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A Novel Transesterification of Thioesters with Alcohols by an Electrochemical Activation

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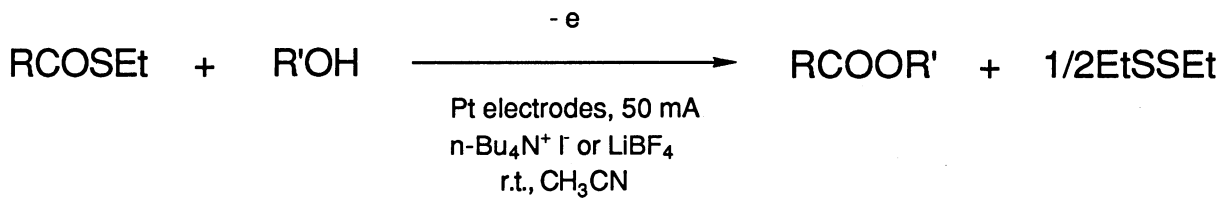
Esters were synthesized from thioesters and alcohols in high yields by an electrochemical activation. Different results were obtained by the use of n-Bu_4N^+ I^- and $LiBF_4$ as the electrolyte.

Ester synthesis is an important process in organic synthesis and various methods have been reported which employ activated carboxylic acid derivatives and alcohols. Thioesters are known to form highly reactive species in the presence of heavy metal salts such as $Hg(OCOCF_3)_2$, $AgOCOCF_3$, $CuOCOCF_3$, or CuOTf.[1] However, these promoters are often toxic or hygroscopic, and are required in stoichiometric amount. Accordingly, more convenient methods have been desired. Previously, it was reported that thioesters were electrochemically activated to give carboxylic acids in aqueous media.[2] The observations were extended here to a novel transesterification reaction of thioesters by alcohols (Scheme 1).

A typical procedure is as follows: Under an argon atmosphere, an acetonitrile (4 ml) solution of a thioester (1.7 mmol), an alcohol (1.0 mmol), and $LiBF_4$ (0.5 mmol) was stirred at room temperature in an undivided cell at a constant current of 50 mA using Pt electrodes (4 cm^2). After most of the thioester was consumed (1 to 2 h), the mixture was poured on 2 M HCl, and organic materials were extracted twice with ethyl acetate. The extracts were washed with water and brine, dried over Na_2SO_4, and concentrated. The ester was isolated by silica gel chromatography.



Scheme 1.

It should be noted that thioesters are required only in slight excess over alcohols, and esters are obtained in high yields (Table 1). The electric current is essential in the present reaction, and no ester production was observed in the absence. Thiol moieties were recovered as disulfides. As for the solvent, acetonitrile gave better results than nitromethane, DMF, or DMI.

Table 1. Transesterification Reaction of Thioesters with Alcohols by an Electrochemical Activation

R	R'	Method[a)]	Yield/%[b)]
n-C_5H_{11}-	$Ph(CH_2)_3$-	A[c)]	83
		B	79
	$PhCH_2$	A	81
	$PhCH_2CH_2(CH_3)CH$-	A[c)]	35
		B	82
	$PhCH_2CH_2$(n-C_5H_{11})CH-	B	77
	t-Bu-	B	45
$PhCH_2CH_2$-	$Ph(CH_2)_3$-	B	90
	n-C_8H_{17}-	A	88
	CH_2=$CHCH_2$-	A	77
	-$CH(CH_2COOEt)_2$	B	64
	Ph-	B	74
C_2H_5-	$Ph(CH_2)_3$-	A	82
PhCH=CH-	$Ph(CH_2)_3$-	B	71
	$PhCH_2CH_2(CH_3)CH$-	B	66
$(CH_3)_2CH$-	$PhCH_2CH_2(CH_3)CH$-	B	65
Ph-	$Ph(CH_2)_3$-	B	59

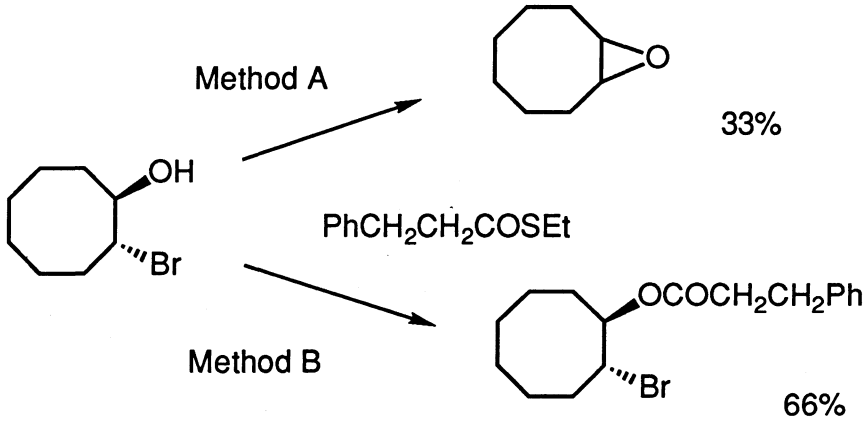
a) Method A: $(n\text{-}C_4H_9)_4N^+ I^-$ was used as the electrolyte. Method B: $LiBF_4$ was used as the electrolyte. Molar ratio of thioester : alcohol = 1.7 : 1.

b) Isolated yields based on alcohols are shown. All the products gave satisfactory H-NMR, IR, and elemental analysis either by high resolution MS or combustion analysis.

c) Molar ratio of thioester : alcohol = 1.5 : 1.

Interesting observations were made on the use of the different electrolytes, $(n\text{-}C_4H_9)_4N^+ I^-$ (Method A), and $LiBF_4$ (Method B).

1) Although the acylation of primary alcohols proceeded smoothly with either of the two methods, esterification of secondary alcohols were more efficiently conducted with Method B. The reaction of a tertiary alcohol, however, resulted in lower yield.



Scheme 2.

2) While an epoxide was formed from a halohydrin by Method A, an ester was obtained in good yield by Method B (Scheme 2). It seems that alkoxides were generated in the former reactions.

3) The use of Pt or Au[3] anode is essential for the $LiBF_4$-mediated reactions (Method B), and Ni, stainless, Mo, Pd, or Ag anode gave none of the products. As for the cathode, Ni, Mo, stainless, and Pt gave similar results provided that Pt cathode was employed.[4] Method A reactions, however, proceeded with a wide range

Table 2. The Effects of Alkylthio Groups on the Transesterification Reaction

$$EtCOSR + Ph(CH_2)_3OH \xrightarrow[\text{Pt electrodes, 50 mA; } n\text{-}Bu_4N^+ I^- \text{ or } LiBF_4\text{; r.t., } CH_3CN]{-e} EtCOO(CH_2)_3Ph$$

RS	Yield / %[a] Method A	Method B
EtS	82, 70,[b] 33[c]	75
i-PrS	75	60
n-$C_6H_{13}S$	86	79
Me_2CHCH_2S	70	80
t-BuS	67	trace
$PhCH_2S$	74	trace

a) The reactions were carried out as described in the footnote a) of Table 1.

b) n-Bu_4N^+ Br^- was used for the electrolyte.

c) $PhCH_2Et_3N^+$ Cl^- was used for the electrolyte.

of electrodes other than Pt either for anode or cathode (for example, stainless, Pd, Ni, Ti, Mo, etc.), although the yields of esters varied.

4) Various alkyl thioesters could be used for the substrate in the Method A transesterification reactions. However, Method B reactions proceeded with relatively small alkyl thioesters, and t-butyl and benzyl thioester did not give the products (Table 2). It appears that a kind of recognition of alkyl groups on sulfur atom is taking place on the Pt electrode surface.

Although it is not possible to present a precise mechanism of these reactions, we have the following working hypothesis: In the Method A reactions, thioesters which are activated by I^+ are attacked by alkoxides. As shown in Table 2, Br^+ and Cl^+ also worked as promoters.[5] In contrast, Method B reactions take place at the surface of the electrode possibly *via* adsorped thioesters. Adsorption phenomenon of organosulfur compounds on Au surface is well known.[6]

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References

1) For examples; S. Masamune, S. Kamata, and W. Schilling, *J. Am. Chem. Soc.*, **97**, 3515 (1975); S. Masamune, Y. Hayase, W. Schilling, W. K. Chan, and G. S. Bates, *ibid.*, **99**, 6756 (1977); J.Huang and J. Meinwald, *ibid.*, **103**, 861 (1981); P. M. Booth, C. M. J. Fox, and S. V. Ley, *J. Chem. Soc., Perkin Trans. 1*, **1987**, 121.

2) M. Kimura, S. Matsubara, and Y. Sawaki, *J. Chem. Soc., Chem. Commun.*, **1984**, 1619. An electrochemically induced rearrangement of benzene-1,2-dicarbothiolates to 3,3-bis(arylthio)phthalides was reported, which involves the intramolecular attack of carbonyl oxygen to thioesters: K. Praefcke, C. Whiehsel, M. Falsig, and H. Lund, *Acta Chem. Scand.*, **B34**, 403 (1980). Electrochemical oxidative activations of organosulfur compounds in protic media are known, which give solvolysis or elimination products. See, for examples; Q. N. Porter and J. H. P. Utley, *J. Chem. Soc., Chem. Commun.*, **1978**, 255; S. Torii, H. Okumoto, and H. Tanaka, *Chem. Lett.*, **1980**, 617; M. Kimura, S. Matsubara, Y. Sawaki, and H. Iwamura, *Tetrahedron Lett.*, **27**, 4177 (1986).

3) A small amount (16 % yield) of t-butyl 3-phenylpropionate was obtained with Au anode and Pt cathode from the corresponding ethyl thioester and t-butanol by Method B.

4) t-Butyl 3-phenylpropionate was obtained in 40 to 50% yield from the corresponding ethyl thioester and t-butanol with Pt anode and Ni, Mo, Stainless, or Pt cathode.

5) An electrochemically generated Br^+/base complex system was noted by Shono et al.: T. Shono, Y. Matsumura, and K. Inoue, *J. Am. Chem. Soc.*, **106**, 6075 (1984).

6) C. D. Bain, E. B. Troughton, Y-T. Tao, J. Evall, G. M. Whitesides, and R. G. Nuzzo, *J. Am. Chem. Soc.*, **111**, 321 (1989); and references cited therein.

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