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1-OXA-2-MAGNESIACYCLOHEXANE

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In a novel ring cleavage reaction "Rieke-magnesium" and tetrahydrofuran at 100 °C yielded 1-oxa-2-magnesia cyclohexane (I) in up to 50% yield.

Normally, ethers are known to be rather unreactive, e.g. towards metals such as magnesium and towards organomagnesium compounds; because of their inertness and their basicity, they are the solvents of choice in the Grignard reaction.

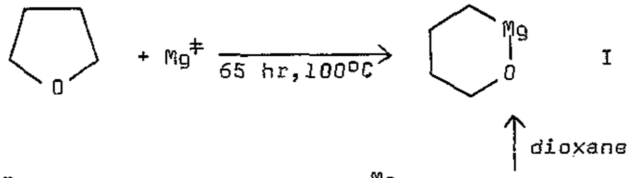
Rieke has described a procedure for the reduction of metal salts by potassium, by which a highly reactive form of the corresponding metal is obtained,[1] e.g.

$$MgBr_2 + 2K \xrightarrow[2\text{ hr, }65\ ^{o}C]{THF} Mg^{\ddagger} + 2\ KBr \qquad (1)$$

When performing this reaction under the usual conditions (2hr, 65 °C, THF)[1,2] we observed, that besides the usual black, voluminous precipitate of active magnesium $Mg^{\ddagger}$ and potassium bromide a clear, slightly yellow supernatant liquid was obtained which, according to acidic and complexometric titration, after hydrolysis, contained "basic" magnesium, (i.e. in the form of Mg-C or Mg-O) and no bromide, if the molar ratio of $MgBr_2$[3]: K was 1:2 ; the yield was 2% relative to potassium. Furthermore, this liquid gave a ^1H-NMR spectrum showing a triplet (δ = -0.30 ppm, J = 7 Hz) indicative of a $-CH_2-C\underline{H}_2-Mg-$ structural fragment.

Obviously, the organometallic compound must have been formed from THF, which was the only organic material introduced into the reaction. The yield could be increased to 50% under more drastic conditions, namely stirring at 100 °C for 65 hr; at higher temperatures decomposition occurred, presumably by attack of the organomagnesium compound on THF [4], as the NMR -spectrum afterwards showed the absorption of ethene at δ = 5.48 ppm.

Hydrolysis of solutions containing the new organomagnesium compound yielded n-butanol (> 90% yield relative to titrated Mg). Deuterolysis gave 4-D-n-butanol with approximately 80% D in position 4 [5]. From these data structure I may be deduced.



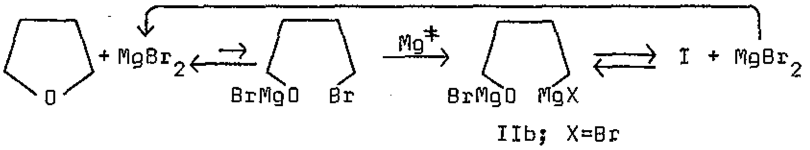
I (2)

$$HOCH_2CH_2CH_2CH_2Cl \xrightarrow[THF]{EtMgBr} BrMgOCH_2CH_2CH_2CH_2Cl \xrightarrow[40\ hr,50\ ^{o}C]{Mg} BrMgOCH_2CH_2CH_2CH_2MgX \quad (3)$$

IIa : X = Cl

Structure I was further corroborated by independent synthesis from IIa by precipitation of the magnesium salts with dioxane; IIa was obtained in 100% yield from 4-chloro-n-butanol by consecutive treatment with ethylmagnesium bromide and magnesium (eqn. 3).

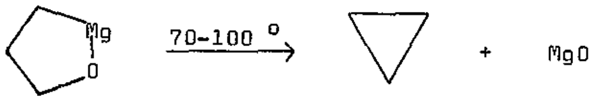
The mechanism of the remarkable formation of I from THF is not clear at the moment. Under identical conditions, neither potassium, nor magnesium, nor the 1:1 mixture of $Mg/MgBr_2$ (prepared by reacting 1 mole of 1,2-dibromoethane with 2 gramatoms magnesium in THF) gave rise to any observable cleavage of THF. When the black precipitate, prepared by Rieke's procedure [1] was washed with THF until no more material could be extracted, and the residue was heated with THF for 65 hr at 100 °C, again a clear solution was obtained containing 50% "basic" magnesium; moreover titration gave one gramatom of magnesium (EDTA titration) for two equivalents of "basic" magnesium (HCl titration). This latter experiment proves that processes involved in the reduction of $MgBr_2$ (e.g. of radical nature) are not responsible for the cleavage reaction; furthermore, it is very unlikely, that traces of $MgBr_2$, remaining after reduction and washing, play a catalytic role in a sequence such as depicted in equation 4:



(4)

Consequently, a direct Grignard-type reaction between the active metal and THF has to be considered as a serious possibility (eqn. 2), unlikely as it may seem at first sight. The only relevant precedent may be found in the cleavage of allyl phenyl ether by magnesium in boiling THF described by Maercker [6]. Obviously, THF shows much less functional resemblance to the alkyl halides of the normal Grignard reaction than allyl phenyl ether does; it may be for this reason that the highly active Rieke-magnesium as well as more drastic conditions are required in our case. Moreover, the occurrence of about 20% unlabeled n-butanol after deuterolysis (vide supra) may be due to radical side reactions well known in the formation of Grignard reagents [7].

As magnesium alkoxides are usually oligomeric in solution, it is likely that I is not monomeric either; in particular, III has been shown to be trimeric in THF [8]. It is not surprising that I is thermally much more stable than III; whereas the latter decomposes above 70 °C to form cyclopropane (eqn. 5), I is stable to 100-120 °C.



III

(5)

The mechanism of formation of I, the details of its structure and its equilibrium with IIb (cf. eqn. 4) will be the subject of further studies, as will be the synthetic utility of I, which - as a functionally substituted Grignard reagent - is so easily obtained from simple starting materials.

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REFERENCES

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2 All reactions involving organomagnesium compounds were performed in a fully sealed high vacuum system; cf. A.D. Vreugdenhil and C. Blomberg, Rec. Trav. Chim. Pays-Bas, 1963, 82, 453, 461.

3 $MgBr_2$ was obtained from high purity sublimed magnesium and 1,2-dibromoethane in THF; if ordinary Grignard grade magnesium turnings were used, the solution was brownish-yellow and the NMR signals less sharp, but yields were not essentially different.

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5 Determined from the NMR spectrum and, more accurately, by conversion with H_2SO_4 / HBr to 4-D-n-butyl bromide and mass spectroscopy of the latter.

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