REACTION OF β,β-DICHLOROVINYLAMIDES WITH MONO- AND DIAMINES

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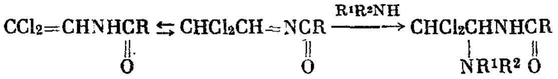
In the present paper, as a continuation of studying the nucleophilic reactions of β,β-dichlorovinylamides, we studied their reaction with primary and secondary amines, and also with ethylene—diamine (EDA), which, by analogy with [1, 2], proceeds by the scheme:



$$CCl_2{=}CHNH\underset{\overset{\|}{O}}{C}R \leftrightarrows CHCl_2CH{=}N\underset{\overset{\|}{O}}{C}R \xrightarrow{R^1R^2NH} CHCl_2\underset{\overset{|}{NR^1R^2}}{C}HNH\underset{\overset{\|}{O}}{C}R$$

This reaction course is confirmed by the absence of reaction between diethylamine and β,β-dichlorovinylpyrrolidone, for which the indicated tautomeric equilibrium is impossible.

The reaction was run either without a solvent or in dioxane, using an equimolar ratio of the amine and β,β-dichlorovinylamide. The amines, listed in Table 1, were selected as the nucleophiles. A double amount of the β-β-dichlorovinylamide was taken in the case of EDA. The reaction conditions and the yields of the products are given in Table 1. The addition products are crystalline compounds that are soluble in most organic solvents and are insoluble in water. The elemental analysis data and the melting points of the obtained compounds are given in Table 2.

From Table 1 it can be seen that the reaction of diethylamine with β,β-dichlorovinylbenzamide proceeds in better yield and much more rapidly than with β,β-dichlorovinylacetamide. This fact is in agreement with the previously mentioned [2] high reactivity of aromtic β,β-dichlorovinylamides. In order to study the effect of the structure of the amine on the course of the reaction we studied the percent conversion as a function of the time for a series of amines (Table 3). According to the data in Table 3, the studied amines can be arranged in the following order of increase in their relative reactivity in the reaction with β,β-dichlorovinylacetamide.

$$O(CH_2)_4NH < C_6H_5CH_2NH_2 < t\text{-}C_4H_9NH_2 \lesssim \text{sec-}C_4H_9NH_2 \lesssim \\ \lesssim n\text{-}C_4H_9NH_2 < (C_2H_5)_2NH$$

TABLE 1. Conditions for Reaction of β,β-Dichlorovinylamides $Cl_2C{=}CH{-}NH{-}COR$ With Amines

R	Amine	K_b^*	Reaction time, min	T., °C	Yield, %
C_6H_5	Diethylamine	$8{,}5\cdot10^{-4}$	5	50	75
CH_3	Diethylamine	$8{,}5\cdot10^{-4}$	60	50	65
CH_3	Morpholine	$5{,}0\cdot10^{-6}$	30	90	60
CH_3	Cyclohexylamine	$4{,}4\cdot10^{-4}$	90	70	60
CH_3	Benzylamine	$4{,}2\cdot10^{-5}$	120	60	80
CH_3	n-Butylamine	$4{,}0\cdot10^{-4}$	30	90	70
CH_3	sec-Butylamine	$3{,}6\cdot10^{-4}$	30	90	70
CH_3	tert-Butylamine	$2{,}8\cdot10^{-4}$	40	90	70
CH_3	Allylamine	$4{,}9\cdot10^{-4}$	120	70	60
CH_3	Ethylenediamine	$1{,}2\cdot10^{-4}$	120	60	70

*Taken from [3].

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TABLE 2. Elemental Analysis Data and Melting Points of Addition Products of Amines to β,β-Dichlorovinylamides

Compound	Formula	mp, °C (solvent)	Found, %				Empirical formula	Calculated, %			
			C	H	Cl	N		C	H	Cl	N
(I)	$C_6H_5CONHCH(CHCl_2)N(C_2H_5)_2$	100 (methanol–water)	53,87	6,39	24,27	9,55	$C_{13}H_{18}Cl_2N_2O$	53,94	6,27	24,52	9,68
(II)	$CH_3CONHCH(CHCl_2)N(C_2H_5)_2$	85 (hexane)	42,41	7,26	31,02	12,47	$C_8H_{16}Cl_2N_2O$	42,31	7,10	31,23	12,34
(III)	$CH_3CONHCH(CHCl_2)NC_4H_8O$	138 (hexane)*	39,80	5,97	29,77	11,81	$C_8H_{14}Cl_2N_2O_2$	39,85	5,85	29,41	11,61
(IV)	$CH_3CONHCH(CHCl_2)NHC_6H_{11}$	63 (hexane)	47,49	7,11	27,97	11,25	$C_{10}H_{18}Cl_2N_2O$	47,45	7,16	28,00	11,06
(V)	$CH_3CONHCH(CHCl_2)NHCH_2C_6H_5$	94 (petroleum ether)	50,89	5,30	26,98	10,66	$C_{11}H_{14}Cl_2N_2O$	50,62	5,40	27,09	10,73
(VI)	$CH_3CONHCH(CHCl_2)NHC_4H_9$-*n*	64 (methanol–water)	42,18	7,13	31,51	12,29	$C_8H_{16}Cl_2N_2O$	42,31	7,10	31,23	12,33
(VII)	$CH_3CONHCH(CHCl_2)NHC_4H_9$-sec	52 (methanol–water)	42,30	7,10	31,21	12,11	$C_8H_{16}Cl_2N_2O$	42,31	7,10	31,23	12,33
(VIII)	$CH_3CONHCH(CHCl_2)NHC_4H_9$-	108 (methanol–water)	42,43	7,12	31,26	12,47	$C_8H_{16}Cl_2N_2O$	42,31	7,10	31,23	12,33
(IX)	$CH_3CONHCH(CHCl_2)NHCH_2CH{=}CH_2$	46 (dioxane)	39,71	5,80	33,70	13,21	$C_7H_{12}Cl_2N_2O$	39,82	5,73	33,59	13,27
(X)	$[CH_3CONHCH(CHCl_2)NHCH_2]_2$	120 (decompn.)	32,73	5,06	38,51	15,35	$C_{10}H_{18}Cl_4N_4O_2$	32,64	4,93	38,53	15,22

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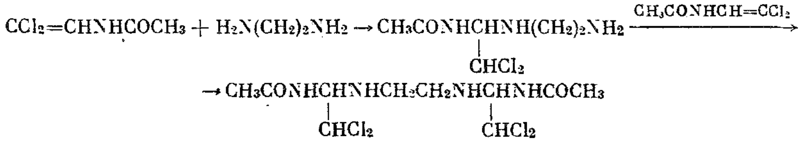
[*] Coincides with [4].

TABLE 3. Relative Reactivity of Amines in Reaction With $CCl_2{=}CHNHCOCH_3$ in Dioxane at 50°

Compound	Conversion, %					
	$(C_2H_5)_2NH$	$n\text{-}C_4H_9NH_2$	sec-$C_4H_9NH_2$	$t\text{-}C_4H_9NH_2$	$C_6H_5CH_2NH_2$	$O(CH_2)_4NH$
30	20	14	14	12	8	3
60	46	36	34	30	20	10
120	66	56	54	52	38	24
180	80	68	70	68	50	34
240	90	82	80	80	58	40
300	94	86	84	84	63	42

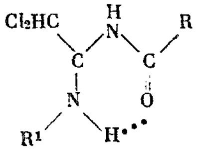
This order coincides with the order of change in the basicity of the amines. The reaction does not go (5 h, 90°) with weakly basic amines like aniline. The addition products of primary amines to the β,β-dichlorovinylamides do not react with a second molecule of the β,β-dichlorovinylamide. Both of the amino groups in EDA react.



$$CCl_2{=}CHNHCOCH_3 + H_2N(CH_2)_2NH_2 \rightarrow \underset{\displaystyle CHCl_2}{CH_3CONHCH}NH(CH_2)_2NH_2 \xrightarrow{CH_3CONHCH{=}CCl_2}$$

$$\rightarrow CH_3CONH\underset{\displaystyle CHCl_2}{CH}NHCH_2CH_2NH\underset{\displaystyle CHCl_2}{CH}NHCOCH_3$$

From a comparison of the IR spectra of compound (IV) (see Table 2) and the starting cyclohexylamine and β,β-dichlorovinylacetamide it can be seen that the band, corresponding to the N—H stretching vibrations in β,β-dichlorovinylacetamide, remains unchanged in the addition product, whereas the band, corresponding to the free stretching vibrations in cyclohexylamine, is shifted in (IV) by 26 cm^{-1} toward lower frequencies and is somewhat broad. This fact can be explained by the formation of an intramolecular hydrogen bond in the addition products of the primary amines, analogous to the bond in chloral amides $CCl_3CH(OH)NHCOR$ [5].



(I)

Substantial differences in the vicinal spin—spin coupling constants are observed in the NMR spectra of the addition products of the primary and secondary amines in CCl_4 (Table 4). For the addition products of the secondary amines J_{CHCl_2-CH} corresponds to an equal population of the three rotational conformers relative to the $CHCl_2$—CH bond. In compounds (IV)-(VII) (see Table 4) a substantial decrease in the vicinal constant (2.5-3.0 Hz) reflects a predominance of the gauche-conformer, which is evidently stabilized by the intramolecular hydrogen bond when the (I) structure is formed. From an examination of the Stuart—Briegleb models it follows that substantial steric interaction of the R^1 substituent and the Cl atoms in the shielded and trans-conformations makes the gauche-conformation of the $CHCl_2$—CH fragment the most favorable for structure (I).

Destruction of the hydrogen bond should reduce the difference in the value of J_{CHCl_2-CH} in the addition products of the primary and secondary amines. Actually, when CF_3COOH is added to solutions of (III) and (V) (see Table 4) in CCl_4 a decrease in the constant (due to an increase in the electronegativity of the nitrogen [6]) from 6.8 to 3.8 is observed in the first case, and an increase from 2.5 to 3.6 is observed in the second case.

EXPERIMENTAL METHOD

The NMR spectra were recorded for 5% CCl_4 solutions on a Tesla BS-487-C spectrometer (80 MHz), using HMDS as the internal standard. The IR spectra were recorded for 0.002 M CCl_4 solutions on a UR-10 instrument.

Preparation of Addition Products of Amines to β,β-Dichlorovinylamides. A solution of 0.02 mole of the β,β-dichlorovinylamide in 0.02 mole of the amine was heated in closed test tubes; the temperature and time of heating are indicated in Table 1. The reaction was terminated when the solution became thick and dark. The mixture was diluted with water, and the obtained precipitate was filtered, dried, and

TABLE 4. Chemical Shifts (δ, ppm) and Spin—Spin Coupling Constants (SSCC) of Protons in NMR Spectra of the Compounds $\mathrm{Cl_2CH\underset{\underset{\displaystyle X}{|}}{C}HNHCOR}$ in CCl_4

Compound	R	X	Chemical shifts (δ, ppm ± 0.05)					SSCC ±0,1 Hz	
			$CHCl_2$	CH	NH†	R	X	J_{CHCl_2-CH}	J_{NH-CH}
(I)	C_6H_5	$N(C_2H_5)_2$	5,83	5,30	7,00	7,5 — 7,70	CH_2 2,70; CH_3 1,12	5,1	9,0
(II)	CH_3	$N(C_2H_5)_2$	5,71	5,10	6,99	2,02	CH_2 2,56; CH_3 1,04	6,3	8,6
(III)	CH_3	NC_4H_8O	5,99	4,91	6,83	2,03	OCH_2 3,64; CH_2 2,59	6,8	9,0
(IV)	CH_3	NHC_6H_{11}	5,85	5,05	6,39	2,02	CH 2,58; CH_2 1,60 and 1,25	2,8	8,2
(V)	CH_3	$NHCH_2C_6H_5$	5,81	4,98	6,14	1,89	CH_2 3,81; C_6H_5 6,69	2,5	8,5
(VI)	CH_3	NHC_4H_9sec	5,82	5,01	6,99	2,00	CH 2,71; CH_2 1,44; CH_3 0,98	2,6	7,8
(VII)	CH_3	$NHCH_2CH{=}CH_2$	5,86	5,03	8,50	2,03	CH_2 3,30; =CH 5,24; $=CH_2$ 7,22	2,6	9.0
(VIII)*	$(CH_3CONH\underset{\underset{\displaystyle CHCl_2}{\vert}}{C}HNHCH_2)_2$		6,06	5,07	7,98	2,01	CH_2CH_2 2,78	2,9	8,0

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*The spectrum was recorded for a 5% DMSO solution.

†The signals of the proton of the amide group are given; in compounds (IV)-(VIII) the second NH proton is located in the region of the signals of the alkyl protons.

purified by recrystallization and by reprecipitation from methanol solution with water. The reaction mixture containing EDA was let stand for a day at ~20°. The product that crystallized when treated with ether was washed with water.

Study of Relative Reactivity (see Table 3). Samples (5 ml each) of 1 M solutions of the amine and the β,β-dichlorovinylamide in dioxane were thermostatted at 50° and then mixed. Aliquots (0.1 ml) of the reaction mixture were removed at definite time intervals, acidified with conc. H_2SO_4, and then 10 ml of a 0.02 N solution of bromine in methanol was added. The free bromine was killed with excess KI and the liberated iodine was titrated with 0.02 M $Na_2S_2O_3$ solution. The degree of conversion is equal to 10 V in %, where V is the volume of $Na_2S_2O_3$ solution consumed for the titration.

CONCLUSIONS

1. β,β-Dichlorovinylamides add primary and secondary amines, and also ethylenediamine. An increase in the basicity of the amine facilitates the addition.

2. It was shown that the addition products of the primary amines contain an intramolecular hydrogen bond by studying their IR and NMR spectra in CCl_4 solution.

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