BECKMANN REARRANGEMENT OF 2-OXIMINOADAMANTANE IN HYDROBROMIC ACID

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Rearrangement of 2-oximinoadamantane in hydrobromic acid and its dependence on acid concentration, temperature and reaction time was studied. The reaction affords 4-bromoadamantan-2-one, together with 4-azatricyclo[4,3,1,1^{3,8}]undecan-5-one and 4-hydroxyadamantan-2-one. This reaction can be used as a preparative method for synthesis of 4-bromoadamantan-2-one.

One of the methods of preparing 2,4-disubstituted oxygen-containing adamantane derivatives consists in Beckmann rearrangement of 2-oximinoadamantane (*I*) in an acidic medium. This reaction is initiated by protonation of the oxygen atom in the oxime *I*, followed by elimination of water. The thus-formed nitrile ion can be stabilized either by transformation to 4-azatricyclo-[4,3,1,1^{3,8}]undecan-5-one (*II*) or to 7-cyanobicyclo[3,3,1]non-2-ene (*III*). The nitrile *III* probably forms an iminocarbonium ion which enables the formation of derivatives with substituents on secondary carbon atoms of the adamantane skeleton (Scheme 1). Beckmann rearrangement of the oxime *I* in sulfuric acid[1,2] or in polyphosphoric acid[2] leads to a mixture of the lactam *II* and the hydroxy ketone *IV*. No mention has been hitherto found in the literature of the use of other acids in rearrangement of the oxime *I* in order to prepare 2,4-disubstituted adamantane derivatives.

In our present study we investigated the use of hydrobromic acid in this reaction. Since this acid acts as a donor of bromide ions, the reaction affords 4-bromoadamantan-2-one (*V*), besides compounds *II* and *IV*. The relative amount of these products depends on the acid concentration, reaction temperature and reaction time. Formation of the compounds *II* and *IV* can be substantially suppressed by suitable experimental conditions and thus this reaction represents a method of choice for preparation of the bromo ketone *V* (see Experimental).

Tables I and II summarize the gas–liquid chromatographic analyses of samples withdrawn during the rearrangement of *I*. It is obvious that concentration of hydrobromic acid has a marked effect on the product composition. Thus, *e.g.*, at 140°C and after 2 h, with 48·4% hydrobromic acid the reaction mixture contained 79% of 4-bromoadamantan-2-one whereas with dilute hydrobromic acid (24·2% wt) only about 10%.

The effect of temperature upon the product composition varies, depending on the concentration of hydrobromic acid used. Whereas in 48·4% acid the yield of the bromo ketone *V* increases with increasing temperature, in dilute acid the reaction at higher temperatures leads to lower yields of the compound *V* and to higher yields of the lactam *II*. As seen from the data in Tables I and II, for the given reaction procedure the maximum yield of the bromo ketone *V* was achieved in most cases after 1–2 h. At

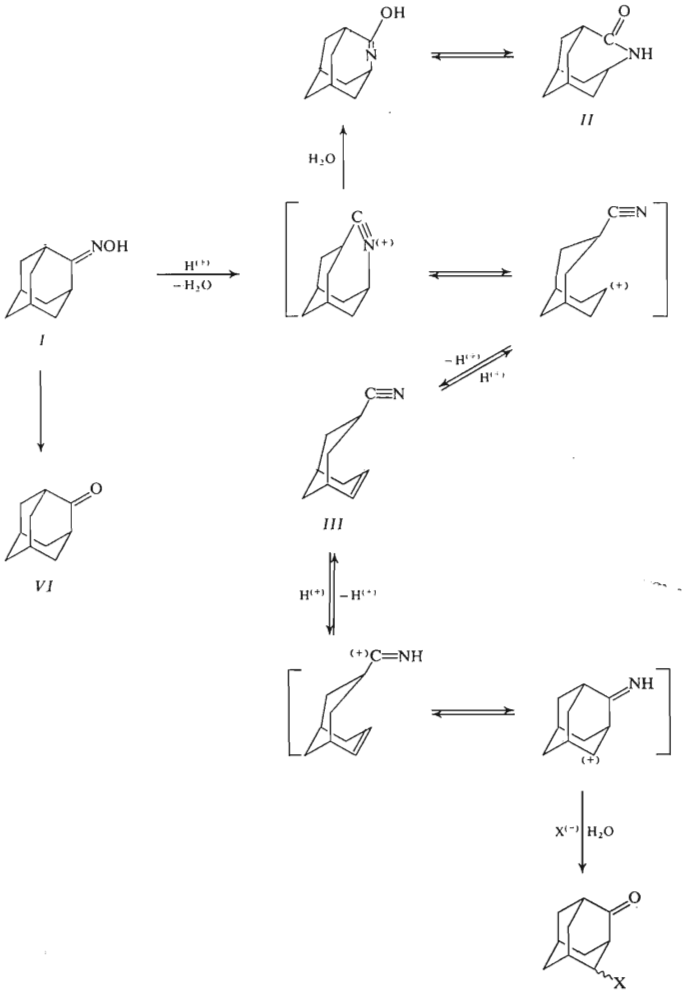
temperatures 140 and 160°C the bromo ketone *V* was obtained in high yield already after 15–30 min; prolongation of the reaction time at these temperatures lowered the yields.

On the basis of the above-mentioned data we can thus recommend the following conditions for preparation of 4-bromoadamantan-2-one from 2-oximinoadamantane: concentrated (48·4% wt) hydrobromic acid, temperature 140–160°C, reaction time 15–30 min. 4-Bromoadamantan-2-one, obtained by this procedure, represents invariably a mixture of equatorial and axial epimer.

TABLE I

Rearrangement of 2-Oximinoadamantane in Hydrobromic Acid (48·4% wt)

Time, min	Compound, %			
	V	*IV*	*II*	*VI*
		Temperature 100°C		
15	57·71	4·11	17·73	18·60
60	54·71	5·20	32·21	6·65
120	58·77	5·47	27·47	8·29
240	75·11	2·80	14·04	8·05
		120°C		
15	40·46	16·03	34·17	8·19
60	50·16	15·63	28·61	5·60
120	54·47	14·05	24·25	7·23
240	53·11	14·72	27·52	4·65
		140°C		
15	79·05	0·65	14·17	6·13
60	70·48	—	20·62	8·90
120	79·02	—	17·84	3·14
140	75·64	—	19·38	4·98
		160°C		
15	100·00	—	—	—
60	90·38	—	9·62	—
120	71·24	—	28·76	—
240	64·52	—	35·48	—


OH
N
O
C
NH
II
H2O
NOH
H(+)
– H2O
C
N(+)
C≡N
(+)
I
– H(+)
H(+)
C≡N
III
O
VI
H(+)
– H(+)
(+)C=NH
NH
(+)
X(–) H2O
O
X
IV, X = OH
V, X = Br

SCHEME 1

Reactions at 100, 120, and 140°C afforded also some adamantan-2-one (*VI*) which was formed by hydrolysis of the oxime *I* in the acidic medium; at temperatures around 160°C the compound *VI* was not found among the products. In the initial stages of the reaction (particularly at lower temperatures) the reaction mixture contained also 1 – 2% of unidentified compounds.

The formation of 4-hydroxyadamantan-2-one (*IV*) from the starting oxime *I* depends mainly on the concentration of the hydrobromic acid. Reaction with a dilute (24·2% wt) acid resulted in formation of greater amount of *IV* (about the same as of *V*) whereas in concentrated acid the amount of *IV* was relatively small (Table I and II).

TABLE II
Rearrangement of 2-Oximinoadamantane in Hydrobromic Acid (24·2% wt)

Time, min	Compound, %			
	V	*IV*	*II*	*VI*
		Temperature 100°C		
15	—	26·03	—	71·82
60	6·65	14·99	69·42	7·47
120	19·88	23·33	52·33	3·23
240	23·46	20·74	40·63	13·39
		120°C		
15	17·97	19·26	34·00	26·56
60	28·09	29·58	40·74	1·59
120	27·13	30·16	42·71	—
240	27·10	30·64	42·26	—
		140°C		
15	22·74	15·44	53·05	8·77
60	12·09	16·35	65·79	5·77
120	10·17	12·53	59·43	17·87
240	10·80	12·02	71·36	5·82
		160°C		
15	44·13	7·21	48·66	—
60	5·88	7·12	87·00	—
120	1·37	5·51	93·12	—
240	—	—	100·00	—

EXPERIMENTAL

Gas–liquid chromatographic analyses were performed on a Chrom IV chromatograph on a 2·4 m column, internal diameter 3 mm, filled with 5% FFAP on Chromosorb. Mass spectra were measured on a single-focus Gas Chromatograph-Mass Spectrometer LKB 9000 instrument. ^{1}H-NMR spectra were taken on a Varian XL-100 spectrometer at 37°C in $CDCl_3$ solutions containing 1% tetramethylsilane. 2-Oximinoadamantane was prepared according to the literature[3] and the compounds *II*, *IV* and *VI* were identified by comparison with standards prepared previously in this Laboratory.

The rearrangement of *I* was studied in the following way: 2-oximinoadamantane (0·99 g) and hydrobromic acid (10 ml) of the appropriate concentration were placed into a 50 ml two-necked flask and the reaction mixture was stirred at the given constant temperature. Samples (0·2 ml) were withdrawn at the time intervals, given in Table I and II, diluted with the same amount of water and extracted three times with chloroform (0·5 ml). The extract was neutralized with a potassium hydrogen carbonate solution, concentrated and analysed by gas–liquid chromatography.

Preparation of 4-Bromoadamantan-2-one (*V*)

The compound *I* (4 g; 24·2 mmol) was mixed with 48% of hydrobromic acid (68 ml) in a 100 ml flask. The reaction mixture was refluxed at 140°C for 2 h, cooled and diluted with the same volume of water. The product was taken up in light petroleum (b.p. 35–50°C) (5× 10 ml), and the extract was washed with water and dried over anhydrous sodium sulfate. After evaporation of the solvent the remaining crude product (3.5 g) was twice crystallized from n-pentane, yielding 3·1 g (55·8%) of the compound *V*, which upon sublimation (120°C/1·33 kPa) melted at 161–163°C. For $C_{10}H_{13}BrO$ (229·1) calculated: 52·42% C, 5·72% H, 34·87% Br; found: 52·43% C, 5·81% H, 34·60% Br.

REFERENCES

1. Korsloot J. G., Keizer V. G.: Tetrahedron Lett. *1969*, 3517.
2. N. V. Philips' Gloeilampenfabrieken: Neth. Appl. 69 04, 911 CA 74, 63 986z.
3. Narayanan V. L., Setescak L.: J. Heterocycl. Chem. *7*, 841 (1970).

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