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Novel Reductive Coupling of Aldimines to Vicinal Diamines

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Abstract - Reductive coupling of aldimines into vicinal diamines has been performed by the action of aluminium/bismuth powder and potassium hydroxide in methanol at ambient temperature in high yields.

The reductive dimerisation of aldehydes or ketones leading to vicinal diols or olefins is promoted by a variety of reductants including low-valent transition metals¹. Similar reactions involving carbon-nitrogen functions are less investigated. Despite the frequent occurrence of vicinal diamine units in natural proudets and medicinal agents², only a few methods are available for their synthesis³. Apparently, the reductive dimerisation of imine is a straightforward route to vicinal diamines. The reagents employed for the formation of vicinal diamines are SmI2⁴, sodium⁵, zirconium⁶ aluminium⁷ and readily available zinc⁸. But these methods have their own merits as well as limitations, as the majority of these rely on olefin addition reaction that require several steps to arrive at the desired diamino products⁹. The carbon-carbon bond forming routes to diamines are especially rare and are typically limited to the synthesis of N,N-disubstituted amines¹⁰. Recently a few results have been reported, the reductive dimerisation of N-methylbenzyl imine with titanium (O)¹¹, the expensive niobium (IV) promoted dimerisation of N-trimethylsilylimines¹² and reductive coupling of aldimines by Indium metal¹³.

As a part of our ongoing studies on metal catalysts¹⁴, we report here a novel rapid one-pot procedure for the reductive coupling of aldimines using inexpensive reagents, aluminium powder and potassium hydroxide. The reaction is very fast with aluminium and gives the corresponding vicinal diamines within (8-15) minutes in excellent yields. This new reductive dimerisation system couples with ease a wide variety of aldimines 1 directly to the corresponding vicinal diamines 2 and there was no evidence for the formation of any carbon-nitrogen bond reduced products¹¹ of the type 3. When aluminium is replaced by bismuth the coupling proceeds effectively and the products were obtained in almost comparable yields. In most cases the reaction is over within few minutes with aluminium, however the reaction takes longer period of time (3-6) hrs with bismuth powder.



In a typical procedure, benzylidine aniline (1.81g,10 mmol) was dissolved in methanol (10 ml). Aluminium powder¹⁵ (0.26g, 10 mmol) and potassium hydroxide (1.68g, 30 mmol) were added and the reaction mixture was stirred at room temperature. The reaction became vigorous immediately after the addition of KOH. The progress of the reaction was monitored by the absence of starting material by TLC. After 10 min. the reaction mixture was filtered to remove the aluminium powder and water (40 ml) was added to the filtrate. It was then extracted with chloroform (3x20 ml), dried over anhydrous sodium sulphate, concentrated under reduced pressure to afford 1,2-dianilino,1,2-diphenyl ethane 2a in 90% yields exclusively. The reaction with bismuth was carried out in the same way and the corresponding diamines were obtained in (55-75)% yields (Table). No significant change in dl:meso ratio was observed when the molar ratio of RCH=N-R':Al:KOH was increased to 1:2:6 or 1:3:9. Interestingly, ketimine Ph(CH₃)C=N-Ph did not afford any detectable amount of dimers even after stirring for 20 h or heating to reflux with 1:1:3 or 1:2:6 equivalent of Al:KOH for 10 h, showing selectivity for the coupling of aldimines.

In conclusion, the present new method has many advantages over other methods as it is a very fast

reaction, the vicinal diamines were obtained in excellent yields and is completely devoid of side products. Moreover, optically pure derivatives of 2 have considerable potential in asymmetric synthesis as evidenced by recent reports⁸. Further, aluminium has the advantage of being readily available, inexpensive, stable, easy to handle and nontoxic.

Pro-	Aldimines		React.	React.	%Yield	%Yield ^b
duct	R	R'	time	time	(dl:meso)	(dl:meso) ^c
2			Al/min	Bi/hr.	Al	Bi
a	Ph	Ph	10	3	90(70:30)	75(55:45)
ь	Ph	Ме	8	5	85(80:20)	70(60:40)
с	4Cl-C6H4	Ph	15	4	86(75:25)	72(65:35)
d	4MeO-C ₆ H4	Ph	15	5	80(70:30)	70(55:45)
e	Ph	Me-C ₆ H4	10	3	83(80:20)	65(60:40)
f	2Cl-C6H4	Ph	10	4	78(60:40)	70(55:45)
g		Ме	10	5	75(70:30)	70(55:45)
ħ	Me	n-Pr	12	4	70(75:25)	65(70:30)
i	Ме	CH2-C6H5	10	5	72(80:20)	70(80:20)
j	c-C6H11	Ме	15	5	65(70:30)	55(60:40)
k	Ph	CH2-C6H5	15	5	75(85:15)	70(70:30)
I	€	Ме	12	6	75 (75:25)	70(70:30)

Table : Reductive coupling of aldimines with Al/Bi-KOH^a.

aCarried out in the manner as described in the text unless otherwise noted.

^bIsolated yields, spectral data are in agreement with the structure.

^c Ratio of dl:meso as calculated from ¹H or ¹³C NMR.

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- 15. Aluminium powder 99+%-325 mesh (packed under argon) was used and procured from Sisco Research Laboratories Pvt. Ltd., Bombay, India.

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