CHEMISTRY LETTERS, pp. 1965-1968, 1991.

Reactions of Aryliminodimagnesium with Some N,N-Dimethylcarboxamides and Benzonitriles Affording Various Types of Amidines. Correction of Previous Results on Formamidine Formation from N,N-Dimethylformamide [1)]

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Some symmetrical and unsymmetrical form- and benzamidines were prepared by the reaction of $ArN(MgBr)_2$ with Ar'CN, $HCONMe_2$ and related compounds in tetrahydrofurn.

Usefulness of aryliminodimagnesium ($ArN(MgBr)_2$, IDMg), derived from anilines in tetrahydrofuran (THF), has been established as shown by the condensation ability with aromatic carbonyl and nitro compounds to afford >C=N-Ar and -N(O)=N-Ar type products. Introduction of nitrogen functionality using IDMg is extended to formation of various type of amidines in the reactions with carboxamides and benzonitriles (Schemes A-E), and is described in this communication.

$$\mathbf{ArN(MgBr)_2} \; + \; \mathbf{H\text{-}CO\text{-}NMe_2} \longrightarrow \mathbf{ArNH\text{-}CH\text{=}N\text{-}Ar} \qquad \text{(A)}$$

[1 : 4] **1**

(62-100% for Ar=p-MeO, Me, H, F, Cl)

For reaction A, three (M. O., M. T., K. M.) of the present authors reported that addition of nitrobenzenes ($Ar'NO_2$) is required to mediate single electron transfer (SET) from IDMg to N,N-dimethylformamide (DMF: two molecules per Mg atom being used).[2)] This description[2)] has to be revised since reaction A was proved to proceed in later experiments without addition of $Ar'NO_2$; the erroneous description arose from failure in the detection of formamidine **1**. In the presence of p-substituted $Ar'NO_2$, formation of **1** competes with that of unsymmetrical azoxy and azo compounds (see Ref. 1), whereas crowded 2,4,6-$Me_3C_6H_2NO_2$ ($MesNO_2$) is completely recovered and **1** is solely formed. When $Ar'NO_2$ is absent, the yield of **1** in the reaction with p-$MeOC_6H_4$-IDMg (for 1 h) is affected by temperature in an interesting manner: [yield /%, temp /℃] = [58, 55], [59, 20], [100, 10], [72, 0], [29, -40], suggesting participation of equilibrium between the reactants or between reactant and the precusor of **1**. This feature concerns that of D, and comparison of mode of A with that of E (and/or F) is given later.

IDMg + **Ar^{1}CN** $\longrightarrow$ **Ar-N=C(Ar^1)-NH$_2$** (B)
[3 : 1] **2** (64-98%; Ar and Ar^1: p-MeO, Me, Cl)

Also for reaction B, an erroneous description was previously given.$^{2)}$ The fact that IDMg reacts with p-nitrobenzonitrile only at its nitro group to afford p-cyanoazoxy- and p-cynoazobenzenes$^{5)}$ was considered to arise from general inertness of CN group. However, p-R-benzonitriles (R= MeO, Me, Cl) without strongly electron-accepting nitro group$^{3)}$ are converted into N-monosubstituted benzamidines **2** in yields higher than that obtained by means of the conventional procedure using $AlCl_3$.$^{6)}$

IDMg + **H-C(OEt)$_2$NMe$_2$** $\longrightarrow$ **Ar-N=CH-NMe$_2$** (C)
[3 : 1] **3** (46-98% for Ar=p-MeO, Me, Cl)

IDMg + **H-CO-NMe$_2$** + **Ar^{1}COCl** $\longrightarrow$ **Ar-N=C(Ar^1)-NMe$_2$** (D)
[3 : 12 : 1] **4** (96% for Ar=Ar^1=p-Me)

Reaction C with DMF-diethylacetal (esterification reagent$^{7,8)}$) leads smoothly to unsymmetrical N,N-dimethyl-N'-arylformamidine (**3**) in good yields, whereas triethyl orthoformate is easily converted into N-arylformamide which is hardly converted further into the symmetrical formamidine **1**. Reaction A is modified into reaction D by means of stepwise addition of DMF and aroyl chloride into IDMg solution in THF: Unsymmetrical benzamidine **4** is formed in fair yield. The formyl-benzoyl exchange in D could be elucidated by the equilibrium suggested in A.

IDMg + **Me-CO-NMe$_2$** **(+ Ar'NO$_2$)** $\longrightarrow$ **Ar-N=C(Me)-NMe$_2$** (E)
[4.2 : 16.8 : 1] **5**
\+ **Me-CO-CH$_2$CONMe$_2$** (F)
6

Reaction E with N,N-dimethylacetamide (DMA) leads in limited cases to unsymmetrical acetamidine **5** accompanying azoxy product, and pathway of E is greatly affected by the substituents of IDMg and $Ar'NO_2$ additives (see Fig. 1). When DMA and p-Cl- or p-Me-$C_6H_4NO_2$ were added, p-ClC_6H_4-IDMg formed **5** (25%) whereas p-MeO and p-Me reagents caused "Claisen-like" self-condensation of DMA in both the absence and presence of $Ar'NO_2$ to give N,N-dimethylacetoacetamide (**6**; reaction F).$^{9)}$ The experiments of F in the absence and presence of $Ar'NO_2$ were carried out under conditions shown in Fig.

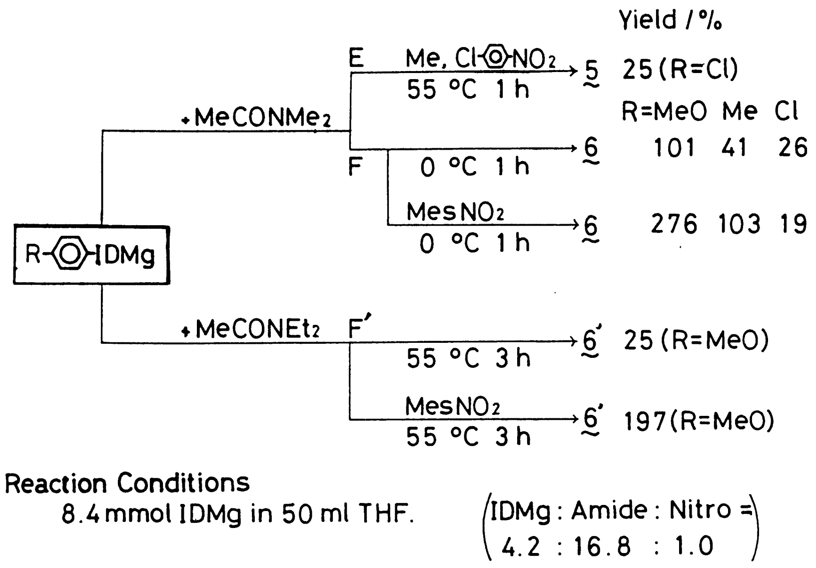

Fig.1.

1; the yields of **6**, calculated based on the amount of Ar'NO_2 (irrespective of its presence or absence), were compared for evaluation of its effect. Great improvement of yield of **6** (with use of p-MeO reagent) due to addition of MesNO_2 indicates that SET process, involved in F, is accelerated by the additive in a catalytic mediation manner (vide supra).

Great effect of bulkiness of not only acyl and amino moieties of carboxamides but also nitro additives on pathways of reactions A, E, and F is demonstrated by the three features. First, reaction mode of DMF having formyl moiety is distinguished from that of DMA having acetyl moiety (see Scheme A and Fig. 1). Second, the efficient reaction of DMF in reaction A is in contrast with low reactivity of N,N-diethylformamide giving no appreciable yield of **1** and also with inertness of N-phenyl- and N,N-dimethylbenzamides. Third, concerning pathway of F, N,N-diethylacetamide gave the corresponding acetoacetamide (**6'**; pathway F') in quite low yield, the yield being improved greatly by addition of crowded MesNO_2: Ordinary p-substituted Ar'NO_2 undergoes the known azoxy formation (see Ref. 1).

Irrespective of comparably strong "coordinating abilities" of DMF and DMA (evaluated by Gutmann's donor numbers (DN)[10]) and similar conditions of A and F, the components of A are bound efficiently to give **1** while the components of F dissociate (probably after SET) to give **6**. From comparison of the processes of coordination of acyl oxygen to Mg atom of IDMg (σ-complexation) accompanied by exchange of THF ligand, small formyl and bulky acetyl moieties of A and F lead to mutual and self-condensation, respectively; the tightness of σ-complexation depends on the bulkiness of acyl group. Bulkiness effect of added Ar'NO_2 on E and F reflects, similarly, the degree of its access to the proximity of ligand sphere.

IDMg is a weaker donor than ArMgBr,$^{4)}$ and the weak electron-accepting ability of DMF is evaluated by its negative reduction potential (E_{red}: -2.01 V)$^{3)}$ larger than that of ordinary p-substituted Ar'NO_2 (-1.25 — -1.51 V) and comparable to that of benzophenone (-1.99 V).$^{4,11)}$ The great structural effect of reactants on the present IDMg reactions with the weak acceptors, amides and nitriles, evokes the behavior of sterically crowded 2,3,5,6-Me_4-benzophenone: No SET takes place because σ-complexation is inhibited on the the treatment with IDMg while facile SET takes place on the treatment with PhMgBr$^{13)}$ (see "Less Reactive, More Selective" principle). Scope and limitations of reactions A-F, optimization of reaction conditions, and precise mechanism and characterization based on defined classification from unified structure-reactivity viewpoint (relative SET efficiency) of reactions of the magnesium reagents$^{12)}$ will be reported elsewhere. At present, the fact that IDMg procedure is extended to provide novel routes to synthetically useful amidines$^{14)}$ should be stressed.

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(Received June 25, 1991)