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# COMPLEXES BETWEEN GRIGNARD REAGENTS AND KETONES

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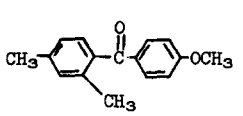
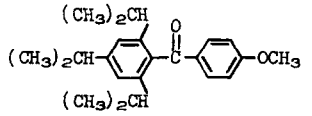
Complex formation between a carbonyl group and a Grignard reagent has frequently been invoked to explain the composition of precipitates,[1,2,3] the effect of magnesium bromide on relative rates of addition and reduction,[4] and the kinetics[5,6,7] of a Grignard reaction. Direct spectroscopic evidence has now been obtained for the occurrence of complexes between some diaryl ketones and methylmagnesium bromide in diethyl ether solvent.

2,4-Dimethyl-4'-methoxybenzophenone (I) at $5 \times 10^{-4}$ M in ether displays a strong absorption with $\lambda_{max}$ 274 mμ ($\epsilon$ $1.9 \times 10^4$). In the



I



II

presence of a filtered solution containing 0.01 to 0.22 M methylmagnesium bromide[8] in ether an additional absorption band is observed,

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[1] M. S. Kharasch and O. Reinmuth, Grignard Reactions of Non-metallic Substances, Prentice-Hall, Inc., New York, N. Y., 1954.

[2] P. Pfeiffer and H. Bland, J. Prackt. Chem. 2, 153, 242 (1939).

[3] H. Gilman and R. G. Jones, J. Am. Chem. Soc. 62, 1243 (1940).

[4] C. G. Swain and H. B. Boyles, ibid. 73, 870 (1951).

[5] J. Miller, G. Gregoriou and H. S. Mosher, ibid. 83, 3966 (1961).

[6] D. O. Cowan and H. S. Mosher, J. Org. Chem. 27, 1 (1962).

[7] M. Anteunis, ibid. 27, 596 (1962); 26, 4214 (1961).

[8] The concentration of the Grignard reagent in the cell was determined by titration of the base developed upon addition of excess ethanol and by iodine titration.

$\lambda_{max}$ 315 mμ, figure 1. Both the ketone band and the new band disappear rapidly at 25.0°, the rate of disappearance of the two bands being identical. The decrease in absorbance follows good first order kinetics[9] and is approximately first order in the concentration of the Grignard reagent. In preparative scale experiments an 85% yield of the olefin, b.p. 164-165° (1.3 mm.) derived from the elimination of water from the expected tertiary alcohol was obtained.

Reaction order has recently been employed as a measure of the composition of the transition state in reactions of Grignard reagents with ketones.[7,10] However, because of ambiguities regarding the nature[11] and state of aggregation[12] of Grignard reagents kinetic order is actually a poor guide to the number of molecules of Grignard reagent involved in the transition state.

The equilibrium between ketone, Grignard reagent, and complex indicated by the reaction kinetics in conveniently studied if the highly hindered ketone[13] II is employed since this substance reacts very slowly with methylmagnesium bromide in ether at 25°. As illustrated in figure 2,

$$\text{Ketone} + MgX_2 \underset{}{\overset{K}{\rightleftharpoons}} \text{Complex}$$

magnesium bromide, methylmagnesium bromide and dimethylmagnesium each give rise to a unique new absorption band with ketone II, the position of the absorption maximum occurring at 319, 313 and ca. 308 mμ, respectively. As expected,[11] addition of dimethylmagnesium and magnesium bromide curves does not reproduce the absorption spectrum obtained in the presence of methylmagnesium bromide.

The concentration of complex and free ketone at various concentrations

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[9]The low concentration of ketone apparently avoids the kinetic complications noted by Bikales and Becker[10] in the reaction of benzophenone with methylmagnesium bromide in tetrahydrofuran.

[10]N. M. Bikales and E. I. Becker, Chem. and Ind. 1831 (1961).

[11](a) R. E. Dessy, G. S. Handler, J. H. Wotiz and C. A. Hollingsworth, J. Am. Chem. Soc. 79, 3476 (1957); (b) R. E. Dessy and G. S. Handler, ibid. 80, 5824 (1958); (c) R. E. Dessy and R. B. Jones, J. Org. Chem. 24, 1685 (1955); (d) R. E. Dessy, ibid. 25, 2260 (1960).

[12]S. J. Storfer and E. I. Becker, J. Org. Chem. 27, 1868 (1962).

[13]R. C. Fuson and W. S. Friedlander, J. Am. Chem. Soc. 75, 5410 (1953).

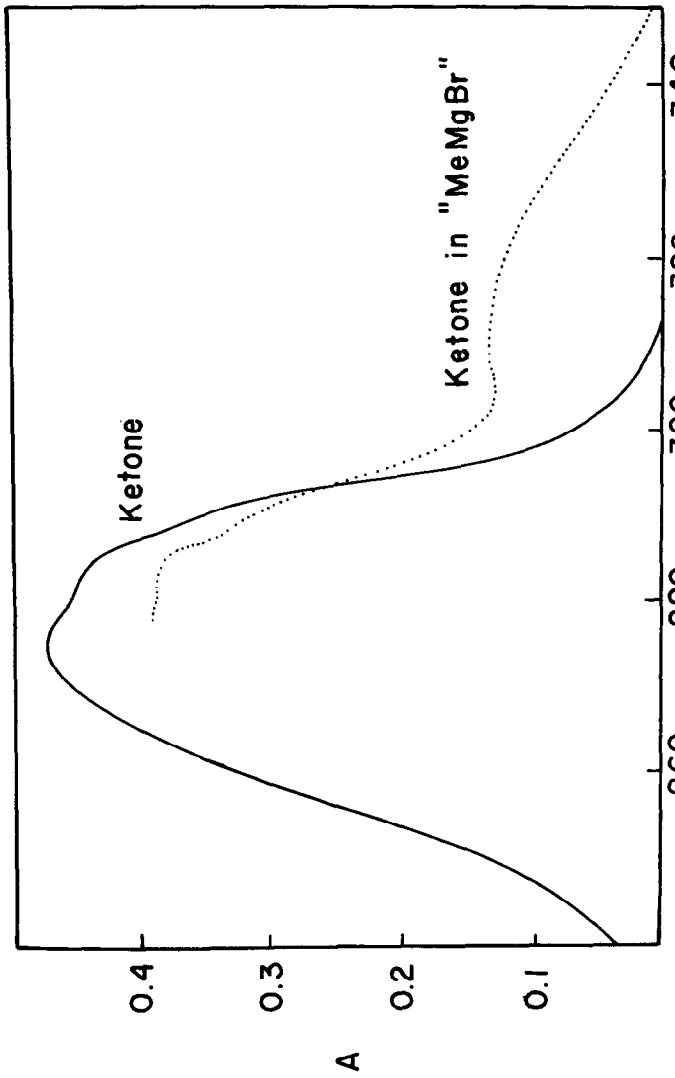


Fig.1.- Ultraviolet spectra of ketone I in (a) ether and (b) 0.062 *M* methylmagnesium bromide in ether.

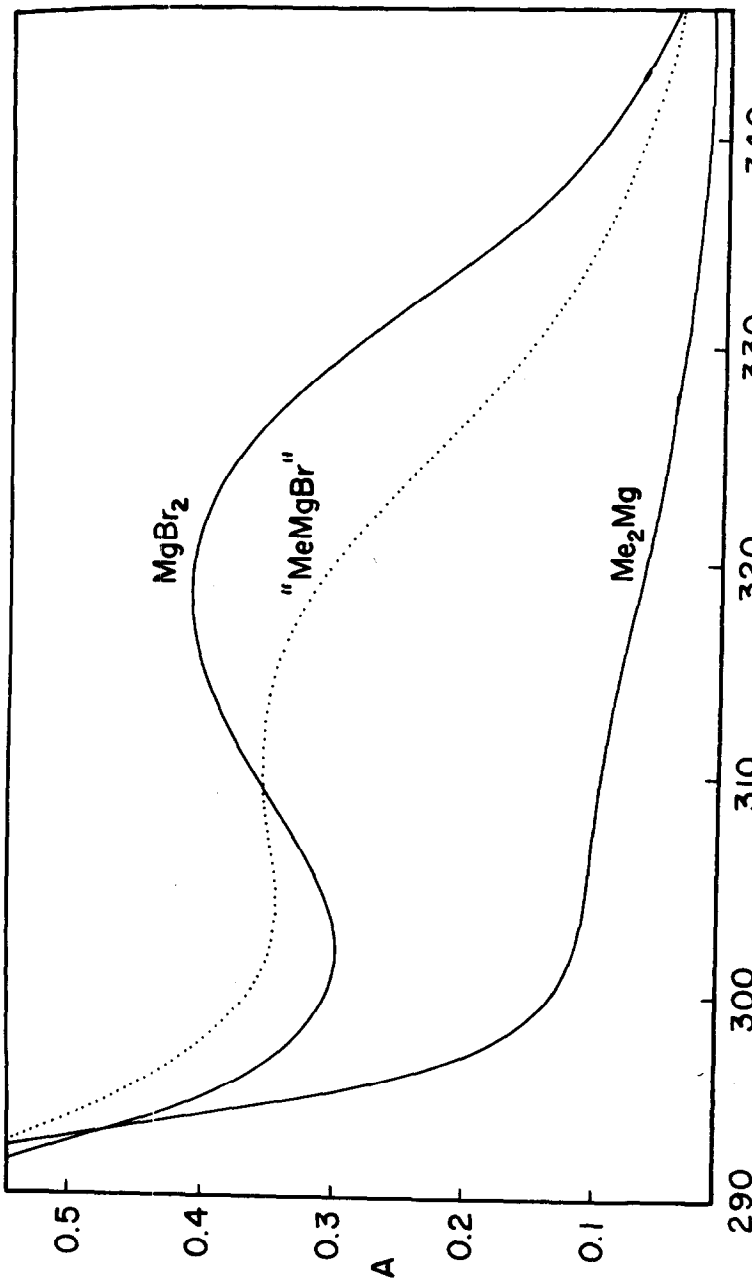


Fig.2.- Ultraviolet spectra of ketone II in (a) 0.07*M* $MgBr_2$, (b) 0.11 *M* "MeMgBr and (c) 0.057 *M* $Me_2Mg$

of magnesium bromide may be estimated from the absorption coefficient of the ketone and the total concentration of ketone assuming no additional interactions. Such data at various magnesium bromide concentrations are adequately described by a simple equilibrium constant,[14] K, as is illustrated in figure 3 and summarized in table I. Since solutions containing

TABLE I

| $MgX_2$ | Complex | | $K$ l/mole |
|---|---|---|---|
| | $\lambda_{max}$ | $\epsilon$ | |
| $MgBr_2$ | 319 | $2.44 \times 10^4$ | 6.5 |
| BeMgBr | 313 | a | 3.7 |
| $Me_2Mg$ | ca. 308 | a | 1.3 |

[a]Assumed to be $2.44 \times 10^4$.

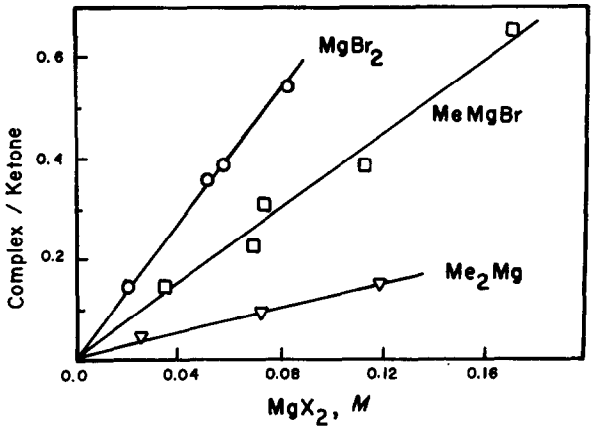


Fig. 3. Plot of the ratio of the concentration of complex to ketone vs. concentration of various magnesium compounds for ketone II in ether at 25.0°.

[14]E. T. McBee, O. R. Pierce and D. D. Meyer, ibid. 77, 83 (1955), have reported that acetone, propionaldehyde and ethyl acetate form 2:1 complexes with magnesium bromide in phenetole solvent.

either methylmagnesium bromide or dimethylmagnesium absorb strongly below about 280 mμ equilibrium constants for these magnesium derivatives could not be determined directly. However, assuming that Grignard and dimethylmagnesium complexes have the same absorption coefficient as the magnesium bromide complex the equilibrium constants summarized in table I may be calculated. These constants indicate that in the presence of 0.1 M methylmagnesium bromide 25% of the unreacted ketone is complexed with the Grignard reagent. The relationship between these complexes, the structure of the Grignard reagent, and the rate and nature of the products obtained in a typical Grignard reaction will be discussed in a subsequent publication.