

[CONTRIBUTION FROM THE SCHOOL OF CHEMISTRY AND PHYSICS OF THE PENNSYLVANIA STATE COLLEGE]

The Action of Primary Grignard Reagents with *t*-Butylacetyl Chloride. II¹

BY FRANK C. WHITMORE, J. S. WHITAKER, K. F. MATTIL AND A. H. POPKIN

This is a continuation of the studies in this Laboratory on the reducing action of Grignard reagents.²

In the first paper of this title¹ the acid chloride was added to excess of Grignard solutions. The chief products isolated were tertiary alcohols of the type $(\text{CH}_3)_3\text{CCH}_2\text{C}(\text{OH})\text{R}_2$ in which R was ethyl, *n*-propyl, *n*-butyl, or *n*-amyl, and the corresponding olefins $(\text{CH}_3)_3\text{CCH}=\text{CR}_2$ and their isomers. The other products were secondary carbinols of the type $(\text{CH}_3)_3\text{CCH}_2\text{CHOHR}$, in which R was *n*-propyl, *n*-butyl, or *n*-amyl. No reduction product of this type was found when ethylmagnesium bromide was used.

In the present study each of the four Grignard solutions was added to a slight excess of *t*-butylacetyl chloride in anhydrous ether.

Ethylmagnesium bromide gave the largest amount of the primary product, the ketone of the type $(\text{CH}_3)_3\text{CCH}_2\text{COR}$, giving about 51% of neopentyl ethyl ketone. The *n*-propyl, *n*-butyl, and *n*-amyl Grignard reagents gave 37, 34, and 29%, respectively, of the corresponding ketones.

Reduction by means of the Grignard reagent would convert these ketones to secondary carbinols $(\text{CH}_3)_3\text{CCH}_2\text{CHOHR}$. These would appear as the *t*-butylacetates. About 7% of such reduction took place with the ethyl Grignard solution. This is in contrast to the result of adding the acid chloride to the ethyl Grignard solution which gave no reduction.¹ The other three Grignard solutions gave about 20, 23, and 21% of the corresponding secondary alcohols as the *t*-butylacetates.

It is significant that these yields are nearly the same as those obtained by adding the acid chloride to an excess of the Grignard reagents.¹ As in the earlier experiments no trace of neopentylcarbinol or its ester was found even by extended searches. This is in contrast to the action of trimethylacetyl chloride which gives neopentyl alcohol in about 20% yields with *n*-propyl, *n*-butyl, and *n*-amyl Grignard reagents.²

A small amount of ethyl *t*-butylacetate was

(1) No. I, Whitmore, Popkin, Whitaker, Mattil and Zech, *THIS JOURNAL*, **60**, 2462 (1938).

(2) Whitmore and co-workers, *ibid.*, **60**, 2028, 2030, 2458, 2462, 2788 (1938).

found in each of the four reactions. This was due apparently to interaction of the acid chloride with the solvent ether.

The Grignard solutions used were filtered from free magnesium under nitrogen pressure.

Experimental

The *t*-butylacetyl chloride, b. p. 76–77° at 140 mm., n_D^{20} 1.4212, used in these reactions was prepared, in 86% yield, from *t*-butylacetic acid and thionyl chloride.

The Grignard compounds were prepared from the corresponding alkyl bromides, magnesium, and dry ether in the usual way. They were filtered and titrated.

Addition of Ethylmagnesium Bromide to *t*-Butylacetyl Chloride.—Ethylmagnesium bromide (1.84 moles in 1 liter of ether) was added to 250 g. (1.86 moles) of *t*-butylacetyl chloride in 1200 cc. of ether, during fifty minutes. After standing overnight, the complex was decomposed with ice, extracted with ether, and the products after removing most of the solvent using column XII³ were fractionated through column XI, using a solid carbon dioxide trap, to give: nos. 1–5, 71.4 g., b. p. 98–100° at 200 mm., n_D^{20} 1.4150–1.4163; residue 130 g.; trap contents 68 g. All fractions contained water, indicating dehydration.

The trap contents with nos. 1–5 were refractionated through column XI to give: 6, 27.5 g., 35° at 736 mm., 1.3580; 7, 1.4 g., 133°, 1.4060; 8–12, 46.5 g., 143°, 1.4150–1.4160. The main residue was added and fractionation continued to give: 13–22, 101.2 g., 62–110° at 23–74 mm., 1.4120–1.4163; 23–24, 14.5 g., 118° at 23 mm., 1.4253–1.4263; 25–27, 15.7 g., 118–135° at 23 mm., 1.4323–1.4500; residue 5 g.

Fractions 6–22, 25–27, and the residue were again refractionated, by parts, through column XI to give: 28–37, 123.2 g., 92° at 150 mm., 1.4130–1.4160; 38, 4.2 g., 105–134° at 150 mm., 1.4175; 39, 7.0 g., 134° at 150 mm., 1.4130; 40–43, 20.0 g., 124–166° at 90 mm., 1.4152–1.4500; residue 6.2 g.

Fraction 7, ethyl *t*-butylacetate, was saponified by aqueous potassium hydroxide to give ethyl alcohol, 3,5-dinitrobenzoate, m. p. and mixed m. p. 92°; and *t*-butylacetic acid, anilide, m. p. and mixed m. p. 130–131°.

Fractions 23, 24, and part of 25 represented a 7% yield of neopentylethylcarbonyl *t*-butylacetate. Alcoholic saponification gave neopentylethylcarbinol, previously reported,¹ b. p. 96° at 150 mm., n_D^{20} 1.4248, 3,5-dinitrobenzoate, m. p. and mixed m. p. 81–82°; and *t*-butylacetic acid, anilide m. p. and mixed m. p. 130–131°.

Fractions 28–37 represented a 51% yield of ethyl neopentyl ketone, m. p. and mixed m. p. of the dinitrophenylhydrazone 135–136°.

The high index of fraction 38 appeared to be due to the

(3) The fractionating columns used have been described: Whitmore, Popkin, Whitaker, Mattil and Zech, *ibid.*, **60**, 2459 (1938).

presence of diethylnepentylcarbinol or the corresponding olefins.¹

Fraction 39 contained *t*-butylacetic acid, m. p. and mixed m. p. of the anilide 130–131°.

All attempts to find neopentylcarbinol and neopentylcarbinyl *t*-butylacetate failed.

Addition of *n*-Propylmagnesium Bromide to *t*-Butylacetyl Chloride.—The addition of 1.85 moles of *n*-propylmagnesium bromide, in 1 liter of ether, to 260 g. (1.94 moles) of *t*-butylacetyl chloride in 600 cc. of ether, was completed in forty-five minutes. The complex stood overnight and the products were isolated as above to give: 1–18, 166.3 g., b. p. 20–98° at 11 mm., n_D^{20} 1.4078–1.4250–1.4147; 19–22, 45 g., 111–112° at 13 mm., 1.4272–1.4181; 23–25, 7.5 g., 121–128° at 13 mm., 1.4340–1.4442; residue 3.8 g.; trap contents 37 g.

The trap contents on removal of the ether yielded 5.7 g. of oil, n_D^{20} 1.3985. This oil together with 1–18 was fractionated by parts through column X to give: 26–29, 14.9 g., 95–102° at 150 mm., 1.4032–1.4085; 30, 5.9 g., 107° at 150 mm., 1.4100; 31–32, 13.1 g., 109.5°, 1.4132–1.4140; 33, 4.8 g., 99–108°, 1.4105; 34–44, 83.5 g., 108–110°, 1.4132–1.4153; 45–47, 15.2 g., 51–58° at 7 mm., 1.4161–1.4273; 48–49, 7.9 g., 64–74° at 7 mm., 1.4315–1.4228; 50–51, 16.7 g., 78°, 1.4135–1.4122; residue 1 g.

Fractions 26–29 were identified as ethyl *t*-butylacetate. Aqueous saponification gave ethyl alcohol, 3,5-dinitrobenzoate m. p. and mixed m. p. 92°; and *t*-butylacetic acid, anilide m. p. and mixed m. p. 130–131°.

Fractions 31–32 and 34–44 were identified as neopentyl *n*-propyl ketone, semicarbazone m. p. and mixed m. p.⁴ 93–94°, yield 36.7%.

Fractions 47–49 contained dodecenes, as previously reported,¹ obtained by dehydration of the tertiary alcohol.

Fractions 50–51 were *t*-butylacetic acid, anilide m. p. and mixed m. p. 130–131°.

Fractions 19–22 represented a 20% yield of neopentyl-*n*-propylcarbinyl *t*-butylacetate. Alcoholic saponification gave neopentyl-*n*-propylcarbinol,¹ b. p. 120–121° at 150 mm., n_D^{20} 1.4270, m. p. and mixed m. p. of phenylurethan 80–82°; and *t*-butylacetic acid, m. p. and mixed m. p. of anilide 130–131°.

All attempts to find neopentylcarbinol and neopentylcarbinyl *t*-butylacetate failed.

Addition of *n*-Butylmagnesium Bromide to *t*-Butylacetyl Chloride.—The addition of 2.01 moles of *n*-butylmagnesium bromide, in 1 l. of dry ether, to 292 g. (2.18 moles) of *t*-butylacetyl chloride, in 600 cc. of ether, was completed in eighty minutes. After standing overnight the products were isolated to give: 1–18, 173.6 g., b. p. 34° at 742 mm. to 59° at 4 mm., n_D^{20} 1.4070–1.4195; 19–23, 27.6 g., 68–95° at 4 mm., 1.4232–1.4415–1.4365; 24–29, 55.2 g., 98–99° at 4 mm., 1.4300–1.4315; 30, 6.1 g., 109° at 4 mm., 1.4430; residue 5.1 g.; trap contents 18.6 g.

The trap contents, on removal of ether, yielded 8.9 g. of oil. This and 1–18 were fractionated by parts through column X to give: 31–32, 2.7 g., 48–52° at 150 mm., 1.4332–1.4300; 33–38, 22.6 g., 63–102°, 1.4030–1.4098; 39–43, 38.6 g., 127°, 1.4192–1.4195; 44–49, 55.0 g., 126–

127°, 1.4182–1.4178; 50–53, 39.6 g., 130–134°, 1.4170–1.4150; 54–55, 8.0 g., 134–155° at 150 mm., 1.4270–1.4400; residue 2.0 g.

Fractions 33–38 were ethyl *t*-butylacetate.

Fractions 39–52 were identified as a mixture of neopentyl *n*-butyl ketone, m. p. and mixed m. p.⁵ of semicarbazone 82–84°, and *t*-butylacetic acid, anilide m. p. and mixed m. p. 130–131°; which contained 105.2 g. of the ketone and 28.0 g. of the acid, as determined from a composition—index of refraction curve. This represented a 34% yield of neopentyl *n*-butyl ketone.

The index of refraction of 20–23 corresponded to tetradecenes.¹

Fractions 24–29 with part of fraction 23 represented a 23% yield of neopentyl-*n*-butylcarbinyl *t*-butylacetate. Alcoholic saponification gave neopentyl-*n*-butylcarbinol,¹ b. p. 92° at 100 mm., n_D^{20} 1.4295–1.4305, phenylurethan m. p. and mixed m. p. 84–85°; and *t*-butylacetic acid, anilide m. p. and mixed m. p. 130–131°.

All attempts to identify neopentylcarbinol and its *t*-butylacetate failed.

Addition of *n*-Amylmagnesium Bromide to *t*-Butylacetyl Chloride.—Addition of 1.9 moles of *n*-amyl Grignard solution to 271 g. (2 moles) of *t*-butylacetyl chloride in fifty minutes as above gave: 1–16, 161.7 g., 67–145° at 150 mm., n_D^{20} 1.4240–1.4090–1.4235; 17–18, 21.8 g., 128–132° at 20 mm., 1.4342–1.4450; 19–22, 42.3 g., 133–144°, 1.4450; 23–27, 54.1 g., 146–147°, 1.4332–1.4350; 28, 7.1 g., 147°, 1.4412; residue 3 g.; trap contents 91 g.

The trap contents with fractions 1–17 gave: 29–30, 9.8 g., 65–90° at 150 mm., 1.4370–1.4210; 31–34, 45.1 g., 90–103°, 1.4060–1.4080; 35–42, 44.6 g., 103–134°, 1.4160–1.4140; 43–52, 76.3 g., 122–138°, 1.4212–1.4280; residue 1 g.

Fractions 31–34 were identified as ethyl *t*-butylacetate.

Fractions 35–42 were largely *t*-butylacetic acid, anilide m. p. and mixed m. p. 130–131°. The other component was identified as neopentyl *n*-amyl ketone, semicarbazone m. p. and mixed m. p. 99–102°.¹

Fractions 43–52 were largely neopentyl *n*-amyl ketone. This together with an estimate from fractions 35–42 represented a 29% yield of this ketone.

Fractions 19–22 were hexadecenes.¹

Fractions 23–27 represented a 21% yield of neopentyl-*n*-amylcarbinyl *t*-butylacetate. Alcoholic saponification of 26–27 gave neopentyl-*n*-amylcarbinol,¹ b. p. 132° at 100 mm., n_D^{20} 1.4340–1.4347, phenylurethan m. p. and mixed m. p. 62–63°; and *t*-butylacetic acid, anilide m. p. and mixed m. p. 130–131°.

All attempts to identify neopentylcarbinol and its *t*-butylacetate failed.

Preparation of Neopentylcarbinyl *t*-Butylacetate.—A solution of 0.8 mole of neopentylmagnesium chloride was prepared from neopentyl chloride, b. p. 82° at 740 mm., n_D^{20} 1.4042. An excess of dry formaldehyde, generated by heating dry paraformaldehyde, was passed into the solution during four hours. The complex was decomposed with ice and 30% H₂SO₄ and fractionated through column X to give 48 g. (0.47 mole) of neopentylcarbinol, b. p. 140–146° at 739 mm., n_D^{20} 1.4120–1.4034.

(4) This ketone and the semicarbazone prepared by H. C. Crafton, Jr., of this Laboratory.

(5) Unpublished work of E. Rohrmann, this Laboratory.

