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ORGANIC CHEMICAL REACTIONS IN MASS-SPECTROMETER

I. THE OXIDATION REACTIONS FOR THIOUREA DERIVATIVES

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A traditional task of organic synthesis has always been the verification of structure. To some extent this assignment depended on physical data, and several instruments, such as n.m.r., IR, UV, have been especially helpful in the investigation of organic synthesis. Recently, a new elegant tool, the mass spectrometer has become commercially available. Instrumentally the verification of the structure is made by the detection of peaks from the decomposition products. It is now possible for the synthesis of organic compounds and verification of the structure to be combined in the mass spectrometer thus shortening the path of the synthetic procedure.

We conceived that the small sample tube attached in a mass spectrometer (JMS-01SG) can serve as a test tube for studies on chemical reactions. The temperature can be always controlled and detected by the mechanism within the mass spectrometer. Less than 10γ of an organic compound and a reagent are mixed in the small sample tube and heated up as usual in taking a mass spectrogram. The mixture reacts in the mass spectrometer and subsequently the ion peaks can furnish information on the course of unknown or proposed reactions, the high resolution technique would give more complete information on this reaction. The mixture should react before one of these compounds evaporates or sublimes. The oxidation of thiourea derivatives was undertaken[1] for this experiment. A mixture of 1,3-dimethyl-thiourea and an equivalent mole of benzoyl peroxide was placed in a sample tube in a mass spectrometer and heated taking care to control the sample temperature. A new peak at m/e 172, which is not shown in the original mixture, is observed at sample temperatures over ca. 50°C.

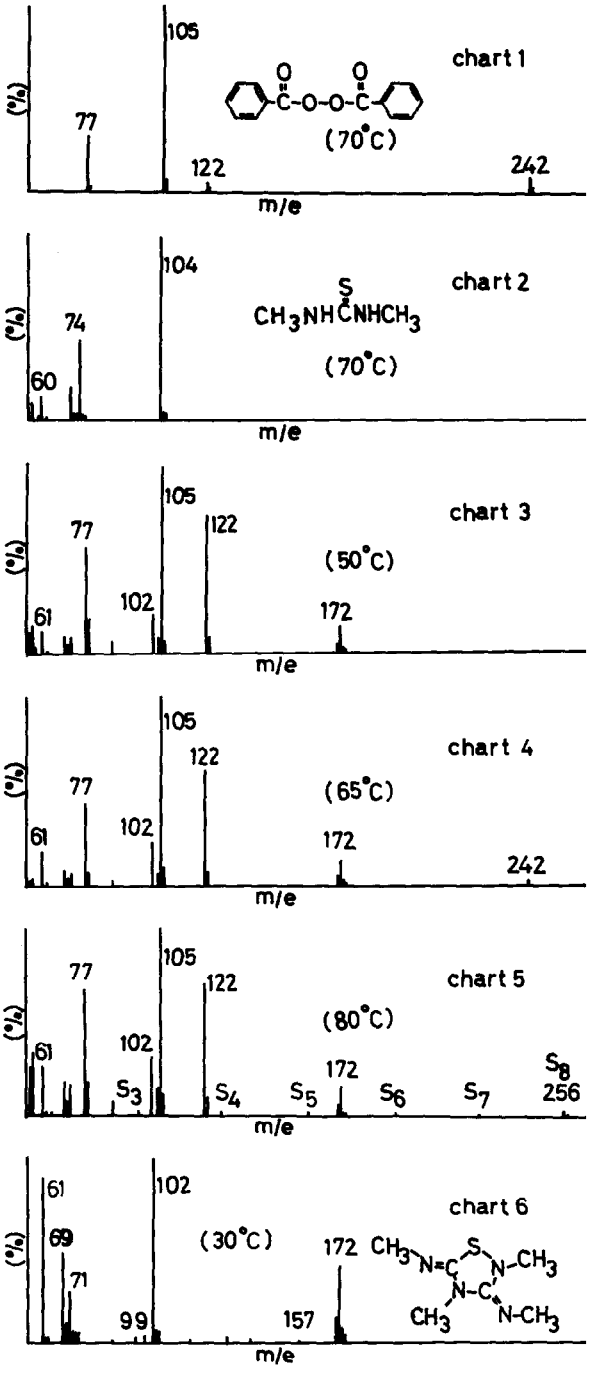
Charts 1 and 2 show the mass spectra of benzoyl peroxide and 1,3-dimethyl-thiourea wherein the respective molecular structures can be confirmed by the fragmentation patterns. Charts 3 to 5 show the mass spectra of the products from the components at different

temperatures.

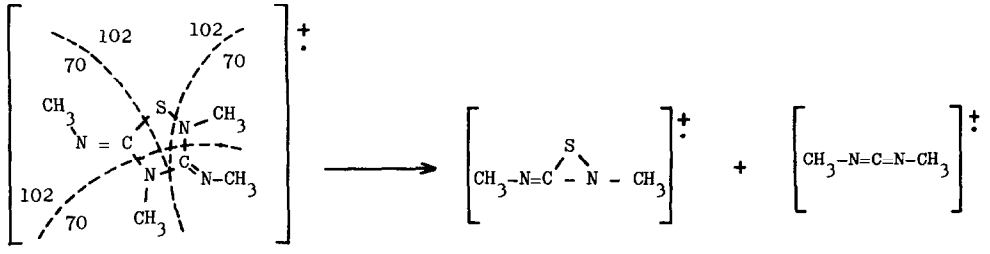
The high resolution technique shows that the peaks at m/e 172 corresponded to $C_6H_{12}N_4S$ (M.W.obs.=172.078, M.W.calc.=172.078) which means that two molecules of 1,3-dimethyl-thiourea combined with elimination of a S and 4 H atoms. This material can easily be obtained by using a standard size flask by carrying out the reaction in dichloromethane wherein the mass pattern is shown in chart 6. The physical data of this compound is given as follows.

$$2CH_3NHCSNHCH_3 + 2(C_6H_5CO_2)_2 = C_6H_{12}N_4S + 4C_6H_5CO_2H + 1/8\ S_8$$

The n.m.r. spectrum in carbon tetrachloride shows singlet peaks at 6.93, 6.95, 7.04 and 7.10 respectively which correspond to the each methyl group placed in a different environment. The infra red spectrum at 1650 cm^{-1} and UV spectrum of λ_{max}^{EtOH} 229 mμ displays that the C=N bond of the molecule is not conjugated. Thus, the structure of this compound is attributed to 2,4-dimethyl-3,5-dimethylimino-1,2,4-thiadiazolidine (I) and was confirmed through its fragmentation pattern. The peaks at m/e 102 ($C_3H_6N_2S$, M.W.obs.=102.024,

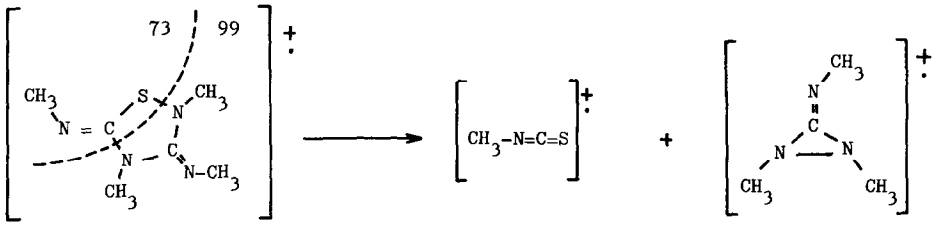


M.W.calc.=102.025), m/e 70 ($C_3H_6N_2$, M.W.obs.=70.052, M.W.calc.=70.053), m/e 99 ($C_4H_9N_3$, M.W.obs.=99.078, M.W.calc.=99.080) and m/e 73 (C_2H_3NS, M.W.obs.=72.996, M.W.calc.=77.999) support the following tentative decomposition mechanism.



(I)

m/e 172 m/e 102 m/e 70



m/e 172 m/e 73 m/e 99

The following compounds are examined in the same fashion.

$CH_3CONHCSNH_2 \xrightarrow{BzO_2^*}$ $CH_3CONH-C$ (S, N, $N-C$, $NHCOCH_3$) (II)

$C_6H_8O_2N_4S$ (M.W.obs.=200.037, M.W.calc.=200.037)

IR (KBr); 1696, 1668, 1583, 1550 cm^{-1}

NMR(DMSO-d_6); 12.92(1H), 10.72(1H), 2.21(3H), 2.10(3H) ppm

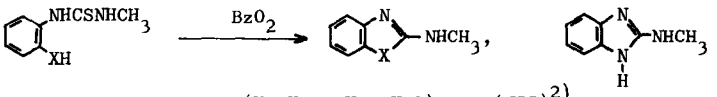
$PhNHCSNHPh \xrightarrow{BzO_2}$ $pH-N=C=N-Ph$ (III)

$PhNHCSNHCH_3 \xrightarrow{BzO_2}$ (Ph, S, Ph, $N=C$, N, $N-C$, CH_3, $N-CH_3$) (IV)

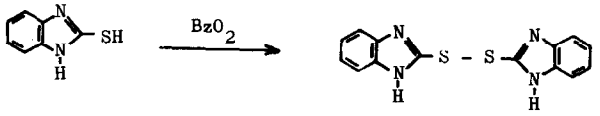
$C_{16}H_{16}N_4S$ (M.W.obs.=296.109, M.W.calc.=296.110)

IR (KBr); 1645, 1632 cm^{-1}

NMR($CDCl_3$); 3.45(3H), 2.66(3H) ppm



(V: X=O, VI: X=S) (VII)[2)]

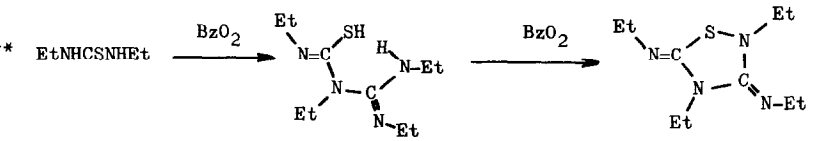


(VIII)[3)]

(* BzO_2; benzoyl peroxide)

We feel that the reaction products in a mass spectrometer (10^{-7}mmHg) are not much different from those in the usual size reactions. Several advantages can be thrown open in future such as;

1) A small amount of reagent would be enough to forecast the reaction products and their structures.
2) A spectrum shows not only new products but also any intermediates** which would indicate the reaction mechanism.
3) The reaction products can be readily isolated in scaled up flask size operation with the aid of the structural knowledge gained from the microscale studies.



(IX) (X)

The peak m/e 230 in the spectrum which corresponded to the intermediate compound (IX) is produced in the mass spectrometer by reacting 1,3-diethylthiourea and benzoyl peroxide. This intermediate (IX) can be obtained using a lesser amount of benzoyl peroxide on a preparative scale, and reacts with benzoyl peroxide to give 2,4-diethyl-3,5-diethylimino-1,2,4-thiadiazolicine (X).

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References

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