

THE COUPLING OF ACID CHLORIDES BY ENNEACARBONYLDIIRON AND BY
NICKEL CARBONYL COMPLEXES. PREPARATION OF SYMMETRICAL PRIMARY ALKYL KETONES.

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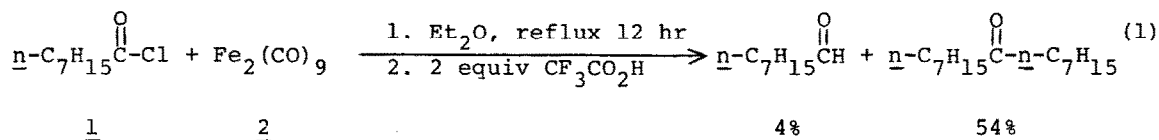
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(Received in USA 22 July 1977; received in UK for publication 16 September 1977)

Metal carbonyls and their anions have been found to be reactive with a variety of organic substrates.¹ In seeking a mild conversion of acid chlorides to aldehydes, without the inconvenient necessity of having to first reduce the metal carbonyl, we submitted octanoyl chloride (1) to reaction with Fe₂(CO)₉ (2) as shown in equation 1. Treatment with CF₃CO₂H



after reaction yielded very little aldehyde, while concurrent treatment with CF₃CO₂H yielded 20% (experiment 1, Table). Most notable was the formation of significant amounts of di-n-heptylketone in both cases. We have found that reaction of α-mono-substituted acetyl chlorides with 2 (in absence of acid) is a mild, general means of preparing symmetrical ketones in fair-to-good yields. In a typical reaction, the acid chloride is heated at reflux with 2² in ether overnight, the mixture is filtered, the solvent evaporated, and the product is purified by conventional techniques. Hexane and Fe(CO)₅³ were usable as solvents (experiments 3 - 5) but resulted in diminished yields. In THF as solvent at 25°, the major product from 1 was n-C₇H₁₅CO-(CH₂)₄Cl (experiment 6).⁴ Only a slight decrease in yield was observed in changing the RCOCl:2 molar ratio from 1:1 to 2:1 (experiments 2, 7), but the standard conditions for examining substrate variation were taken to be Et₂O solvent at reflux, 12 hours, and a 1:1 molar ratio of RCOCl:2.

The reaction conditions were tolerant of the ester group in CH₃O₂C(CH₂)₃-COCl (experiment 13), and of the ether in p-MeOC₆H₄CH₂COCl (experiment 11). Reaction of CH₂=CH(CH₂)₈COCl with 2 yielded [CH₃CH=CH(CH₂)₇]₂CO as the only

TABLE ^a

Expt	Substrate	Reagent	Reactant Ratio ^b	Products	% Yield
1	CH ₃ (CH ₂) ₆ COCl	Fe ₂ (CO) ₉ + CF ₃ CO ₂ H	1:1:1	CH ₃ (CH ₂) ₆ CHO + [CH ₃ (CH ₂) ₆] ₂ CO	20 18
2	CH ₃ (CH ₂) ₆ COCl	Fe ₂ (CO) ₉	1:1	[CH ₃ (CH ₂) ₆] ₂ CO	71
3	"	"	" ^c	"	24
4	"	"	" ^d	"	26
5	"	"	" ^e	"	46
6	"	"	" ^f	"	13
7	"	"	2:1	"	62
8	"	Ni(CO) ₂ (PPh ₃) ₂	2:1	"	40
9	"	(η ² -PhCH=CH ₂)Fe(CO) ₄	1:1	"	62
10	PhCH ₂ COCl	Fe ₂ (CO) ₉	1:1 ^g	[PhCH ₂] ₂ CO	33
11	p-MeOC ₆ H ₄ CH ₂ COCl	"	"	[p-MeOC ₆ H ₄ CH ₂] ₂ CO	59
12	CH ₃ CH(Ph)CH ₂ COCl	"	"	[CH ₃ CH(Ph)CH ₂] ₂ CO	38
13	CH ₃ O ₂ C(CH ₂) ₃ COCl	"	"	[CH ₃ O ₂ C(CH ₂) ₃] ₂ CO	24
14	CH ₂ =CH(CH ₂) ₈ COCl	"	"	[CH ₃ CH=CH(CH ₂) ₇] ₂ CO ^h	40
15	p-MeOC ₆ H ₄ CH ₂ COCl + CH ₃ (CH ₂) ₆ COCl	" "	1:1:2	[p-MeOC ₆ H ₄ CH ₂] ₂ CO + CH ₃ (CH ₂) ₆ COCH ₂ C ₆ H ₄ pOme + [CH ₃ (CH ₂) ₆] ₂ CO	18 20 13

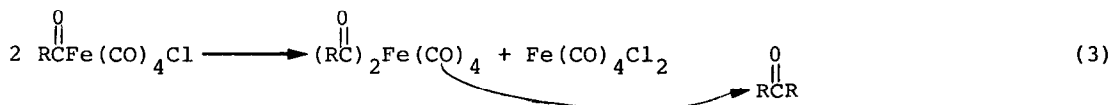
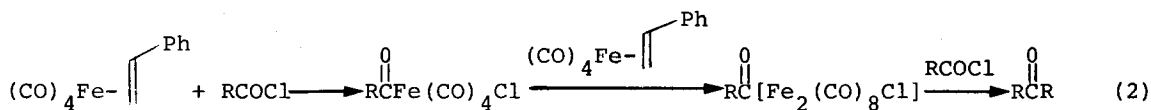
^aConditions, unless otherwise noted: Et₂O solvent at reflux for 12 hr, under nitrogen atmosphere. ^bRatio = acid chloride:metallic reagent. ^cHexane solvent reflux, 1 hr. ^dHexane solvent, 25°, 12 hr. ^eFe(CO)₅ solvent, 35°, 12 hr. ^fTHF solvent, 25°, 12 hr. ^gFour hr. ^hThe only isomer detectable by NMR.

positional isomer (experiment 14). Iron carbonyls are well-known olefin isomerization catalysts, ⁵ but the selectivity of the isomerization in this last case is noteworthy. Aromatic nitro compounds are known to be reduced by iron carbonyls, ⁶ so that as anticipated no isolable product could be obtained from the reaction of 2 with p-NO₂C₆H₄CH₂COCl. Aliphatic bromides are similarly labile since Br(CH₂)₅COCl yielded only a complex reaction mixture.

The scope of this reaction is limited to α-mono-substituted acetyl chlor-

ides (no ketone could be isolated from reaction of 2 with C_6H_5COCl , $p-C_6H_{11}COCl$, $t-BuCOCl$, $CH_3CH=CHCOCl$, or $CH_3CHBrCOCl$) and to mono acid chlorides ($ClOC(CH_2)_nCOCl$, $n = 4, 7, 8, 11, \text{ and } 14$, and $p-ClOCC_6H_4CH_2COCl$ all failed to cyclize). As anticipated, when 2 was submitted to reaction with an equimolar ratio of 1 and $p-CH_3OC_6H_4CH_2COCl$, the three possible products were formed all in low yield (experiment 15).

The choice of metallic reagent is not incidental since $Fe(CO)_5$ ($h\nu$ or Δ),⁷ $Fe_3(CO)_{12}$, $Co_2(CO)_8$, $Fe_2(CO)_7(\mu-(PPh_2)_2CH_2)$ (3), and $Fe(CO)_3(\mu-PMe_2)_2Fe(CO)_3$ (4) do not yield any ketone products in reaction with 1. However, $Ni(CO)_2(PPh_3)_2$ (5) did afford diheptyl ketone⁷ in moderate yield (experiment 7). It is interesting to speculate that 2 causes coupling via interaction of two equivalents of acid chloride with the dimeric reagent. If one believes that both $RCOCl$ equivalents are activated by oxidative addition to iron, then either a transient $Fe(IV)$ must be postulated, or two atoms of iron are involved. Experiment 8 wherein $(\eta^2\text{-styrene})Fe(CO)_4$ was used in place of 2 is ambiguous in this regard since the path of equation 2 or 3 might obtain. The insolubility of 2 and the lack of reactivity of the more soluble dimers 3 and 4 have precluded detailed mechanistic studies.



The fact that nickel(0) effects the dimerization of acid chlorides is not unreasonable for a mononuclear species, since oxidative addition of one equivalent of $RCOCl$ would yield $NiL_2Cl(COR)$, or perhaps $NiL_2(COR)_2$ by metathesis, and addition of "oxidizing" agents such as alkyl, aryl, or acyl halides to such species is known to induce coupling reactions.⁸ Preliminary results indicate that $Ni(0)$ complexes may have a wider scope in this reaction than does 2, and this is being further investigated.

Acknowledgement. This work was supported in part by the National Science Foundation Grant CHE 75-1344.

Notes and References

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