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A NEW SELECTIVE FREE-RADICAL SYNTHESIS OF γ-LACTONE AND β-SCISSION OF γ-PHENYLPROPYL RADICAL

A. Clerici, F. Minisci and O. Porta
Istituto di Chimica del Politecnico, P.za L. da Vinci 32, 20133 Milano

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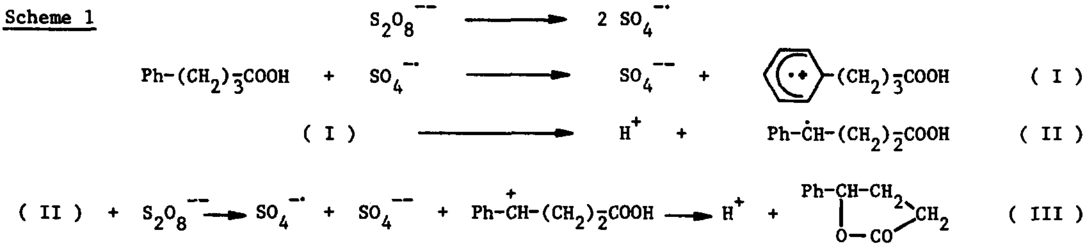
A simple selective synthesis of γ-lactone has been accomplished by oxidation of γ-phenylbutyric acid by ammonium peroxydisulphate. A solution of $(NH_4)_2S_2O_8$ (0.03 mol) in water (10 ml) was added during 30 min. to a well stirred mixture of γ-phenylbutyric acid (0.03 mol) in water (10 ml). The mixture was kept at 90°C for 1 hr. and then extracted with ether. After evaporation of the solvent, the residue (4.5 g) was analyzed by G.L.C. Only two compounds were revealed: γ-phenylbutyric acid (35%) and phenyl-γ-butyrolactone (III) (65%). Conversion 70%, yield based on converted acid 91%. The pure lactone was isolated by washing the mixture with 5% NaOH solution and characterized by I.R., N.M.R. and Mass spectra.

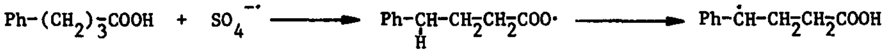
We interpret the mechanism of formation of the γ-lactone according to the Scheme 1:

Scheme 1



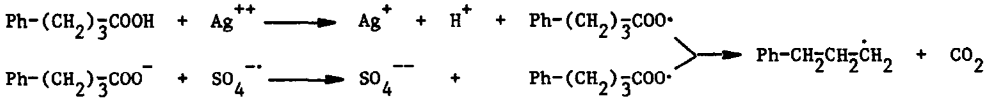
We rule out the possibility of formation of the radical (II) by hydrogen abstraction by $SO_4^{-\cdot}$ owing to the complete selectivity of attack and above all because high yields of lactone are obtained even with high conversions. That is not consistent with a hydrogen abstraction because this abstraction should be much easier from the γ-lactone than from the γ-phenylbutyric acid.

The electron transfer accounts for this behaviour owing the electron-withdrawing inductive effect of the lactone group on benzene ring. The oxidation of the radical (II) by peroxydisulphate is supported by the observed induced decomposition (at 90°C the half-life of $S_2O_8^{--}$ alone (0.75 mol) is about 27 min. and in presence of γ-phenylbutyric acid it is about 7 min.). A third possible way (Scheme 2) for obtaining the radical (II) was unlikely, due to the rapidity of the decarboxylation of aliphatic acyloxy radicals so that, in general, they can only be trapped in cage processes[1]: Scheme 2



$$\text{Ph-(CH}_2)_3\text{COOH} + \text{SO}_4^{-\cdot} \longrightarrow \text{Ph-}\underset{\text{H}}{\text{CH}}\text{-CH}_2\text{CH}_2\text{COO}\cdot \longrightarrow \text{Ph-}\dot{\text{C}}\text{H-CH}_2\text{CH}_2\text{COOH}$$

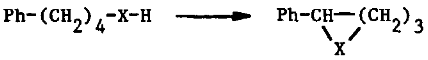
However the oxidation of γ-phenylbutyric acid by peroxydisulphate has been investigated under conditions of oxidative decarboxylation of aliphatic acids. In the presence of silver salt[2] or with sodium carboxylate[3] a partial decarboxylation takes place according to the following reactions:



$$\left.\begin{array}{l}\text{Ph-(CH}_2)_3\text{COOH} + \text{Ag}^{++} \longrightarrow \text{Ag}^{+} + \text{H}^{+} + \text{Ph-(CH}_2)_3\text{COO}\cdot \\ \text{Ph-(CH}_2)_3\text{COO}^{-} + \text{SO}_4^{-\cdot} \longrightarrow \text{SO}_4^{--} + \text{Ph-(CH}_2)_3\text{COO}\cdot\end{array}\right\rangle \longrightarrow \text{Ph-CH}_2\text{CH}_2\dot{\text{C}}\text{H}_2 + \text{CO}_2$$

Benzaldehyde is in both cases the main product of the oxidative decarboxylation, indicating the β-scission of the γ-phenylpropyl radical: $\text{Ph-CH}_2\text{CH}_2\dot{\text{C}}\text{H}_2 \rightleftharpoons \text{Ph-}\dot{\text{C}}\text{H}_2 + \text{CH}_2\text{=CH}_2$ Evidence for the formation of γ-phenylpropyl radical and its β-scission was obtained working in the presence of protonated quinoline, a very efficient trap of alkyl radicals[4]; 2- and 4-phenylpropyl quinolines and traces of 2- and 4-benzylquinolines were obtained. The absence of decarboxylation during the formation of γ-lactone therefore rules out the mechanism of the Scheme 2.

Owing to the semplicity of this new synthesis of γ-lactone, further studies are in progress to investigate the possibility of a general synthesis of five-membered cyclic compounds with different nucleophile (X = O,S,NR, etc.) according to the Scheme:



$$\text{Ph-(CH}_2)_4\text{-X-H} \longrightarrow \text{Ph-}\underbrace{\text{CH—(CH}_2)_3}_{\text{X}}$$

REFERENCES

1) J.K. Kochi, "Free Radicals", vol.II, Ed. by J.K. Kochi, J. Wiley, New York, pg. 698 (1973).
2) F. Minisci, R. Mondelli, G.P. Gardini and O. Porta, Tetrahedron 28, pg. 2403 (1972).
3) F. Bertini, T. Caronna, R. Galli, F. Minisci and O. Porta, Chim. Ind. 54, pg. 425 (1972).
4) F. Minisci, A. Selva, O. Porta, P. Barilli and G.P. Gardini, Tetrahedron 28, pg. 2415 (1972).

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