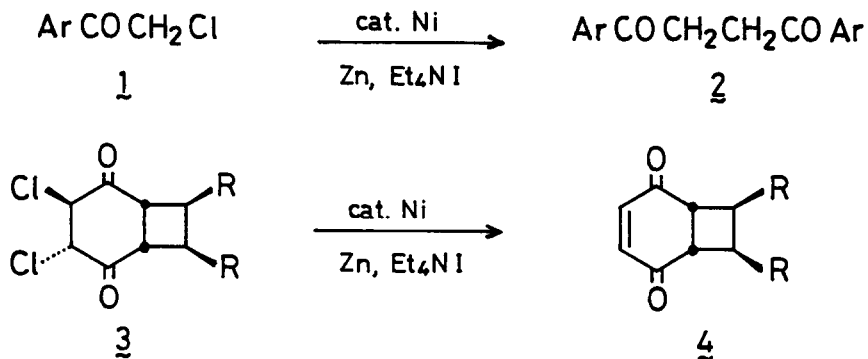


NEW AND EFFICIENT DEHALOGENATIVE COUPLING AND REDUCTION OF
 α -HALOKETONES WITH ACTIVE NICKEL COMPLEX. FACILE SYNTHESSES
OF 1,4-DIKETONES AND BICYCLO[4.2.0]OCT-3-ENE-2,5-DIONES

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Summary: The active nickel complex generated *in situ* by reduction of $\text{NiBr}_2(\text{PPh}_3)_2$ with zinc in the presence of Et_4NI is a useful reagent for the dehalogenative coupling of phenacyl halides to 1,4-diaryl-1,4-diketones and for the dechlorination of 3,4-dichlorobicyclo[4.2.0]octane-2,5-diones to bicyclo[4.2.0]oct-3-ene-2,5-diones.

Although several zerovalent nickel complexes exhibit specific ability in a reductive coupling of aryl or alkenyl halides,¹⁾ little is known about the nickel-catalyzed coupling of α -haloketones or reductive dehalogenation of *vic*-dihalides.²⁾ Recently, we have reported the reductive coupling of alkenyl, aryl and benzyl halides using the active nickel complex generated *in situ* by reduction of $\text{NiX}_2(\text{PPh}_3)_2$ with zinc in the presence of Et_4NI .³⁾ The reductive homo-coupling reactions of alkenyl, aryl and benzyl halides with the active nickel complex proceed under mild conditions to afford the corresponding coupling products in good to high yields. In this paper we describe the use of the active nickel catalyst to convert phenacyl chlorides (**1**) and 3,4-dichlorobicyclo[4.2.0]octane-2,5-diones (**3**) into 1,4-diarylbutane-1,4-diones (**2**) and bicyclo[4.2.0]oct-3-ene-2,5-diones (**4**), respectively.



As shown in Table 1, the reductive coupling of phenacyl chloride with the active nickel complex proceeded smoothly in THF, DME and benzene to give 1,4-diphenylbutane-1,4-dione in good yields (entries 1-3). However, the yield of the coupling product decreased in acetonitrile as solvent and also in the case of phenacyl bromide as starting material (entries 4 and 6). Although the reductive coupling of phenacyl chloride occurred with zinc alone, the yield of 1,4-diphenylbutane-1,4-dione was low and a considerable amount of reduction product (*i.e.*, acetophenone) was formed (entry 5). Additionally, the reductive coupling of phenacyl chloride with $\text{Ni}(\text{PPh}_3)_4$, which was generated in DMF from $\text{NiBr}_2(\text{PPh}_3)_2\text{-Zn-PPh}_3$, gave also the 1,4-diketone (16%) and acetophenone (22%). Therefore, the coupling reaction listed in entries 1-4 is catalyzed by nickel(0) complex and Et_4NI , and the formation of acetophenone was not observed in these cases. As exhibited by entries 7-10, the coupling of phenacyl chlorides (**1**) bearing methyl, chloro or methoxy group proceeded in good yields. Steric hinderance due to *ortho*-substituents slowed down the reaction rate, and the coupling of the *ortho*-methoxy derivative was unsuccessful owing to the competitive reduction catalyzed by zinc.

Table 1. Coupling of phenacyl halides (**1**) to 1,4-diarylbutane-1,4-diones (**2**).

Entry	R	X	Conditions ^{a)}		Solvent	Yield of 2 (%) ^{c)}
			Catalyst (mol%)	Time (h) ^{b)}		
1	H	Cl	5	2.5	THF	79
2	H	Cl	5	2.5	DME	71
3	H	Cl	10	2	Benzene	68
4	H	Cl	5	3	CH_3CN	48
5	H	Cl	0	6	THF	8 ^{d)}
6	H	Br	5	2	THF	41
7	2- CH_3	Cl	5	20	THF	71
8	2-Cl	Cl	10	8	Benzene	70
9	4-Cl	Cl	5	2.5	THF	63
10	4- OCH_3	Cl	5	6	THF	81

a) 5-10 mol% of $\text{NiBr}_2(\text{PPh}_3)_2$, 1.5 molar equiv. of activated zinc, and 1 equiv. of Et_4NI were used. b) At room temperature. c) Isolated yield. d) Acetophenone (18%) was obtained along with the 1,4-diketone.

The above-mentioned nickel complex is also applicable to the mild reductive dechlorination of *trans*-3,4-dichlorobicyclo[4.2.0]octane-2,5-dione (**3a**)⁵⁾ which can be easily prepared by the photochemical [2+2]addition of ethylene to *trans*-5,6-dichloro-2-cyclohexene-

-1,4-dione (5)⁶). Although the photoadduct (3a) is not stable and decomposed slowly both in solution and in the solid state, the nickel-catalyzed reduction of chlorine in 3a proceeded smoothly and selectively in the presence of Et₄NI in THF at room temperature to give the enedione (4a) in 57% yield based on 5. By the use of Ni(PPh₃)₄, which is generated *in situ* in DMF, the photoadduct (3a) could be also converted into the enedione (4a) in 22% yield, but bicyclo[4.2.0]octane-2,5-dione (6, 9%) was formed as a by-product in this case. In contrast to the results obtained by the nickel-catalyzed reaction, the attempted preparation of 4a by reduction of 3a with zinc or other reducing agents was unsuccessful. Similar reduction of the photoadducts (3b, 3c and 3d)⁵ afforded the corresponding enediones (4b, 4c and 4d), respectively (Table 2). Since the reaction conditions are very mild, the enediones (4a-4d) do not isomerized to the corresponding hydroquinones.⁷

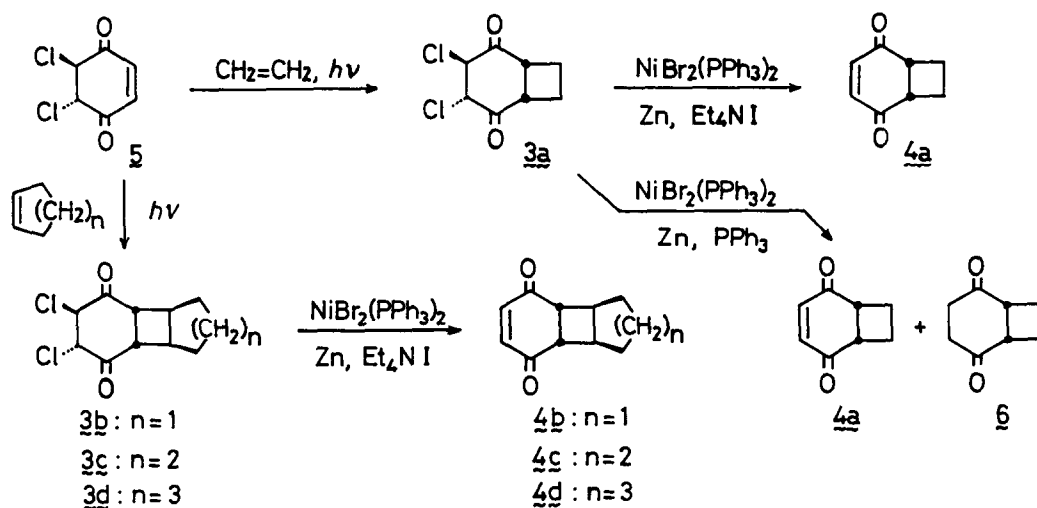


Table 2. Synthesis of bicyclo[4.2.0]oct-3-ene-2,5-dione and its derivatives (4a-4d).

Entry	Photoadduct	Conditions		Product	Yield (%) based on <u>5</u>
		Catalyst (mol%)	Time (h)		
11	<u>3a</u>	5	1.5	<u>4a</u>	57
12	<u>3b</u>	5	2	<u>4b</u>	50
13	<u>3c</u>	5	1.5	<u>4c</u>	43
14	<u>3d</u>	5	2	<u>4d</u>	60

In conclusion, the reductive coupling or dechlorination of α -haloketones using the active nickel complex⁸) can be effectively used for the syntheses of 1,4-diarylbutane-1,4-diones (2) and bicyclo[4.2.0]oct-3-ene-2,5-diones (4), which are useful intermediates in organic synthesis.

The following general procedure was used for the synthesis of $\overset{\curvearrowright}{4}$: a mixture of the photoadduct [$\overset{\curvearrowright}{3}$, prepared from $\overset{\curvearrowright}{5}$ (60 mmol)⁵⁾], $\text{NiBr}_2(\text{PPh}_3)_2$ (3 mmol), activated zinc (240 mmol), and Et_4NI (120 mmol) was evacuated and flushed with argon. Degassed THF (200 ml) was added and the mixture was stirred at room temperature for 1.5-2 h. Benzene (200 ml) was added to the reaction mixture, and the precipitate was collected and washed with benzene. The filtrate and washings were evaporated *in vacuo* and the residue was chromatographed on silica gel to give $\overset{\curvearrowright}{4}$.

References and Notes

- 1) P. W. Jolly, "Nickel Catalyzed Coupling of Organic Halides and Related Reactions", in "Comprehensive Organometallic Chemistry", ed by G. Wilkinson, Pergamon Press, Oxford (1982) Vol. 8, p 723.
- 2) P. W. Jolly and G. Wilke, "The Organic Chemistry of Nickel", Academic Press, New York and London (1974), Vol. 2, p 246; E. Yoshisato and S. Tsutsumi, *J. Chem. Soc., Chem. Commun.*, 1968, 33; I. Hashimoto, N. Tsuruta, M. Ryang, and S. Tsutsumi, *J. Org. Chem.*, 35, 3748 (1970).
- 3) a) M. Iyoda, M. Sakaitani, T. Miyazaki, and M. Oda, *Chem. Lett.*, 1984, 2005.
b) M. Iyoda, M. Sakaitani, H. Otsuka, and M. Oda, *ibid.*, 1985, 127.
c) M. Iyoda, K. Sato, and M. Oda, the preceeding paper.
- 4) A. S. Kende, L. S. Liebeskind, and D. M. Braitsch, *Tetrahedron Lett.*, 1975, 3375; M. Zembayashi, K. Tamao, J. Yoshida, and M. Kumada, *ibid.*, 1977, 4089; D. J. Pasto and D. K. Mitra, *J. Org. Chem.*, 47, 1381 (1982).
- 5) Photochemical [2+2]addition of 5,6-dichloro-2-cyclohexene-1,4-dione ($\overset{\curvearrowright}{5}$) to olefin was carried out in CH_2Cl_2 at 0 °C for 4-5 h. The crude photoadducts ($\overset{\curvearrowright}{4}$) were obtained as crystalline solids after removal of the solvents *in vacuo*. Since the photoadducts ($\overset{\curvearrowright}{4}$) decomposed slowly on standing at room temperature, $\overset{\curvearrowright}{4}$ was used for the nickel-catalyzed reactions without further purification.
- 6) J. Y. Savoie and P. Brassard, *Can. J. Chem.*, 44, 2869 (1966).
- 7) Synthesis of $\overset{\curvearrowright}{4a}$ and $\overset{\curvearrowright}{4c}$ was reported previously using oxidation of bicyclo[4.2.0]octane-2,5-diones with SeO_2 : M. Oda and Y. Kanao, *Chem. Lett.*, 1981, 37.
- 8) The active nickel complex generated *in situ* in the presence of Et_4NI is presumed to be distinct from $\text{Ni}(\text{PPh}_3)_4$ or $\text{Ni}(\text{PPh}_3)_3$. The electronic spectra of the active nickel complex showed the absorption maxima at 383 nm in THF and 388 nm in benzene (the reported absorption maximum in benzene^{3b)} was erroneously printed). ³¹P-NMR spectrum of the nickel complex showed a signal at upper field as compared with those of $\text{Ni}(\text{PPh}_3)_4$ and $\text{Ni}(\text{PPh}_3)_3$.

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