Cyano or Acyl Group Migration by Consecutive Homolytic Addition and β-Fission

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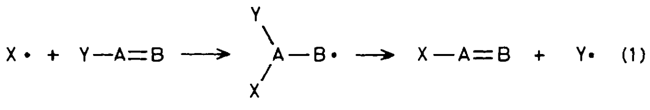
Suitably constituted aryl and alkyl radicals readily rearrange by 1,2- or 1,4-acyl or cyano migration.

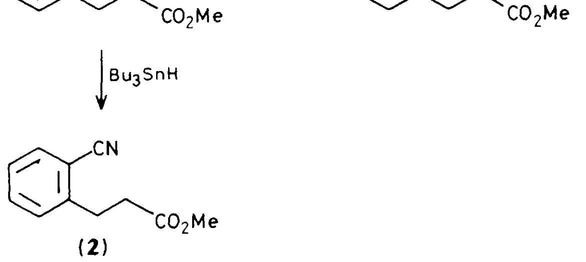
The transformation represented in a general way by equation (1) is expected to proceed readily in the forward direction when neither step has a high barrier and when the heat of formation of the X–A bond is greater than that of the Y–A bond. Previous work[1—5] suggests that these criteria will be met when A=B is $-C{\equiv}N$ or $>C{=}O$, X• is an aryl radical, and Y• is an alkyl radical.† We now show that this hypothesis is correct and describe some mechanistically interesting consequences when the process is applied intramolecularly.

Suitable substrates (**1**, X = Br) and (**3**) were readily available by alkylation of cyanoacetic or acetoacetic ester with *o*-bromobenzyl bromide.‡ Heating of the cyanoacetate (**1**; X = Br) with tributylstannane (0.02 M) in degassed benzene under reflux for 3 h afforded the nitrile (**2**) (60%) expected on the basis of the mechanism of Scheme 1 together with the direct reduction product (**1**, X = H) (12%). Likewise, the ketone (**3**), when similarly treated, gave the rearranged ketone (**4**) and the direct reduction product in 38 and 59% yield respectively. The analogous naphthalene derivatives (**5**) and (**6**) also underwent rearrangement by cyano and acetyl migration respectively when heated with tributylstannane to afford (**7**) and (**8**) in yields of 97% and 58%.

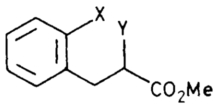
Application of the method to the cyclic keto-ester (**9**, *n* = 1, X = Br) gave the benzo-cyclo-octanone (**11**, *n* = 1) expected to arise *via* formation and β-fission of the alkoxyl radical (**10**, *n* = 1), but the yield was low (14%) and the major product was



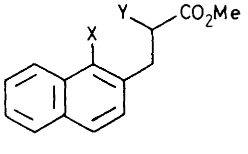
$$X\bullet + Y{-}A{=}B \longrightarrow \overset{Y}{\underset{X}{>}}A{-}B\bullet \longrightarrow X{-}A{=}B + Y\bullet \quad (1)$$



Scheme 1



(**3**) X = Br, Y = COMe
(**4**) X = COMe, Y = H



(**5**) X = Br, Y = CN
(**6**) X = Br, Y = COMe
(**7**) X = CN, Y = H
(**8**) X = COMe, Y = H

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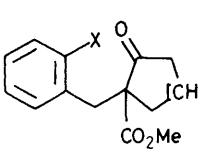
† The heat of formation of the Ar–C bond is considerably greater than that for the R–C bond,[1] alkyliminyl and alkoxy radicals undergo ready β-fission,[2] and intramolecular addition of alkyl radicals to the cyano or carbonyl group has already been observed.[3,4] By analogy with rates of addition to the C=C bond[5] the aryl radicals would be expected to react with $-C{\equiv}N$ or $>C{=}O$ more rapidly than alkyl.

‡ All new compounds gave satisfactory spectral and microanalytical data.



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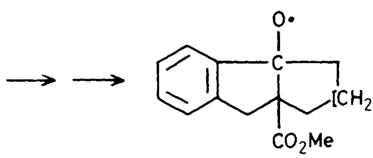
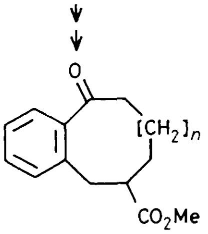


(10)



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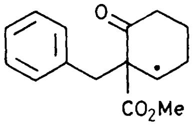
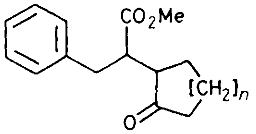


(12)



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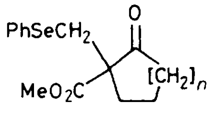
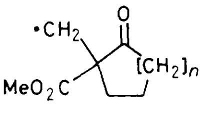
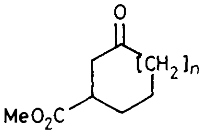


(14)



(15)



(16)

(**9**, $n = 1$, X = H). However, when the keto ester (**9**, $n = 4$, X = Br) was treated with tributylstannane the major products (86%) were the diastereoisomers of the ring-contracted compound (**13**, $n = 3$), while (**9**, $n = 2$, X = Br) gave reduced (**9**, $n = 2$, X = H), (58%), ring-expanded (**11**, $n = 2$) (21%), and ring-contracted (**13**, $n = 1$) (15%) products. The most probable route for formation of the latter involves an addition–β-fission sequence within the radical (**12**) formed by an initial intramolecular hydrogen-atom transfer which must proceed more rapidly than the desired aryl addition to the carbonyl group. Presumably the radical derived from (**9**, $n = 1$, X = Br) also undergoes 1,6-hydrogen atom transfer but in this particular case ring contraction by acyl migration is precluded by the strain engendered in formation of the cyclobutanone ring. In conformity with this view the ^{2}H n.m.r. spectrum of the direct reduction product from (**9**, $n = 1$, X = Br) and deuteriostannane showed the presence of deuterium on both the aryl and cycloalkyl rings.

Encouraged by the propensity of radicals such as (**12**) to undergo rapid acyl migration, we examined the possible synthetic utility of similar rearrangements[4] of analogous exocyclic radicals (**15**, $n = 1,2,4$). Slow addition of tributylstannane and an initiator to boiling benzene or toluene solutions of the selenides (**14**, $n = 1,2,4$), which were readily prepared by alkylation of the keto-esters with bromomethyl phenyl selenide, gave the ring expanded products (**16**, $n = 1,2,4$) in yields of 70—90%.

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