Study of the Decomposition Rates of Aqueous Peroxydisulphate in the Presence of Selected Amides and *N*-Acetylamino-acids

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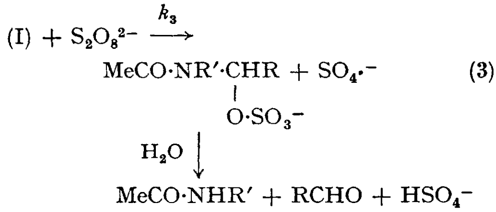
To obtain further insight into free-radical attack adjacent to peptide bonds, we have made a kinetic study of the decomposition of aqueous peroxydisulphate in the presence of selected model amides and *N*-acetyl-α-amino-acids. The stoicheiometry and product distribution in the reaction has been reported[1] and a reaction scheme was then suggested, which involved induced decomposition of peroxydisulphate by the intermediate radicals derived from the amides, analogous to the induced decomposition of persulphate in the presence of methanol:[2]

$$S_2O_8^{2-} \xrightarrow{k_1} 2\,SO_4{\cdot}^- \qquad (1)$$

$$MeCO{\cdot}NR'{\cdot}CH_2R + SO_4{\cdot}^- \xrightarrow{k_2} MeCO{\cdot}NR'\text{-}\dot{C}HR \qquad (2)$$

(I)



$$(I) + S_2O_8^{2-} \xrightarrow{k_3} \underset{\displaystyle O{\cdot}SO_3^-}{MeCO{\cdot}NR'{\cdot}CHR} + SO_4{\cdot}^- \qquad (3)$$

$$\xrightarrow{H_2O} MeCO{\cdot}NHR' + RCHO + HSO_4^-$$

$$2(I) \xrightarrow[\text{disproportionation}]{k_4\ \text{Termination via}} \text{products} \qquad (4)$$

This sequence of steps leads to the kinetic equations:

$$\frac{d[S_2O_8^{2-}]}{dt} = k_1[S_2O_8^{2-}] + k_3\sqrt{\frac{k_1}{k_4}}\,[S_2O_8^{2-}]^{3/2} \qquad (5)$$

In the absence of amides and at pH 8, peroxydisulphate decomposed by first-order kinetics as had been reported previously.[2,3] Peroxydisulphate also decomposed by first-order kinetics in the presence of acetamide, indicating that this amide has little or no influence on the decomposition. However, in the presence of the other amides and of the *N*-acetyl-α-amino-acids studied, a marked acceleration of decomposition was noted, suggesting that induced decomposition was involved and the second term of right-hand side of the equation (5) was likely to predominate. In the presence of these compounds, the decomposition of persulphate was clearly 3/2 order through 60—90% reaction. Variation of the concentration of selected amide or of *N*-acetyl-α-amino-acid from 0·005 to 0·43M did not significantly alter the rate of induced peroxydisulphate decomposition or the reaction order. The rates of reaction, reaction order, and relative rates are summarised in the Table. The rate constants were determined from the slopes of a least-square linear fit of the experimental data using a suitable computer.

The rates of reaction were followed using the analytical procedure of Bartlett and Cotman.[2] It was found necessary to exclude rigorously oxygen and heavy-metal ions to eliminate prolonged induction periods and to obtain reproducible results.

To obtain additional evidence for the attack of $SO_4{\cdot}^-$ on the hydrogen of the nitrogen-α-carbon in step (2) of the reaction sequence, a separate experiment was carried out employing *N*-acetyl-L-alanine. In this experiment the change in peroxydisulphate concentration was followed as usual, TABLE

Rate of decomposition of peroxydisulphate (0·01M) *in the presence of amides and amino-acids* (0·01M) *at* 55° *at* pH 8 [a]

Compound	Order	Rate [b]	Relative rates based on *N*-methylacetamide	Relative rates based on *N*-acetylglycine
Control	1	$2{\cdot}19 \times 10^{-4}$	—	—
$AcNH_2$	1	$4{\cdot}10 \times 10^{-4}$	—	—
N-$MeAcNH_2$	3/2	$1{\cdot}81 \times 10^{-2}$	1·00	—
NN-$DiMeAcNH_2$	3/2	$3{\cdot}56 \times 10^{-2}$	1·97	—
N-$EthylAcNH_2$	3/2	$1{\cdot}87 \times 10^{-2}$	1·03	—
N-Isopropylacetamide	3/2	$1{\cdot}01 \times 10^{-2}$	0·56	—
N-Acetylglycine	3/2	$5{\cdot}44 \times 10^{-3}$	—	1·0
N-Acetylalanine	3/2	$2{\cdot}49 \times 10^{-3}$	—	0·46
N-Acetylaminoisobutyric acid ..	3/2	$1{\cdot}17 \times 10^{-3}$	—	0·22

[a] Initial concentration $[S_2O_8^{2-}]_0 = 0{\cdot}01$M; [amide], [*N*-acetylamino-acid] = 0·01M; 55° ± 0·05, pH 8.

[b] Units: 1st Order = min^{-1}; 3/2 Order = $l.^{\frac{1}{2}}$ moles $min.^{-1}$.

and simultaneously the change in the concentration of *N*-acetyl-L-alanine (by following changes in optical rotation). It was found that peroxydisulphate disappeared at exactly the same rate as *N*-acetyl-L-alanine. This provides substantial additional support for attack on the α-hydrogen at the optically active centre as proposed earlier.

These results combined with those reported previously[1] provide additional insight into the nature of attack of a free radical in the vicinity of peptide bonds. The results are consistent with those obtained for several proteins (keratin,[4] silk,[5] gelatin[6]) and demonstrate the use of selected model compound in studies of the free radical reactions with the more complex natural systems.

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