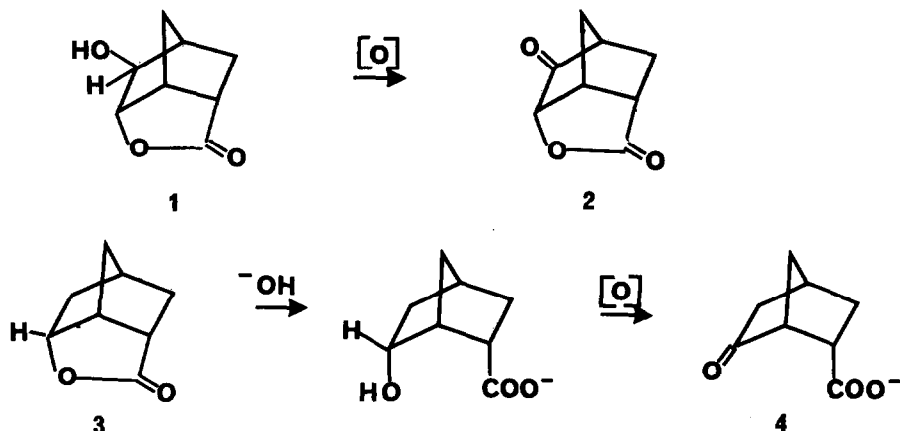


RUTHENIUM TETROXIDE OXIDATION OF SECONDARY
ALCOHOLS IN NEUTRAL AND BASIC MILIEU

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In our research on another project⁴ it became necessary to carry out oxidations 1→2 and 3→4:

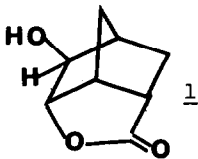
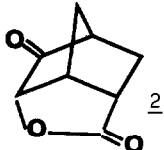
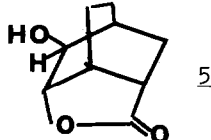
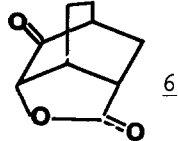
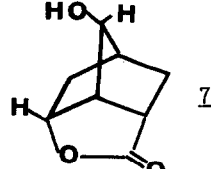
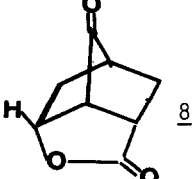
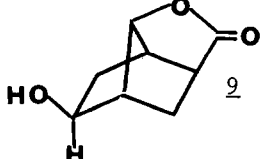
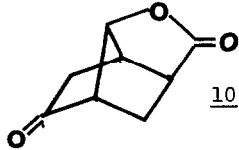


Oxidation 1→2 proved to be inordinately difficult. Over fifteen standard oxidizing procedures failed⁵. In fact the virtual impossibility of effecting this transformation has been published⁶. The acid sensitivity of 2 may be the cause of these difficulties. Successful oxidation of 1 was realized by using RuO₂ - NaIO₄ in CCl₄ - H₂O. The high yield obtained as well as the applicability of the oxidizing reagent to related systems prompts us to call attention to this valuable synthetic procedure.

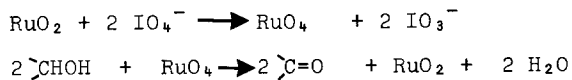
Furthermore, oxidations of the type 3→4 using $\text{KMnO}_4/\text{HO}^-$ gives poor yields. We find that $\text{RuO}_2\text{-NaIO}_4/\text{HO}^-$ is uniquely useful for high yield accomplishment of this type of transformation.

Ruthenium tetroxide has already seen some limited use for the oxidation of secondary alcohols under neutral conditions.^{7 a,b,c,d,e,f} The method which we have adapted involves the in situ generation of RuO_4 in a two phase system.^{7 b,8,9} To an aqueous solution containing 30 mmoles of hydroxylactone, one adds a suspension of 250 mg. of RuO_2 in CCl_4 . Then with vigorous stirring a 10% aqueous solution of NaIO_4 (40 mmoles) is added dropwise to the cooled mixture until the yellow color of RuO_4 persists. The excess oxidizing agent is destroyed with $i\text{-PrOH}$ and the organic product is isolated from the CCl_4 layer. Table I lists typical examples and yields.

TABLE I
Ketolactones from RuO_4 Oxidation of Hydroxylactones

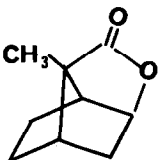
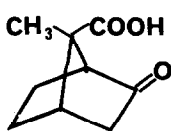
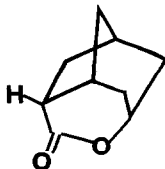
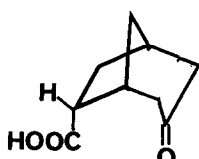
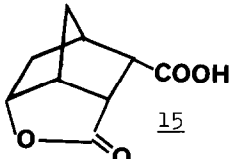
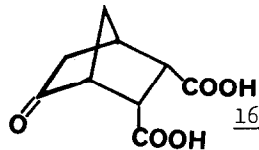
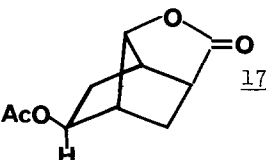
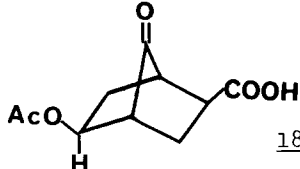
Compound	Ketolactone	Yield %
 <u>1</u>	 <u>2</u>	80
 <u>5</u>	 <u>6</u>	87
 <u>7</u>	 <u>8</u>	76
 <u>9</u>	 <u>10</u>	88

We have established by means of quantitative studies the following stoichiometry for the RuO_4 oxidation under neutral conditions.



For the RuO_4 oxidation of lactones to ketoacids the lactone is first hydrolysed to the hydroxycarboxylate with 1 molar equivalent of aqueous base. Then 0.02 molar equivalent of RuO_2 is added and with stirring one adds dropwise an aqueous solution containing one molar equivalent of NaIO_4 . Table II lists typical results and yields.

TABLE II

Compound	Ketocarboxylates	Yield %
 <u>11</u>	 <u>12</u>	97
 <u>13</u>	 <u>14</u>	88
 <u>15</u>	 <u>16</u>	68
 <u>17</u>	 <u>18</u>	60

(a) S. Beckmann and H. Gelger, Chem. Ber., 94, 48 (1961), These workers report a 53% yield for 11→12 using alkaline KMnO_4 ;

One limitation encountered in our use of RuO_4 is the concurrent oxidation of α -methylene groups as exemplified by 19 \rightarrow 20 + 1 in 30 and 40% yield, respectively.



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