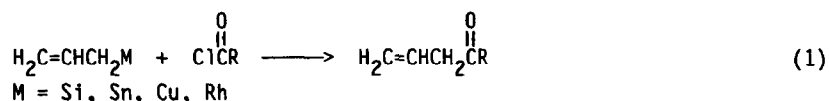


SYNTHESIS OF ALLYLIC KETONES VIA ACYLATION OF ALLYLIC MERCURIALS

Richard C. Larock* and Yong-de Lu
Department of Chemistry, Iowa State University, Ames, Iowa 50011

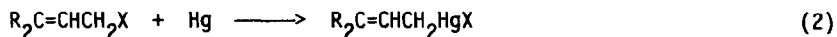
Summary. Allylic mercurials, readily available from allylic halides and mercury(0), react with acyl chlorides and AlCl_3 under mild reaction conditions to afford high yields of allylic ketones.

One valuable approach to allylic ketones involves the reaction of acyl halides and allylic organometallics of silicon,¹ tin,² copper³ or rhodium⁴ (eq. 1). Since these



organometallics are most commonly prepared from the corresponding alkali metal or magnesium compounds, little functionality in the allylic moiety can be accommodated by this process.

On the other hand, allylic mercurials are readily prepared from the appropriate allylic halide and mercury(0) (eq. 2).⁵ Since allylic chlorides and bromides are readily available,



but the corresponding iodides are relatively unstable and difficult to work with, though considerably more reactive towards mercury(0), we have modified previous literature procedures to obtain the desired allylic mercuric iodides. The appropriate allylic halide (10 mmol) was reacted with NaI (20 mmol) in THF (10 ml) for 2-8 hours (Time 1) and then mercury(0) (4 g) was added. The reactants were vigorously stirred for 4-24 hours (Time 2) under a nitrogen atmosphere before filtering through Celite to remove unreacted mercury(0), adding ether, washing with water and drying over anhydrous MgSO_4 (Procedure A). Removal of the solvent afforded essentially pure allylic mercurial which could be recrystallized from ethanol if need be. This procedure did not work well with all allylic halides, but a simplified procedure (Procedure B) which involves mixing all reagents together from the start and stirring the appropriate period of time at 0°C generally provided good yields (Entries 7-9). Some representative yields using these procedures are summarized in Table I. Note that a variety of substituted allylic chlorides, bromides or iodides can be employed successfully in this process and that ester groups and presumably many other functional groups can be readily accommodated (Entries 8 and 9).

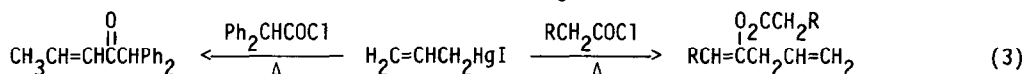
With a variety of allylic mercurials now in hand, we set out to examine their reaction with acyl halides. While alkyl,^{6,7} aryl,⁶⁻⁸ vinylic,⁹ allenic,¹⁰ propargylic¹⁰ and alkynyl¹¹

TABLE I. SYNTHESIS OF ALLYLIC MERCURIC IODIDES

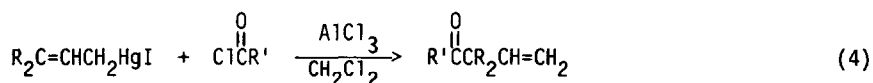
Entry	Allylic Halide	Procedure	Reaction Times (hours)		Allylic Mercuric Iodide	% Isolated Yield
			Time 1 ;	Time 2		
	$H_2C=CHCH_2X$				$H_2C=CHCH_2HgI$	
1	X = Cl	A	4 ;	24		78
2	X = Br	A	2 ;	8		92
3	X = I	a	- ;	4		98
4	$H_2C=C(CH_3)CH_2Cl$	A	8 ;	24	$H_2C=C(CH_3)CH_2HgI$	79
5	<i>E</i> - $CH_3CH=CHCH_2Br$	A	4 ;	24	<i>E</i> - $CH_3CH=CHCH_2HgI$	78
6	<i>E</i> - $PhCH=CHCH_2Br$	A	4 ;	24	<i>E</i> - $PhCH=CHCH_2HgI$	38 ^b
7	$(CH_3)_2C=CHCH_2Br$	B	6		$(CH_3)_2C=CHCH_2HgI$	44
8	<i>E</i> - $EtO_2CCH=CHCH_2Br$	B	3		<i>E</i> - $EtO_2CCH=CHCH_2HgI$	43
9	$H_2C=C(CO_2Et)CH_2Br$	B	1		$H_2C=C(CO_2Et)CH_2HgI$	47

^aCommercially available allyl iodide was used directly, omitting the sodium iodide step. ^bThe corresponding cinnamylmercuric bromide can be prepared in higher yield by shaking with mercury(0) for 15 minutes in 95% ethanol (see reference 5d).

mercurials undergo facile acylation by acyl halides either directly or preferably in the presence of aluminum halides or $Pd(PPh_3)_4$,¹² only the direct reaction of allylmercuric iodide and acyl halides has previously been examined¹³ and none of the anticipated allyl ketone was observed (eq. 3). Undaunted, we have examined the $AlCl_3$ -promoted acylation of allylic



mercurials under conditions very similar to those reported previously by us.^{9,10} We wish to report now that this affords a very useful new approach to allylic ketones, one which should accommodate considerable functionality (eq. 4). Our results are summarized in Table II.



Several points are noteworthy. First, allylic mercurials bearing a variety of substituents about the double bond all react readily, even when the double bond is in conjugation with an aromatic ring (Entry 9) or a carbonyl group (Entry 10). The reactions proceed in a matter of minutes at room temperature or temperatures as low as $-78^\circ C$. Considerable functionality should be accommodated by this reaction. All reactions proceed with allylic rearrangement, even when it means that the double bond is removed from conjugation. While allenic¹⁰ and vinylic⁹ mercurials react under similar conditions with aliphatic and α,β -unsaturated acyl chlorides, but not aromatic acyl chlorides, and propargylic¹⁰ mercurials only react well with aliphatic acyl chlorides, allylic mercurials give excellent yields with all three types of acyl chlorides. This affords a particularly

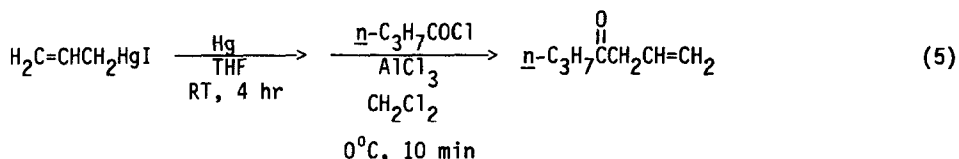
TABLE II. SYNTHESIS OF ALLYLIC KETONES

Entry	Allylic Mercurial	Acyl Chloride	Reaction Conditions ^a	Allylic Ketone	% Isolated Yield
1	$\text{H}_2\text{C}=\text{CHCH}_2\text{HgI}$	$\text{n-C}_3\text{H}_7\overset{\text{O}}{\parallel}\text{CCl}$	0°C, 10 min	$\text{n-C}_3\text{H}_7\overset{\text{O}}{\parallel}\text{CCH}_2\text{CH}=\text{CH}_2$	82
2		$(\text{CH}_3)_2\text{CH}\overset{\text{O}}{\parallel}\text{CCl}$	-78°C, 7 min	$(\text{CH}_3)_2\text{CH}\overset{\text{O}}{\parallel}\text{CCH}_2\text{CH}=\text{CH}_2$	84
3		$E\text{-CH}_3\text{CH}=\overset{\text{O}}{\parallel}\text{CCl}$	40°C, 4 min	$E\text{-CH}_3\text{CH}=\overset{\text{O}}{\parallel}\text{CCH}_2\text{CH}=\text{CH}_2$	97
4		$p\text{-CH}_3\text{OC}_6\text{H}_5\overset{\text{O}}{\parallel}\text{CCl}$	0°C, 10 min	$p\text{-CH}_3\text{OC}_6\text{H}_4\overset{\text{O}}{\parallel}\text{CCH}_2\text{CH}=\text{CH}_2$	90
5	$E\text{-CH}_3\text{CH}=\text{CHCH}_2\text{HgI}$	$\text{n-C}_3\text{H}_7\overset{\text{O}}{\parallel}\text{CCl}$	0°C, 20 min	$\text{n-C}_3\text{H}_7\overset{\text{O}}{\parallel}\text{CCH}(\text{CH}_3)\text{CH}=\text{CH}_2$	70
6	$(\text{CH}_3)_2\text{C}=\text{CHCH}_2\text{HgI}$	$\text{n-C}_3\text{H}_7\overset{\text{O}}{\parallel}\text{CCl}$	25°C, 6 min	$\text{n-C}_3\text{H}_7\overset{\text{O}}{\parallel}\text{C}-\overset{\text{CH}_3}{\underset{\text{CH}_3}{\text{C}}}-\text{CH}=\text{CH}_2$	86
7		$(\text{CH}_3)_2\text{CH}\overset{\text{O}}{\parallel}\text{CCl}$	-60°C, 15 min	$(\text{CH}_3)_2\text{CH}\overset{\text{O}}{\parallel}\text{C}-\overset{\text{CH}_3}{\underset{\text{CH}_3}{\text{C}}}-\text{CH}=\text{CH}_2$	93
8		$(\text{CH}_3)_2\text{C}=\overset{\text{O}}{\parallel}\text{CCl}$	-60°C, 15 min	$(\text{CH}_3)_2\text{C}=\overset{\text{O}}{\parallel}\text{C}-\overset{\text{CH}_3}{\underset{\text{CH}_3}{\text{C}}}-\text{CH}=\text{CH}_2$	96
9	$E\text{-PhCH}=\text{CHCH}_2\text{HgI}$	$\text{CH}_3\overset{\text{O}}{\parallel}\text{CCl}$	-78°C, 10 min	$\text{CH}_3\overset{\text{O}}{\parallel}\text{CCH}(\text{Ph})\text{CH}=\text{CH}_2$	82
10	$E\text{-EtOCCH}=\text{CHCH}_2\text{HgI}$	$\text{n-C}_3\text{H}_7\overset{\text{O}}{\parallel}\text{CCl}$	25°C, 10 min	$\text{n-C}_3\text{H}_7\overset{\text{O}}{\parallel}\text{CCH}(\text{CO}_2\text{Et})\text{CH}=\text{CH}_2$	89

^aAll reactions were run by adding 2 mmol of allylic mercurial dissolved in 10 ml of CH_2Cl_2 to 15 ml of CH_2Cl_2 containing 2.2 mmol of AlCl_3 and 2 mmol of acyl chloride. After the appropriate reaction time, the reaction was quenched with 5% aq. NaHCO_3 , washed with 3 M $\text{Na}_2\text{S}_2\text{O}_3$ and saturated aq. NaCl , dried, and the solvent removed.

convenient preparation of the naturally occurring monoterpene artemisia ketone (Entry 8).

One can simplify this overall process still further by employing the crude allylic mercurial obtained from the first step in the acylation step after a change of solvents. In this manner allylmercuric iodide has been converted to 1-hepten-4-one in an overall 78% yield (eq. 5).



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