THE PALLADIUM CATALYSED CROSS-COUPLING REACTION OF TRIETHYL (1-METHYLINDOL-2-YL)BORATE WITH PROPARGYL CARBONATE

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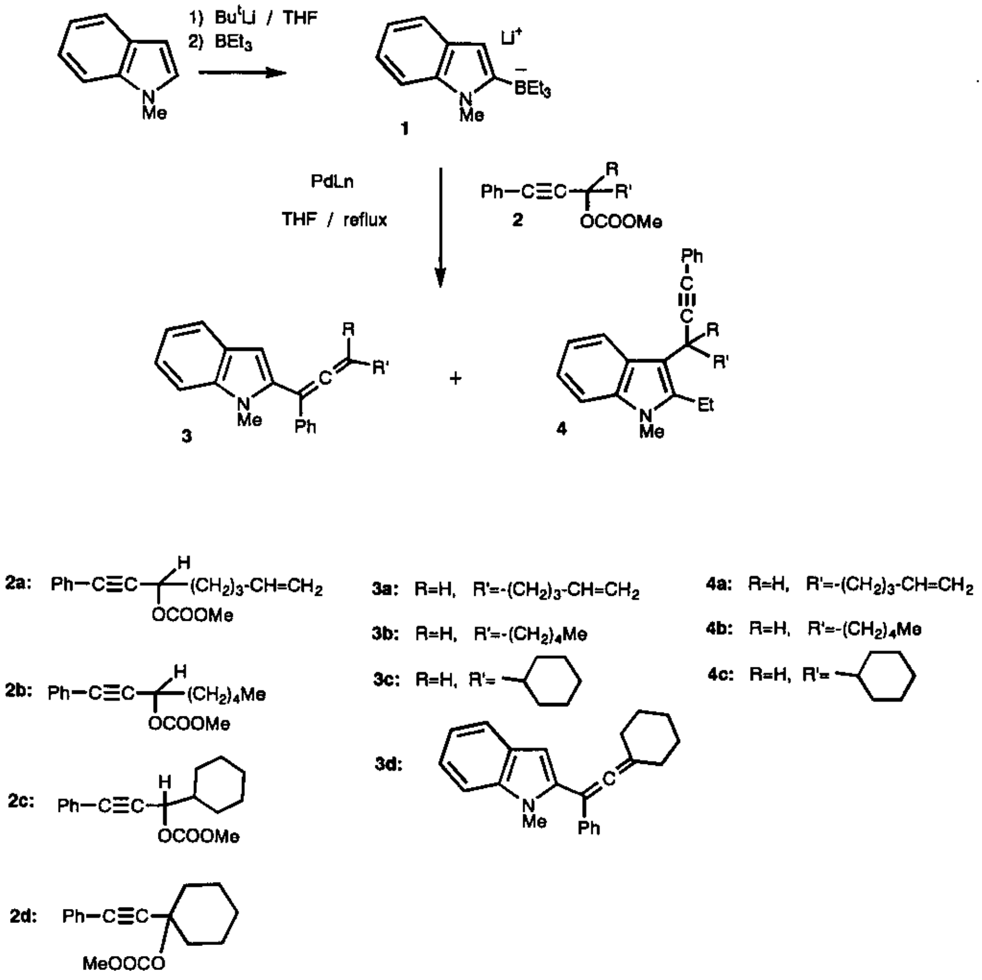
Abstract - The palladium catalysed cross-coupling reaction of triethyl (1-methylindol-2-yl)borate with propargyl carbonates could be used for a simple formation of 2-allenylindoles.

Palladium (0) complexes are known to attack propargyl halides or esters in a S_N2' type manner to form allenylpalladium complexes,[1] and their use for the transition metal catalysed cross-coupling reaction provides a simple access to allenic compounds.[2] In continuation of our ongoing studies of the palladium catalysed cross-coupling reaction with triethyl-2-indolylborate,[3] our further interest was drawn to the question as to whether the palladium catalysed reaction of triethyl (1-methylindol-2-yl)borate (**1**) with propargylic esters might be applicable for the formation of 2-allenylindoles. This paper describes our recent results of the palladium catalysed cross-coupling reaction of the indolylborate (**1**) with propargyl carbonates (**2**).

Thus, the reaction was simply carried out by heating a mixture of the borate (**1**) (generated *in situ* from 1-methylindole and *tert*-butyllithium, followed by treatment with triethylborane in THF), propargyl carbonate (**2**) (1.5 equiv.), and palladium complex (5 mol%) in THF under an argon atmosphere at 60°C for 30 min, providing allenylindole (**3**) and/or propargylindole (**4**) after treatment with alkaline hydrogen peroxide (Scheme 1). The reaction could not be effected in the absence of the palladium catalyst. Table represents the marked dependency of the product distribution of **3** and **4** on the nature of the palladium catalyst used. The use of $Pd_2(dba)_3{\cdot}CHCl_3$ solely produces allenylindole (**3**), otherwise triphenylphosphine ligated palladium catalysts are prone to form propargylindoles (**4**).



Scheme 1

The intervention of the equilibrium of allenylpalladium complex (**A**) and propargylpalladium complex (**B**) seems to be responsible for the observed results, as shown in Scheme 2. The complex (**A**), formed by the attack of palladium complex to propargyl carbonate (**2**) in a S_N2' manner,[2] could lead to allenylindole (**3**) through the transmetalation with the borate (**1**), followed by the reductive elimination process. The triphenylphosphine ligated palladium complex is likely to induce the elimination of the carbonate group in a SN2 manner to form the complex (**B**).[4] Reaction of the complex (**B**) with the borate (**1**), accompanying simultaneous alkyl migration, produces propargylindole (**4**) after treatment with alkaline hydrogen peroxide. Sole formation of **3d** from the carbonate (**2d**) and the borate (**1**) even in the presence of the triphenylphosphine ligated palladium complex could be accounted in terms of the steric crowding .

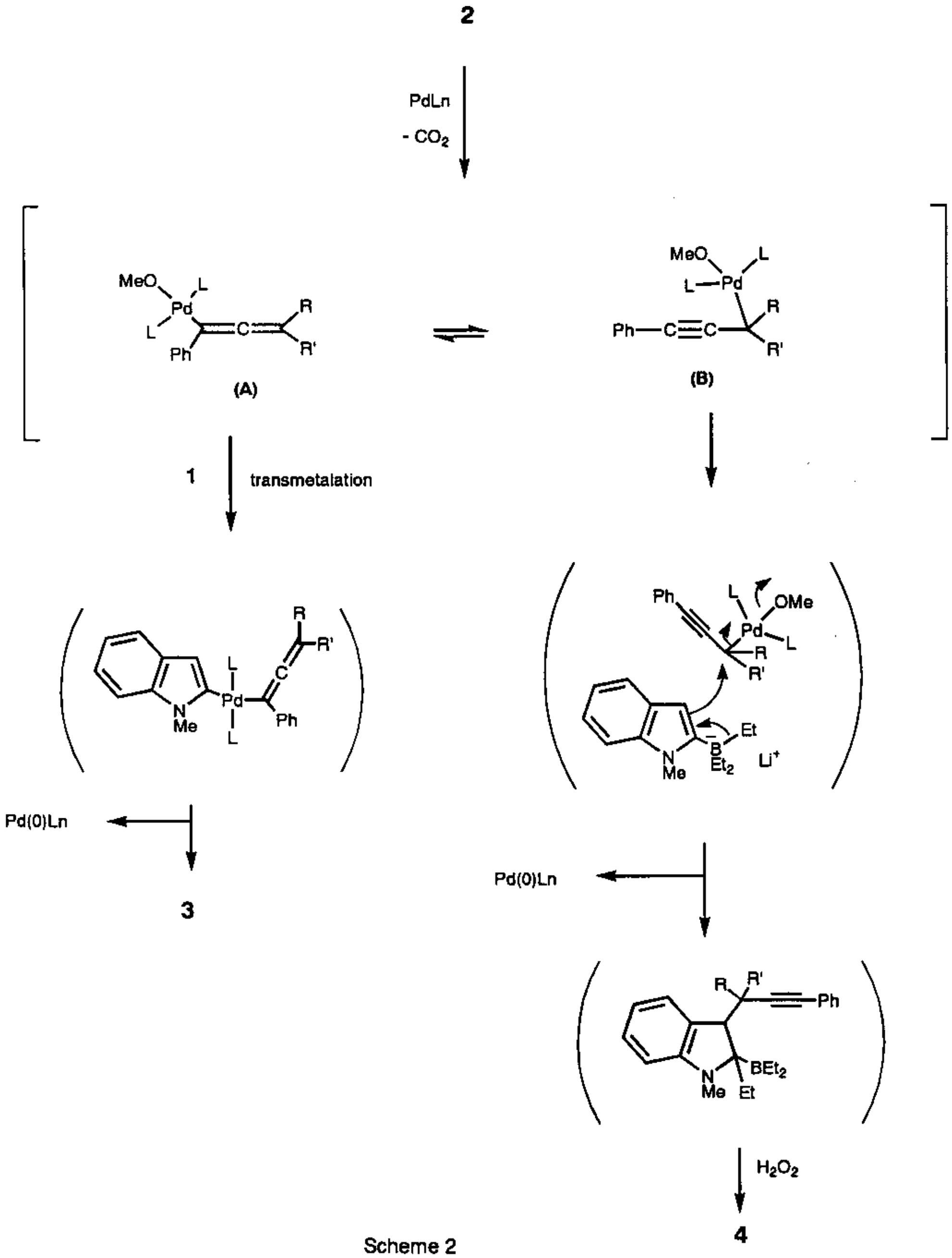
Table The palladium catalysed cross-coupling reaction of indolylborate (**1**) with propargyl carbonate (**2**)

		Yields [a]	
2	PdLn	**3**	**4**
2a	$Pd_2(dba)_3$•$CHCl_3$	30% (**3a**)	
	$PdCl_2(PPh_3)_2$	8% (**3a**)	36% (**4a**)
	$Pd_2(dba)_3$•$CHCl_3$ + 8PPh_3		60% (**4a**)
	$Pd(PPh_3)_4$		62% (**4a**)
2b	$Pd_2(dba)_3$•$CHCl_3$	47% (**3b**)	
	$PdCl_2(PPh_3)_2$	16% (**3b**)	31% (**4b**)
	$Pd_2(dba)_3$•$CHCl_3$ + 8PPh_3		63% (**4b**)
	$Pd(PPh_3)_4$		60% (**4b**)
2c	$Pd_2(dba)_3$•$CHCl_3$	60% (**3c**)	
	$PdCl_2(PPh_3)_2$	41% (**3c**)	5% (**4c**)
	$Pd_2(dba)_3$•$CHCl_3$ + 8PPh_3		27% (**4c**)
	$Pd(PPh_3)_4$		30% (**4c**)
2d	$Pd_2(dba)_3$•$CHCl_3$	65% (**3d**)	
	$PdCl_2(PPh_3)_2$	63% (**3d**)	
	$Pd_2(dba)_3$•$CHCl_3$ + 8PPh_3	63% (**3d**)	
	$Pd(PPh_3)_4$	64% (**3d**)	

[a] All yields are based on 1-methylindole.

In summary, the palladium catalysed cross-coupling reaction of indolylborate (**1**) with propargyl carbonate (**2**) afforded 2-allenylindole (**3**) and the observed dependency of the reaction mode on the nature of the palladium catalyst used is also notable.

Further studies designed to probe the present results in greater detail, including the mechanistic consideration, are in progress.



Scheme 2

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Received, 17th April, 1996