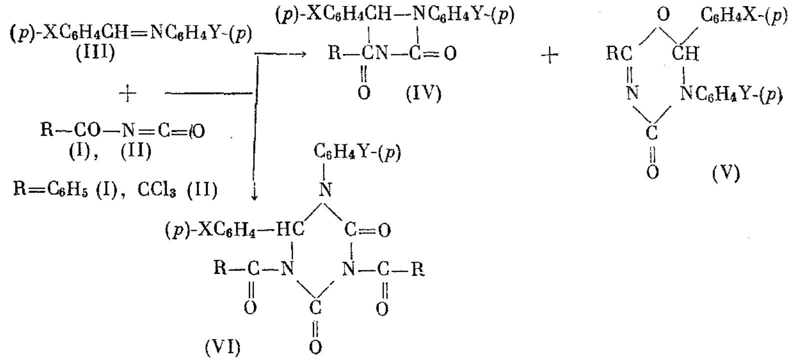
REACTION OF ISOCYANATES WITH SCHIFF BASES

N. N. Zobova, G. N. Rusanov,
and B. A. Arbuzov

UDC 547.239.1:542.953.4

The question of the reaction of ketenes and isocyanates with compounds, containing a C=N bond, evokes great interest both from the synthetic (synthesis of 4- and 6-membered nitrogen-containing heterocycles) and theoretical (mechanism of the reaction, competing 2 + 2- and 2 + 4-cycloaddition) standpoints [1-5].

In the present communication are reported some data on the reactions of the benzoyl (I) and trichloroacetyl (II) isocyanates with some Schiff bases (III), which proceed with the formation of cyclic 1 : 1 adducts [derivatives of 1,3-diazetidinones (IV) and oxadiazionones (V)] and 2 : 1 adducts [hexahydro-S-triazinediones (VI)]



For (III), (IV), (V)

	a	b	c	d	e	f	g	h	i	j
X	Et_2N	$(CH_3)_2N$	Et_2N	H	O_2N	O_2N	O_2N	Br	O_2N	Et_2N
Y	OCH_3	H	H	OCH_3	OCH_3	$CH_2C_6H_5$	H	H	NO_2	NO_2

The effect of temperature, reaction time, solvent, and reactant ratios on the direction of addition was studied on the example of the reaction of (I) and (II) with p-dimethylaminobenzalaniline (IIIb) (Table 1).

The cyclic 1 : 2 adducts (VI) were isolated when the reactions were run in SO_2. The obtained experimental data corroborate the two-step mechanism of the reaction [3-6]. The Schiff bases (IIIa, c, d) reacted with (I) and (II) in the same manner as does p-dimethylaminobenzalaniline; (IIIa) reacts with (II) in dimethyl sulfoxide with the formation of the 1 : 2 adduct (VI) (Tables 2 and 3).

Schiff bases (IIIe, f, g, j) proved to be very reactive toward (I) and (II), since here the p-substituents in the aromatic rings facilitate a polarization of the C=N bond, in this way increasing its reactivity, but at the same time also decreasing its nucleophilicity somewhat when compared with (IIIa, b, d), which affects the direction of addition. (IIIe, f, g, j) add to (I) and (II) mainly with the formation of (V) (see Tables 2 and 3). The dimers of the Schiff bases were isolated as by-products. The reaction of (IIIg) and (IIIi) with (I) and (II), leading to the formation of the cyclic adducts (V), went with more difficulty.

All of the obtained products (see Tables 2 and 3) are crystalline compounds.

In those cases where (IV) and (V) were formed at the same time they were separated by fractional recrystallization from ether, CCl_4, benzene, or THF. Adducts (IV) and (V) decompose when stored in the

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V. I. Ul'yanov-Lenin Kazan State University. Translated from Izvestiya Akademii Nauk SSSR, Seriya Khimicheskaya, No. 9, pp. 2016-2020, September, 1972. Original article submitted February 9, 1971.

TABLE 1

Reaction time, h	Reaction temp., °C	Solvent	Yield, %			
			(IV) $R=C_6H_5$	(V) $R=C_6H_5$	(IV) $R=CCl_3$	(V) $R=CCl_3$
4	20	Ether	60	—	52	—
6	20	"	86	—	62	—
9	20	CCl_4	72	14	83	—
48	20	"	62	24	79	10
4 days	20	Ether	54	36	76	14
21 days	20	CCl_4	1,2	88	—	—
9	40—50	"	70	22	—	—
6*	20	Ether	30	62	—	—

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*Excess isocyanate.

TABLE 2

Starting compounds	Weight, g	Conditions of expt.			Yield, %	Mp, °C
		solvent, ml	T, °C	time, h		
C_6H_5CONCO	0,73	CCl_4	20	1,5	(IV)23,8	104—106
$Et_2NC_6H_4CH=NC_6H_4OCH_3$	1,4	30				
C_6H_5CONCO	0,73	CCl_4	70—80	10	(IV)30	119—121
$C_6H_5CH=NC_6H_4OCH_3$	1,05	30			(V)52,9	128—130
C_6H_5CONCO	1,9	Ether	20	48	(IV)62	113—115
$(CH_3)_2NC_6H_4CH=NC_6H_5$	3,00	50			(V)24	189—190
C_6H_5CONCO	1,5	CCl_4	20	48	(IV)57	162—163
$Et_2NC_6H_4CH=NC_6H_5$	2,5	30			(V)27	107—108
C_6H_5CONCO	0,74	CCl_4	2—3	3	(V)72,7	127—129
p-$O_2NC_6H_4CH=NC_6H_4OCH_3$	1,5	50				
C_6H_5CONCO	0,74	CCl_4	60—70	10	(V)50	110,5—112
p-$O_2NC_6H_4CH=NCH_2C_6H_5$	1,2	30				
a) C_6H_5CONCO	0,15	CCl_4	20	72	(V)81	52—54 (decompn.)
p-$O_2NC_6H_4CH=NC_6H_5$	0,22	10				
b) C_6H_5CONCO	1,5	CCl_4	20	22	(IV)32	132—134
p-$O_2NC_6H_4CH=NC_6H_5$	2,3	40			(V)49	52—54 (decompn.)
C_6H_5CONCO	0,74	CCl_4	70—80	16	(V)80	119—120
p-$BrC_6H_4CH=NC_6H_5$	1,3	20				
a) C_6H_5CONCO	0,75	CCl_4	70—80	24	(V)11,4	157—158
p-$O_2NC_6H_4CH=NC_6H_4NO_2$	1,35	30				
b) C_6H_5CONCO	0,55	CCl_4	20	72	(V)75	157—158
p-$O_2NC_6H_4CH=NC_6H_4NO_2$	1,00	30				
C_6H_5CONCO *	3,8	SO_2	20	1 week		
$(CH_3)_2NC_6H_4CH=NC_6H_5$	3,00					
C_6H_5CONCO †	3,8	DMSO	20	"		
$Et_2NC_6H_4CH=NC_6H_4OCH_3$	3,00					

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*(VI) was obtained in 40% yield; mp 195-196°; $\nu_{C=O}$ 1760, 1675 cm^{-1}.

†(VI) was obtained in 56% yield; mp 184-186°; $\nu_{C=O}$ 1760, 1674 cm^{-1}.

air. The structure of the adducts was confirmed by the data of the IR spectra. In the IR spectra of (IV) are present the absorption bands of the stretching vibrations of the C=O group in the regions 1677-1688 and 1772-1797 cm^{-1}. In the spectra of (V) are present the bands of the stretching vibrations of the C=N and C=O bonds in the regions 1614-1634 and 1672-1694 cm^{-1}. The IR spectra of (VI) have two absorption bands of the C=O group in the region 1675-1690 and 1760-1774 cm^{-1}.

The order in which isocyanates (I) and (II) added to the Schiff bases was established by acid hydrolysis in acetone. Here the corresponding aldehydes and substituted ureas were obtained, which were also synthesized by counter synthesis. The corresponding mixed melting points were not depressed. The elemental analysis of all of the obtained products for C, H, N (and Cl) gave results that were in satisfactory agreement with the calculated values.

TABLE 3

Starting compound	Weight, g	Experimental conditions			Yield, %	Mp, °C	$\nu_{C=O}$, cm^{-1}		$\nu_{C=N}$, cm^{-1}(V)	$\nu_{C=O}$, cm^{-1}(VI)
		solvent, ml	T, °C	time, h			(IV)	(V)		
CCl_3CONCO $Et_2NC_6H_4CH{=}NC_6H_4OCH_3$	0,94 1,4	CCl_4 30	20	144	(V)80,9	140—142		1675	1624	
a) CCl_3CONCO $Et_2NC_6H_4CH{=}NC_6H_4NO_2$	0,94 1,5	CCl_4 30	20	Instantly	(IV)95,8	170—172	1779 1692			
b) CCl_3CONCO $Et_2NC_6H_4CH{=}NC_6H_4NO_2$	0,94 1,5	CCl_4 50	70—80	1 week	(IV)50 (V)33,3	170—172 139—141	1779 1692	1682	1619	
CCl_3CONCO $O_2NC_6H_4CH{=}NC_6H_5$	0,73 1,13	CCl_4 30	20	72	(V)72	89—91		1690	1615	
CCl_3CONCO $Et_2NC_6H_4CH{=}NC_6H_4OCH_3$	1,34 1,00	DMSO 30	20	1 week	(VI)82,6	154—156				1774 1681
CCl_3CONCO $(CH_3)_2NC_6H_4CH{=}NC_6H_5$	2,5 3,00	SO_2 (liquid)	20	»	(VI)78	169—171				1772 1680
a) CCl_3CONCO $(CH_3)_2NC_6H_4CH{=}NC_6H_5$	2,5 3,00	Ether 40	20	9	(IV)83	126—128	1797 1690			
b) CCl_3CONCO $(CH_3)_2NC_6H_4CH{=}NC_6H_5$	2,5 3,00	Ether 40	20	48	(IV)79 (V)10	126—128 160—162	1797 1690	1690	1626	

TABLE 4

Starting adduct	Formed urea	Yield of urea, %	Mp, °C
(IVa) $R=C_6H_5$	$C_6H_5CONHCONHC_6H_4OCH_3$	81,4	212—213
(IVb) $R=C_6H_5$	$C_6H_5CONHCONHC_6H_5$	82	203—204
(IVc) $R=C_6H_5$	The same	91,6	203—204
(IVd) $R=C_6H_5$	$C_6H_5CONHCONHC_6H_4OCH_3$	91,5	212—213
(Ve) $R=C_6H_5$	The same	76,9	212—213
(Vc) $R=C_6H_5$	$C_6H_5CONHCONHC_6H_5$	83,3	203
(Vc) $R=CCl_3$	$CCl_3CONHCONHC_6H_5$	85,5	162—163
(Va) $R=CCl_3$	$CCl_3CONHCONHC_6H_4OCH_3$	75	135—136
(Vi) $R=C_6H_5$	$C_6H_5CONHCONHC_6H_4NO_2$	94,4	248—249
(Vg) $R=C_6H_5$	$C_6H_5CONHCONHC_6H_5$	88,8	203
(Vd) $R=C_6H_5$	$C_6H_5CONHCONHC_6H_4OCH_3$	79,1	212—213

EXPERIMENTAL METHOD

The IR spectra were taken as Nujol mulls and in CCl_4 solution on a UR-10 instrument using NaCl and LiF prisms.

The experimental conditions are given in Tables 2 and 3. The (IV) and (V) adducts were hydrolyzed by the following general procedure: 0.4 g of (Vd) in 20 ml of acetone was acidified with one drop of conc. HCl and then heated at 60° for 3 h. The crystals of $C_6H_5CONHCONHC_6H_4OCH_3$ that were obtained on cooling were filtered and repeatedly washed with ether; yield 0.26 g (96.4%).

The counter synthesis of the corresponding ureas was run by the following general procedure: to 0.5 0.5 g of $p\text{-}CH_3OC_6H_4NH_2$ in 10 ml of ether was added 0.6 g of benzoyl isocyanate. The reaction goes instantly. The precipitate was filtered and washed with ether. The yield of $C_6H_5CONHCONHC_6H_4OCH_3$ was 1 g (96.5%). The data on the hydrolysis of the other adducts are given in Table 4.

The authors express their gratitude to A. B. Remizov for taking the IR spectra, and to N. I. Plakatina for running the analyses.

CONCLUSIONS

1. Electron-donor substituents in the p-positions of the aromatic rings in Schiff bases increase the overall addition rate of the benzoyl and trichloroacetyl isocyanates to Schiff bases and shift the reaction toward the formation of 4-membered rings, whereas electron-acceptor substituents shift the reaction toward the formation of oxidiazinone derivatives.

2. Highly polar solvents (dimethyl sulfoxide and SO_2) promote the formation of hexahydro-S-triazinedione derivatives.

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