. Florian, N. Schön, and G. Stopp, *Ann.*, **641**, 1 (1961).

(2) H. Bredereck, F. Effenberger, and D. Zeyfang, *Angew. Chem.*, **77**, 219 (1965).

(3) H. Bredereck, F. Effenberger, and T. Brendle, *ibid.*, **78**, 147 (1966).

(4) H. Weingarten and W. A. White, *J. Am. Chem. Soc.*, **88**, 2885 (1966).

(5) Our results are in agreement with those reported in ref 3: (CH₃)₂NCH=C(CN)COOCH₃, mp 100.5–101.5°, nmr in benzene solvent, TMS internal standard, singlets at τ 2.65, 6.46, 7.35, and 8.03 (1:3:3:3).

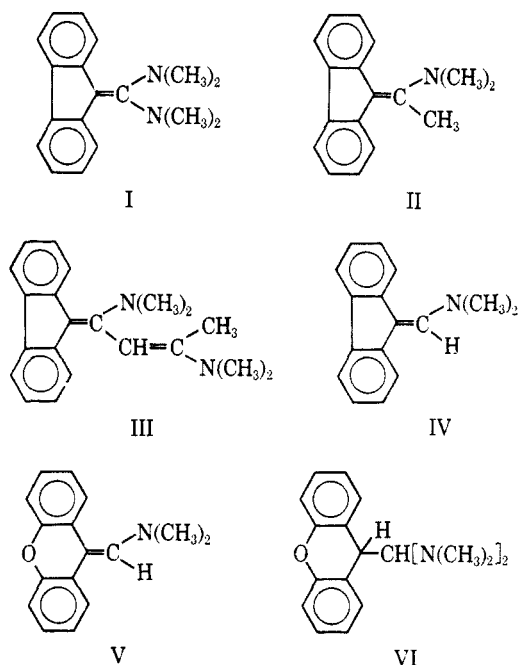
(6) Dimethyl malonate was used since it gave a product with more manageable physical properties.

Vinylidenebisdialkylamines, to our knowledge, have not been condensed with carbon acids,⁷ although simple protonation would lead to the amidinium cations believed to be reaction intermediates. Thus, vinylidenebisdimethylamine reacts readily with malononitrile to yield 2-cyano-3-dimethylaminocrotonitrile, [(CH₃)₂N](CH₃)C=C(CN)₂.

Condensations of *gem*-multiamines with weak carbon acids are also unreported and it was of interest to us to determine the approximate lower limit of acidity required to yield reasonable reaction rates. This chemistry is somewhat more engaging, being more novel and producing, in the main, new compounds.

Tetrakis(dimethylamino)methane reacts with fluorene (*p*K_a = 25)⁸ at elevated temperatures to yield 9-[bis(dimethylamino)methylene]fluorene (I) (Chart I).

CHART I



Vinylidenebisdimethylamine reacts with fluorene to yield (1-fluorenylideneethyl)dimethylamine (II). Compound II appears to be acidic enough to react further with the vinylidenebisdimethylamine to yield 1-(fluorenylidene)-N,N,N',N'-tetramethyl-2-butene-1,3-diamine (III).⁹ Reaction in the presence of excess fluorene inhibits the formation of this secondary product.

(7) Enamines have been shown to react with strong carbon acids; see K. C. Brannock, R. D. Burpitt, H. E. Davis, H. S. Pridgen, and J. G. Thweatt, *J. Org. Chem.*, **29**, 2579 (1964).

(8) W. K. McEwen, *J. Am. Chem. Soc.*, **58**, 1124 (1936).

(9) Compound III has not been isolated and unambiguously identified. Its assignment rests on its nmr ((s) τ 5.20, 7.26, 7.74, and 8.64 (1:6:6:3), benzene solvent, TMS internal standard).

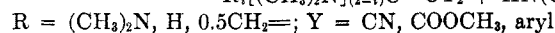
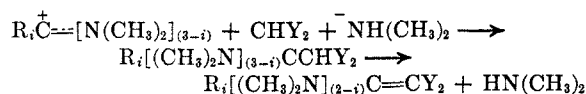
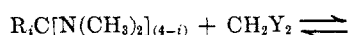
TABLE I
 PHYSICAL PROPERTIES OF THE PRODUCTS

Product	Caled, %			Found, %			Mol wt (mass spectrometry)	Mp, °C ^a	Bp, °C (mm) ^a	Yield, %	Nmr, τ
	C	H	N	C	H	N					
Hexamethylguanidiniumbis-(carbomethoxy)methylide	52.4	9.2	15.3	52.1	9.4	15.1		146		97	(s) 6.24, (s) 6.94 (1:3) ^b
2-Cyano-3-dimethylaminocrotonitrile	62.2	6.7	31.1	62.1	6.8	31.1	135	60		76	(s) 7.62, (s) 8.45 (2:1) ^c
9-[Bis(dimethylamino)methylene]fluorene	81.8	7.6	10.6	81.7	7.9	10.6	264	75	220(0.1)	87	(m) 2.00-3.20, (s) 7.18 (2:3) ^d
(1-Fluoren-9-ylideneethyl)dimethylamine	86.8	7.3	6.0	86.7	7.2	6.0	235	89	170(0.1)	60	(m) 2.06-3.08, (s) 7.03, (s) 7.40 ^d (8:6:3)
Fluoren-9-ylidenetrimethylamine	e						221	69	170(0.2)	95	(m) 2.00-2.91, (s) 2.62, (s) 7.06 ^d (8:1:6)
Xanthen-9-ylidenetrimethylamine	81.0	6.4	5.9	81.3	6.6	6.3	237	69	150(0.1)	71	(m) 2.07-3.12, (s) 3.39, (s) 7.34 ^d (8:1:6)

^a These are uncorrected. ^b Chloroform solvent. ^c Benzene solvent. ^d Dioxane solvent. ^e See Experimental Section.

Tris(dimethylamino)methane also reacts with fluorene yielding fluoren-9-ylidenetrimethylamine (IV). Its reaction with xanthene ($pK_a = 29$),⁸ although much slower, yields the expected xanthen-9-ylidenetrimethylamine (V). The latter condensation affords us an unusually informative view, *via* nuclear magnetic resonance (nmr), of the reaction intermediates. Analyses of the reaction mixture at intermediate stages provide evidence for the intermediacy of 9-[bis(bimethylamino)methyl]xanthene (VI). Doublets appearing at τ 5.73 and 7.10 ($J = 3.5$ cps) are best interpreted as arising from the interaction of the adjacent single protons on the 9 and side-chain carbons of VI. The bisdimethylamino protons of VI appear as a singlet at τ 7.92 (benzene was used as the solvent, TMS as internal standard). While reactions with still weaker carbon acids, such as diphenylmethane ($pK_a = 35$),⁸ take place, they generally yield complex mixtures which we have not been able to interpret as yet.

A mechanistic sequence consistent with the observations described above is as follows. When the starting



amine is vinylidenebisdiamine the first step is simple protonation without loss of dialkylamine.

The fluorenylidene and xanthenylidene products have very interesting properties in their own right and will constitute the subject of future reports.

Experimental Section

Proton nmr spectra were obtained from a Varian Model A-60 spectrometer. The ethyl ether solvent was purified by distillation from $LiAlH_4$. The reagents were the best commercial grades available or prepared by previously described methods.^{4,10} All operations were carried out in an atmosphere of dry nitrogen.

Preparation of Hexamethylguanidiniumbis(carbomethoxy)methylide.—A solution of tetrakis(dimethylamino)methane (1.88 g, 0.01 mole) in 10 ml of ethyl ether was combined with a solution of (1.32 g, 0.01 mole) of dimethyl malonate also in 10 ml of ether. A white precipitate formed immediately and the mixture was allowed to stand several hours. The precipitate was collected, washed several times with ether, dried, and weighed (2.68 g, 97%). The hexamethylguanidiniumbis(carbomethoxy)methylide was recrystallizable from tetramethylurea. See Table I for physical properties.

(10) H. Weingarten and W. A. White, *J. Org. Chem.*, **31**, 2874 (1966).

Preparation of 2-Cyano-3-dimethylaminocrotonitrile.—A solution of vinylidenebisdiamine (2.00 g, 0.0175 mole) in 10 ml of ether was added to a solution of malononitrile (1.19 g, 0.0178 mole) also in 10 ml of ether. A second phase separates immediately and gradually solidifies. The precipitate is collected, washed with ether, and dried yielding 1.8 g (76%) of 2-cyano-3-dimethylaminocrotonitrile, recrystallizable from water.

Preparation of 9-[Bis(dimethylamino)methylene]fluorene.—A mixture of tetrakis(dimethylamino)methane (1.88 g, 0.01 mole) and fluorene (1.66 g, 0.01 mole) was placed in a 10-ml round-bottom flask equipped with a condenser. The flask, kept under a small pressure of dry nitrogen, was immersed in an oil bath maintained at 140° for 6 hr. The progress of the reaction was monitored *via* nmr. The reaction mixture was distilled at reduced pressure yielding 2.3 g (87%) of a syrupy product which cooled to a glass. The yellow 9-[bis(dimethylamino)methylene]fluorene is recrystallizable from benzene-pentane.

Preparation of (1-Fluoren-9-ylideneethyl)dimethylamine.—Vinylidenebisdimethylamine (2.0 g, 0.0175 mole) and fluorene (9 g, 0.059 mole) are combined in a 25-ml round-bottom flask equipped with a condenser. The flask, kept under a small pressure of dry nitrogen, was immersed in an oil bath maintained at 150° for 5 hr. The progress of the reaction was monitored by nmr. The reaction mixture is distilled at reduced pressure separating the desired product (2.5 g, 60%) from the excess fluorene. The yellow (1-fluoren-9-ylideneethyl)dimethylamine is recrystallizable from benzene-pentane.

Preparation of Fluoren-9-ylidenetrimethylamine.—Tris(dimethylamino)methane (2.0 g, 0.014 mole) and fluorene (2.3 g, 0.014 mole) are combined in a 10-ml round-bottom flask equipped with a condenser. The flask, kept under a small pressure of dry nitrogen, is immersed in an oil bath maintained at 150° for 5 hr. The reaction is monitored *via* nmr. The reaction mixture is distilled at reduced pressure yielding 2.9 g (95%) of yellow fluoren-9-ylidenetrimethylamine, which is recrystallizable from benzene-pentane. The instability of the compound prevented us from obtaining a satisfactory elemental analysis confirming Miller and Wagners¹¹ observation with 9-(diethylaminomethylene)fluorene.

Preparation of Xanthen-9-ylidenetrimethylamine.—Tris(dimethylamino)methane (2.0 g, 0.014 mole) and xanthene (2.5 g, 0.014 mole) are combined in a 10-ml round-bottom flask equipped with a condenser. The flask, kept under a small pressure of dry nitrogen, is immersed in an oil bath maintained at 150° for 48 hr. The progress of the reaction is monitored *via* nmr. The reaction mixture is distilled at reduced pressure yielding 2.3 g (71%) of yellow xanthen-9-ylidenetrimethylamine, which is recrystallizable from pentane.

Registry No.—I, 14271-15-9; II, 14164-27-3; IV, 4476-94-2; V, 14164-29-5; tetrakis(dimethylamino)methane, 10524-51-3; tris(dimethylamino)methane, 5762-56-1; vinylidenebisdimethylamine, 815-62-3; hexamethylguanidiniumbis(carbomethoxy)methylide, 14164-25-1; 2-cyano-3-(dimethylamino)crotonitrile, 14164-26-2.

(11) F. D. Miller and E. C. Wagner, *ibid.*, **16**, 279 (1951).