Electroreductive Double Carbon-Carbon Bond Formation of Alkyl Methacrylates

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Extensive studies have been concentrated on synthesis of 1,4-dicarbonyl compounds, especially 1,4-diketones, which are of much importance as the synthetic intermediates of many biologically active substrates and useful heterocyclic compounds such as pharmaceutical drugs, insecticides and perfume materials containing the ring systems of cyclopentenones, furans, pyrroles, and thiophenes. We have already reported electrochemical or Mg-promoted regioselective C-acylation of α,β-unsaturated carbonyl compounds to give the corresponding C-acylated 1,4-dicarbonyl compounds.[1)-3)]

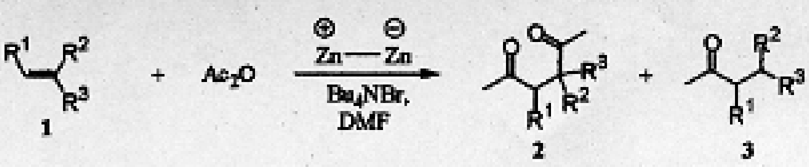
In this study, we wish to present the vicinal double C-acylation of methacrylate derivatives by electroreduction using Zn-plates as the anode and the cathode. Although electrochemical vicinal double C-carboxylation[4)] and C-formylation[5)] of styrene derivatives has been reported to give the corresponding 1,4-dicarbonyl compounds, vicinal double C-acylation has not been known as yet to our best knowledge.

The electroreduction of methacrylates was carried out at 15~25°C using an undivided cell in the presence of acetic anhydride in *N,N*-dimethylformamide (DMF) containing tetra-*n*-butylammonium bromide as a supporting electrolyte under the constant current condition (current density : 7mA/cm^2) until 6F/mol of electricity passed through the system. The corresponding 1,4-diketones (**2a**)~(**2d**) were obtained in satisfactory yields. On the contrary, only mono acylated products (**3e**), (**3f**) were obtained from the reaction of ethyl cinnamate (**1e**) and crotonate (**1f**) under the same conditions, as shown in Table 1.

On the basis of these experimental results, the first electron transfer from cathode to alkyl methacrylates (**1**) generates anion radicals (**4**) which may be subjected to the first electrophilic attack of acetic anhydride at β-carbon of **1** followed by the fast second electron transfer, giving enolate anions (**5**). The tertiary enolate anions (**5**) from **1a**~**1d** may be less stable and more reactive to the second acylation than the secondary ones (**5**) from **1e** and **1f** (Scheme 1). Thus, the corresponding 1,4-diketones (**2a**)~(**2d**) were obtained by electrophilic attack of acetic anhydride to the tertiary enolate anions (**5**) (R^2=CH$_3$) and the secondary enolate anions (**5**) (R^2=H) were subjected to the protonation.

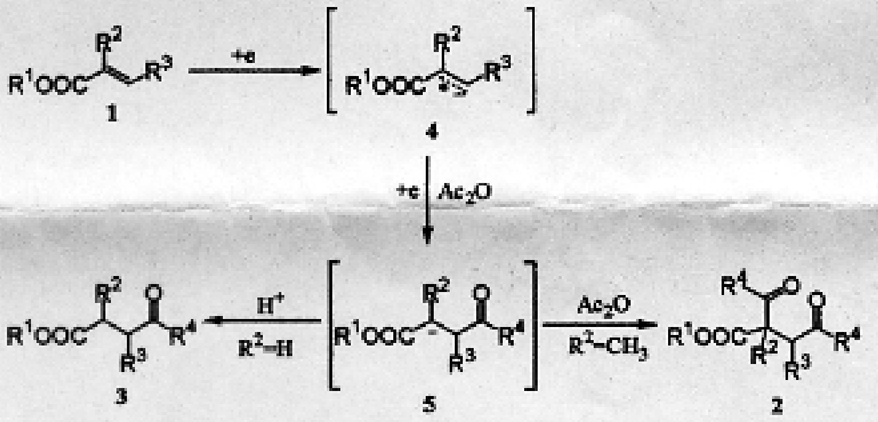
Furthermore, electroreduction of benzyl methacrylate (**1a**) with ethyl iodide under similar conditions also provided the corresponding vicinal double C-alkylated product (**6**) as the main product (Yield=35%) (Scheme 2). On the other hand, the same product (**6**) was obtained without any electricity in similar yield (Yield=36%). The detailed mechanism is not still obvious.

Table 1. Electroreductive C-Acylation of Activated Olefins

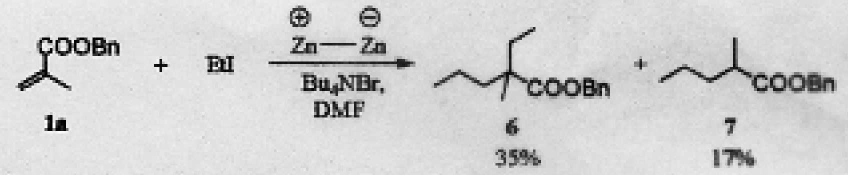


Entry	R^1	R^2	R^3	Yield (%)[a)] 2	Yield (%)[a)] 3
1	-H	-Me	-COOBn [1a]	72 [2a]	11 [3a]
2	-H	-Me	-COOMe [1b]	61 [2b]	-
3	-H	-Me	-COOEt [1c]	59 [2c]	-
4	-H	-Me	-CN [1d]	45 [2d]	-
5	-Ph	-H	-COOEt [1e]	-	68 [3e]
6	-Me	-H	-COOEt [1f]	-	50 [3f]

Reaction Conditions: Substrate (10mmol), Acetic Anhydride (15eq.mol), Bu$_4$NBr (1.66eq.mol), Current Density (7mA/cm^2),
Supplied Electricity (6F/mol), DMF (60ml), 15~25°C, under N$_2$ atmosphere
a) GC Yield



Scheme 1. Proposed Reaction Mechanism for C-Acylation of Alkyl Methacrylates, Ethyl Cinnamate and Crotonate



Reaction Conditions: Substrate (10mmol), Ethyl iodide (10eq.mol), Bu$_4$NBr (1.66eq.mol), Current Density (5mA/cm^2), Supplied Electricity (6F/mol), DMF (60ml), 15~25°C, 16hr., under N$_2$ atmosphere

Scheme 2. Double C-Alkylation of Benzyl Methacrylate

References

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