ORGANIC AND BIOLOGICAL CHEMISTRY

ADDITION OF BENZENETHIOL TO 2-CYANOVINYL KETONES

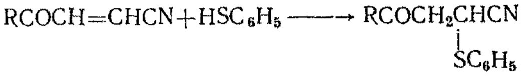
A. N. Nesmeyanov, L. V. Rybin, and M. I. Rybinskaya

Institute of Heteroorganic Compounds, Academy of Sciences, USSR

Translated from Izvestiya Akademii Nauk, Otdelenie Khimicheskikh Nauk, No. 8,
pp. 1451-1453, August, 1961
Original article submitted August 13, 1960

The 2-cyanovinyl ketones that we prepared previously [1] are 3-acylacrylonitriles and have been studied very little, particularly in the case of the difficultly accessible 3-alkanoylacrylonitriles. An investigation of the properties of the 2-cyanovinyl ketones that have become available as a result of the synthesis developed by us on the basis of 2-chlorovinyl ketones is therefore of interest. We showed that 2-cyanovinyl ketones contain a double bond that is active toward nucleophilic reagents [2].

In the present work we investigated the conditions for the reaction of 2-cyanovinyl ketones with benzenethiol. It was found that alkyl 2-cyanovinyl ketones undergo addition with benzenethiol at the double bond on simple mixing of the reactants in ether solution, when reaction proceeds with evolution of heat. In the case of 2-cyanovinyl phenyl ketone the reaction with benzenethiol is slow, but is accelerated by traces of alkali:

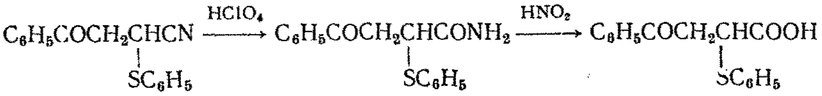


$$RCOCH{=}CHCN + HSC_6H_5 \longrightarrow RCOCH_2\underset{\displaystyle |\atop \displaystyle SC_6H_5}{C}HCN,$$

in which $R = CH_3$, $n\text{-}C_3H_7$, C_6H_5.

The yields of the 3-acyl-2-(phenylthio)propionitriles were almost quantitative. 3-Acyl-2-(phenylthio)propionitriles are almost colorless crystalline substances; their structure was confirmed by the hydrolysis of 3-benzoyl-2-(phenylthio)propionitrile into the corresponding acid.

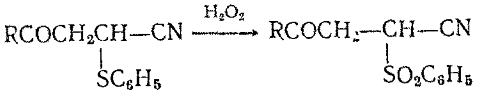
However, we did not succeed in hydrolyzing this nitrile to the acid in one stage. Under the action of alkaline reagents the nitrile underwent some complex transformations which did not lead to the formation of the acid. When the nitrile was treated with concentrated sulfuric acid in the cold the hydrolysis went as far as the amide, though this was obtained in very low yield and in a highly contaminated state. The hydrolysis of the nitrile to the amide stage was effected with the best results by the use of 70% perchloric acid. The resulting amide was converted by very careful treatment with nitrous acid into the already described 3-benzoyl-2-(phenylthio)propionic acid [3].



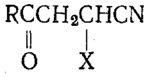
$$C_6H_5COCH_2\underset{\displaystyle |\atop \displaystyle SC_6H_5}{C}HCN \xrightarrow{HClO_4} C_6H_5COCH_2\underset{\displaystyle |\atop \displaystyle SC_6H_5}{C}HCONH_2 \xrightarrow{HNO_2} C_6H_5COCH_2\underset{\displaystyle |\atop \displaystyle SC_6H_5}{C}HCOOH$$

The presence of vibration frequencies at 1700 cm^{-1} in the infrared spectra of 3-benzoyl- and 3-acetyl-2-(phenylthio)propionitriles confirms the presence of the $C = O$ group in these compounds. Hence, benzenethiol adds to 2-cyanovinyl ketones in a way analogous to that in which it adds to amines [2], so that the carbonyl group has the strongest orienting action.

In alcoholic solution 3-benzoyl-2-(phenylthio)propionitrile readily gives a double salt with silver nitrate (decomp. temp. 126-127°), which rapidly decomposes into the original substances when heated in an aqueous medium. 3-Acyl-2-(phenylthio)propionitriles may be oxidized with hydrogen peroxide to the corresponding sulfones in good yield:



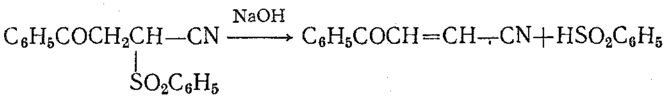
$$RCOCH_2\underset{\displaystyle |\atop \displaystyle SC_6H_5}{C}H{-}CN \xrightarrow{H_2O_2} RCOCH_2{-}\underset{\displaystyle |\atop \displaystyle SO_2C_6H_5}{C}H{-}CN$$



$$\mathrm{R\underset{\underset{O}{\|}}{C}CH_2\underset{\underset{X}{|}}{C}HCN}$$

R	X	M.p. (°C)	Yield (%)	Analytical figures (%)							
				C		H		N		S	
				found	calc.	calc.	found	calc.	calc.	found	calc.
CH_3	C_6H_5S	34—34,5	90	64,20	64,36	5,38	5,40	6,79	6,82	15,62	15,62
n-C_3H_7	C_6H_5S	35,5—36	84	66,95	66,89	6,40	6,48	6,12	6,00	13,66	13,75
C_6H_5	C_6H_5S	62—63	85	71,86	71,88	4,90	4,90	5,40	5,24	11,96	11,99
CH_3	$C_6H_5SO_2$	116	65	55,50	55,68	4,50	4,67	5,82	5,90	13,41	13,51
n-C_3H_7	$C_6H_5SO_2$	64	70	58,83	58,84	5,74	5,69			12,14	12,09
C_6H_5	$C_6H_5SO_2$	151	80	64,07	64,13	4,32	4,38	4,72	4,68	10,67	10,71

These are more stable in recrystallization than the original sulfides. On treatment of 3-benzyl-2-(phenylsulfonyl)-propionitrile with alkali, benzenesulfinic acid is eliminated and 2-cyanovinyl phenyl ketone is recovered in 80% yield. The sulfinic acid was identified by its reaction with mercuric chloride [4].



$$\mathrm{C_6H_5COCH_2\underset{\underset{SO_2C_6H_5}{|}}{CH}{-}CN \xrightarrow{NaOH} C_6H_5COCH{=}CH{-}CN+HSO_2C_6H_5}$$

The elimination of the sulfinic acid proves conclusively that in the oxidation of 3-acyl-2-(phenylthio)propionitriles with hydrogen peroxide it is the sulfur atom that is oxidized.

EXPERIMENTAL

Addition of benzenethiol to 2-cyanovinyl ketones. Benzenethiol (0.02 mole) was added to an ether solution of 0.02 mole of the 2-cyanovinyl ketone. The mixture was left at room temperature for one day. Solvent was evaporated off, and the residue was crystallized from petroleum ether (see table).

Oxidation of 3-acyl-2-(phenylthio)propionitriles to sulfones. To an acetic acid solution of 0.01 mole of the 3-acyl-2-(phenylthio)propionitrile we added 0.06 mole of 28% hydrogen peroxide and a few drops of concentrated sulfuric acid. The precipitate that formed after several days was filtered off and dried in a vacuum desiccator. By the addition of water some more sulfone was isolated from the filtrate. In the case of 3-butyryl-2-(phenylthio)-propionitrile there was no precipitate. The sulfone was isolated by the addition of water to the acetic acid solution. The 3-acyl-2-(phenylsulfonyl)propionitriles were recrystallized from alcohol (see table).

Hydrolysis of 3-benzoyl-2-(phenylthio)propionitrile to the amide. Dropwise addition was made with stirring of 10 ml of 70% perchloric acid to 4 g of 3-benzoyl-2-(phenylthio)propionitrile in 50 ml of glacial acetic acid. The mixture was poured into water, and the precipitate formed was filtered off and dried in a vacuum desiccator; weight 4.05 g; yield 95%; m.p. 155° (from alcohol). Found: C 67.43; H 5.27; N 4.99; S 11.18%. $C_{16}H_{15}O_2NS$. Calculated: C 67.34; H 5.30; N 4.91; S 11.23%.

Hydrolysis of 3-benzoyl-2-(phenylthio)propionamide to 3-benzoyl-2-(phenylthio)propionic acid. To a solution of 1 g (0.0116 mole) of potassium nitrite in 10 ml of water cooled to its freezing point we added, under cooling, 1 g (0.0035 mole) of 3-benzoyl-2-(phenylthio)propionamide in 20 ml of glacial acetic acid and 2 ml of concentrated sulfuric acid. The mixture was warmed gradually to room temperature and then left overnight. On the next day the mixture was heated at 60° until nitrogen ceased to be liberated. The precipitate formed on dilution was filtered off and treated with saturated sodium carbonate solution. Acidification of the sodium carbonate solution with 10% hydrochloric acid gave 0.6 g (60%) of 3-benzoyl-2-(phenylthio)propionic acid, m.p. 133-133.5° (from aqueous alcohol), undepressed by admixture of a known sample prepared by the method in [3].

Elimination of benzenesulfinic acid from 3-benzoyl-2-(phenylsulfonyl)propionitrile. An ethereal solution of 1 g of 3-benzoyl-2-(phenylsulfonyl)propionitrile was shaken with 150 ml of 0.5% NaOH (as five 30 ml portions). The ether layer was washed with water and dried over anhydrous sodium sulfate. After evaporation of the ether we isolated 0.43 g (82%) of 2-cyanovinyl phenyl ketone. The alkaline solution was neutralized with 10% hydrochloric acid, and a solution of 1 g of mercuric chloride in 30 ml of water heated to the boil was added to the hot solution.

The mixture was boiled until a precipitate ceased to separate. The precipitate was filtered off. The phenylmercury chloride separated by extraction with nitromethane could not be purified by the usual methods and was therefore converted into diphenylmercury (m.p. 125°). A mixture melting point test with a known sample [5] showed no depression.

SUMMARY

1. Benzenethiol adds to 2-cyanovinyl ketones in the α-position to the CN group.

2. The resulting 3-acyl-2-(phenylthio)propionitriles can be oxidized to sulfones and hydrolyzed to the corresponding acids.

LITERATURE CITED

1. A. N. Nesmeyanov and M. I. Rybinskaya, Dokl. AN SSSR, 115, No. 2, 315 (1957).
2. A. N. Nesmeyanov and M. I. Rybinskaya, Dokl. AN SSSR, 120, No. 4, 793 (1958).
3. J. Bougault and P. Chabrier, Compt. rend. 224, 395 (1947).
4. W. Peters, Ber. 38, 2567 (1905).
5. J. Z. Maynard, J. Am. Chem. Soc. 46, 1511 (1924).