535. *The Preparation of Capillin and Some Related Compounds, and of Some Substituted Pent-4-en-2-yn-1-ones*

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1-Phenylhexa-2,4-diyn-1-ol (I; R = Ph, R′ = Me) has been prepared from 1-phenylprop-2-yn-1-ol and 1-bromopropyne by the method of Chodkiewicz [1] and oxidised to capillin (1-phenylhexa-2,4-diyn-1-one) (II; R = Ph; R′ = Me) by manganese dioxide. Several other diacetylenic ketones have been similarly prepared. The scope and limitations of the coupling reaction are discussed. Some ethynyl carbinols have been prepared in good yield from ethynylmagnesium bromide in tetrahydrofuran.

Pent-4-en-2-yn-1-ols (III) have been prepared by condensing aldehydes with Grignard reagents derived from 1- and 2-substituted but-1-en-3-ynes (IV) and have been oxidised, usually with manganese dioxide, to the corresponding ketones (V). A convenient synthesis of 2-methylpent-2-en-4-yne is described. The oxidation of sensitive acetylenic alcohols to ketones by " nickel peroxide " is reported.

Capillin (II; R = Ph, R′ = Me) was isolated from *Artemisia capillaris Thunb.* at the Sankyo Company, Tokyo [2] in 1956 and shown to have powerful antifungal properties. The structure was later confirmed by synthesis from 1,4-dichlorobut-2-yne; [3a] the alcohol was obtained in 28% yield and oxidised to the ketone. A later synthesis [4] starts from the Grignard reagent derived from penta-1,3-diyne.

$$\underset{\text{(I)}}{RCH(OH)\cdot[C{:}C]_2R'} \qquad \underset{\text{(II)}}{RCO\cdot[C{:}C]_2R'}$$

Neither of these syntheses was suitable for larger-scale preparation of capillin and of similar compounds containing functional groups. We applied Chodkiewicz's method [1] of preparing diacetylenes to 1-phenylprop-2-yn-1-ol and 1-bromopropyne [5] and obtained 1-phenylhexa-2,4-diyn-1-ol in 83% yield. The alcohol was oxidised to capillin in more than 90% yield by active manganese dioxide [6] in chloroform or ethyl acetate.

$$PhCH(OH)\cdot C{:}CH + BrC{:}CMe \xrightarrow[EtNH_2]{CuCl} PhCH(OH)\cdot[C{:}C]_2Me$$

Capillin proved to be too irritant for topical use, so we prepared the carbinols enumerated in Table 1 and oxidised them to the corresponding ketones [the ketone (II; R = $HO_2C\cdot C_6H_4(p)$, R′ = Me) was not obtained pure], but none proved suitable for topical use * because of instability, irritancy, or reduced antifungal activity.

The coupling reaction mentioned can also be applied to terminal acetylenes containing functional groups different from hydroxyl (a tertiary aromatic amino-compound and a carboxylic acid both reacted satisfactorily), but 1-phenylprop-2-yn-1-one and 1-(*N*-acetylindol-3-yl)prop-2-yn-1-ol did not react. 1-Bromo-3-(*NN*-dimethylamino)-3-methylbut-1-yne coupled in 93% yield with 1-phenylprop-2-yn-1-ol.

* An account of the antifungal activity of these and other acetylenic compounds is being prepared by Monica J. Marshall, P. W. Muggleton *et al.* for publication elsewhere.

[1] W. Chodkiewicz, *Ann. Chim.* (*France*), 1957, 852.
[2] K. Tanaka, I. Iwai, Y. Okajima, and T. Konotsune, *Antibiotics and Chemotherapy*, 1959, **9**, 151.
[3] (*a*) K. Imai, N. Ikeda, K. Tanaka, and S. Sagawara, *J. Pharm. Soc. Japan*, 1956, **76**, 405 (*Chem. Abs.*, 1956, **50**, 10,340; (*b*) I. Iwai and T. Konotsune, Jap. P. 17,027, 17, 206 (*Chem. Abs.*, 1961, **55**, 18,687, 18,684).
[4] B. P. Gusev and V. F. Kucherov, *Izvest. Akad. Nauk S.S.S.R., Otdel. khim. Nauk*, 1963, 517 (*Chem. Abs.*, 1963, **59**, 3800).
[5] F. F. Cleveland and M. J. Murray, *J. Chem. Phys.*, 1943, **11**, 451.
[6] J. Attenburrow, A. F. A. Cameron, J. H. Chapman, R. M. Evans, B. A. Hems, A. B. A. Jansen, and T. Walker, *J.*, 1952, 1094.

TABLE 1

Substituted hexa-2,4-diyn-1-ols (I) RCH(OH)·[C:C]$_2$R′

R	R′	R	R′
Ph	Me	C_4H_3S(2-)	Me
ClC_6H_4(*p*)	Me	$Me_2N{\cdot}C_6H_4$(*p*)	Me
$MeO{\cdot}C_6H_4$(*p*)	Me	Ph	$C(NMe_2)Me_2$
Ph	Ph	$HO_2C{\cdot}C_6H_4$(*p*)	Me
$C_{10}H_7$(1-)	Me	Me	Ph
C_4H_3O(2-)	Me		

Ketones (II) in which R′ = Ph are less stable than those in which R′ is an aliphatic group.

Most of the aryl ethynyl carbinols used in our work were prepared by treating ethynylmagnesium bromide with aldehydes in tetrahydrofuran. This route is much more satisfactory than that from sodium acetylide in liquid ammonia.

We also prepared for biological testing some compounds similar in structure to capillin, but having a double bond instead of the triple bond remote from the carbonyl group. This triple bond does not lend itself to selective reduction, so we prepared the carbinols (III) in Table 2, and oxidised them to the corresponding ketones, as indicated below:

$$\underset{\text{(IV)}}{HC{:}C{\cdot}CR'{:}CR''R'''} \xrightarrow{EtMgBr} BrMgC{:}C{\cdot}CR'{:}CR''R''' \xrightarrow{RCHO} \underset{\text{(III)}}{RCH(OH){\cdot}C{:}C{\cdot}CR'{:}CR''R'''} \longrightarrow \underset{\text{(V)}}{RCO{\cdot}C{:}C{\cdot}CR'{:}CR''R'''}$$

$$\underset{\text{(VI)}}{HC{:}C{\cdot}CH{:}CMe_2}$$

The substituted butenynes chosen were styrylacetylene, pent-2-en-4-yne, 2-methylpent-2-en-4-yne, and the commercially available 2-methylbut-1-en-3-yne. 2-Methylpent-2-en-4-yne (VI) was prepared in 11% yield by Mondon [7] from 2-methylpent-4-yn-2-ol by repeated distillation from potassium hydrogen sulphate. We have dehydrated the same carbinol in 61% yield by the action of phosphoryl chloride in pyridine.

All the carbinols were cleanly oxidised to ketones by manganese dioxide except 1-(2-furyl)hex-4-en-2-yn-1-ol (III; R = C_4H_3O, R′ = R″ = H, R‴ = Me), which was evidently attacked in the furan ring. However, " nickel peroxide " [8] in benzene gave a pure product in 74% yield. We have also satisfactorily oxidised other unsaturated alcohols in the same manner, including 1-phenylhex-4-en-1-yn-3-ol and 1-(2-furyl)but-2-yn-1-ol.

The ketones corresponding to the carbinols enumerated in Table 2 are powerful antifungal agents *in vitro*, but are unsuitable for topical application.

TABLE 2

Pent-4-en-2-yn-1-ols (III), RCH(OH)·C:C·CR′:CR″R‴

R	R′	R″	R‴	R	R′	R″	R‴
Et	H	H	Ph	Ph	Me	H	H
Ph	H	H	Me	C_4H_3O(2-)	H	H	Me
Ph	H	Me	Me	C_4H_3S(2-)	H	H	Me
Ph	H	H	Ph	C_4H_3S(2-)	H	Me	Me

EXPERIMENTAL

Thin-layer chromatography was carried out on " Kieselgel " plates in benzene–ethyl acetate (usually 10 : 1). Plates were sprayed with Brady's reagent for ketones (orange or red spots) and with 1% $SbCl_3$ in ethanol for alcohols (grey spots) and heated for 5 min. at *ca.* 100°. Melting points are corrected. Ultraviolet spectra were measured in ethanol. Urethanes were crystallised from light petroleum (b. p. 80—100°).

1-*Bromopropyne*.—Propyne (research grade, Farchan Laboratories) was passed through a

[7] A. Mondon, *Annalen*, 1952, **577**, 181.
[8] K. Nakagawa, R. Konaka, and T. Nakata, *J. Org. Chem.*, 1962, **27**, 1597.

little water, then through two 250-ml. Dreschel bottles fitted with fine, sintered-glass filter-discs at the bottom of the gas inlets. Each bottle contained half a solution made at 0° from 85% potassium hydroxide (88 g.), water (400 ml.), and bromine (17·5 ml.); the second led to a U-tube immersed in ice–water, and finally to a low-temperature condenser. When propyne began to condense (*ca.* 100 min.), the aqueous layer was removed from the bottles and the colourless lower layer (13·0 g.) was washed with water and dried ($MgSO_4$). Bromopropyne so prepared was pure enough for use; distillation in nitrogen gave 10·0 g., b. p. 64·5°/750 mm. (lit.,[5] b. p. 64·5°/750 mm.). An aged sample ignited spontaneously in air.

1-*Bromo*-3-(NN-*dimethylamino*)-3-*methylbut*-1-*yne*.—Bromine (8·75 ml.) was added to 85% potassium hydroxide (44 g.) in water (200 ml.) at 0°, followed by 3-(*NN*-dimethylamino)but-1-yne [9] (2·3 g.); the mixture was shaken for 2 hr. The solid was recrystallised from ethanol to give 1-*bromo*-3-(NN-*dimethylamino*)-3-*methylbut*-1-*yne* as long needles (3·2 g., 81%), m. p. 160—162° (sublimes) (Found: C, 44·6; H, 6·5; Br, 42·4; N, 7·3. $C_7H_{12}BrN$ requires C, 44·2; H, 6·4; Br, 42·0; N, 7·4%).

1-(p-*Dimethylaminophenyl*)*prop*-2-*yn*-1-*ol*.—*p*-Dimethylaminobenzaldehyde (20·0 g.) in tetrahydrofuran (20 ml.) was added dropwise to a stirred solution of ethynylmagnesium bromide (prepared from magnesium, 4·9 g.) in tetrahydrofuran (200 ml.), and the mixture worked up in the usual way after 1 hr. to give an oil, which crystallised when treated with hexane at 0°. Recrystallisation from benzene–hexane gave the *carbinol*, photosensitive needles (17·1 g., 73%), m. p. 71·5—72° (Found: C, 75·2; H, 7·4; N, 8·2. $C_{11}H_{13}NO$ requires C, 75·2; H, 7·5; N, 8·0%).

The following carbinols were similarly prepared: 1-(N-*acetylindol*-3-*yl*)*prop*-2-*yn*-1-*ol* (80%), m. p. 110—111° (from ethyl acetate) (Found: C, 73·1; H, 5·3; N, 6·3. $C_{13}H_{11}NO_2$ requires C, 73·2; H, 5·2; N, 6·6%); 1-(p-*cyanophenyl*)*prop*-2-*yn*-1-*ol* (88%), m. p. 81—83° (from benzene) (Found: C, 76·4; H, 4·8; N, 8·7. $C_{10}H_7NO$ requires C, 76·4; H, 4·5; N, 8·9%); 1-(α-*naphthyl*)*prop*-2-*yn*-1-*ol* (49%), b. p. 174—178°/2 mm., m. p. 61—63° (from benzene–light petroleum) (Found: C, 85·8; H, 5·7. $C_{13}H_{10}O$ requires C, 85·7; H, 5·5%).

p-(1-*Hydroxyprop*-2-*ynyl*)*benzamide*.—1-(*p*-Cyanophenyl)prop-2-yn-1-ol (14·4 g.) was stirred with 4% aqueous hydrogen peroxide (420 ml.) in acetone (290 ml.) at 40—50°, and 40% sodium hydroxide solution (4·3 ml.) was added. After 5 hr. at 50° the solution was concentrated below 40° and left at 0° overnight. The solid was washed with water, and the residual amide (13·6 g., 85%) had m. p. 128—134°. Recrystallisation from water gave short *needles*, m. p. 138—140°, $\lambda_{max.}$ 233 mμ (ε 14,000) (Found: C, 68·8; H, 5·4; N, 7·7. $C_{10}H_9NO$ requires C, 68·5; H, 5·2; N, 8·0%).

1-(p-*Carboxyphenyl*)*prop*-2-*yn*-1-*ol*.—The preceding compound (10·7 g.) in 2N-hydrochloric acid (140 ml.) was treated at 0—5° with sodium nitrite (11·0 g.). The filtered solution at 0° slowly deposited the crude acid (6·95 g., 67%). Three crystallisations from water gave pale yellow *prisms*, m. p. 163°, $\lambda_{max.}$ 234 mμ (ε 16,300) (Found: C, 68·3; H, 4·8; $C_{10}H_8O_3$ requires C, 68·2; H, 4·6%).

1-*Phenylhexa*-2,4-*diyn*-1-*ol*.—1-Phenylprop-2-yn-1-ol (2·64 g.) in methanol (25 ml.) was stirred with cuprous chloride (40 mg.) and 33% (w/v) aqueous ethylamine (5·6 ml.) at 16°, then 1-bromopropyne (2·38 g.) in methanol (10 ml.) was slowly added (15 min.) at 20—22°. A little powdered hydroxylamine hydrochloride was added as required to discharge the blue colour. After 15 min. more, potassium cyanide (100 mg.) in water (2 ml.) was added, then more water (25 ml.), and the product was isolated with the aid of ether, giving a pale yellow solid. This crystallised from 50% ethanol (20 ml.) giving 1-phenylhexa-2,4-diyn-1-ol (2·16 g., 62%), m. p. 87·5—88° (lit.,[3a] m. p. 86°), $\lambda_{max.}$ 241·5, 256 mμ (ε 858, 612). This compound resembled the alcohol prepared by the method of Imai *et al.*[3a] in liquid ammonia (infrared spectrum and mixed m. p.). In a 20-g. experiment the yield of alcohol, m. p. 87—88° (from benzene–hexane), was 83%.

The following carbinols were prepared similarly; an asterisk denotes that dioxan was added to dissolve a methanol-insoluble copper complex. 1-*p*-Chlorophenylhexa-2,4-diyn-1-ol * (90%), needles, m. p. 73—74° (from aqueous ethanol) [α-*naphthylurethane*, m. p. 146° (decomp.); (Found: C, 73·8; H, 4·3; Cl, 9·2; N, 3·7. $C_{23}H_{16}ClNO_2$ requires C, 74·0; H, 4·3; Cl, 9·5; N, 3·7%)]; 1-*p*-methoxyphenylhexa-2,4-diyn-1-ol * (84%), needles, m. p. 50—53° (from hexane) [α-*naphthylurethane*, m. p. 127° (decomp.) (Found: C, 77·7; H, 5·4; N, 3·95.

[9] G. F. Hennion, J. J. Sheehan, and D. E. Maloney, *J. Amer. Chem. Soc.*, 1950, **72**, 3542; G. F. Hennion and K. W. Nelson, *ibid.*, 1957, **79**, 2142.

$C_{24}H_{19}NO_3$ requires C, 78·0; H, 5·2; N, 3·8%)]; 1,5-diphenylpenta-2,4-diyn-1-ol (68%), photosensitive needles, m. p. 84—86° (from hexane) [α-*naphthylurethane*, m. p. 144° (decomp.) (Found: C, 83·6; H, 4·9; N, 3·55. $C_{28}H_{19}NO_2$ requires C, 83·8; H, 4·8; N, 3·5%)]; 1-(1-naphthyl)hexa-2,4-diyn-1-ol * (87%), needles, m. p. 85—86° (from xylene–light petroleum) (lit.,[3b] m. p. 87°); 1-(*2-furyl*)*hexa*-2,4-*diyn*-1-*ol* (71% after chromatography on alumina), *needles*, m. p. 64—66° (from benzene–light petroleum) (Found: C, 74·8; H, 5·1. $C_{10}H_8O_2$ requires C, 75·0; H, 5·0%); 1-(2-thienyl)hexa-2,4-diyn-1-ol (60% after chromatography on silica gel), pale orange oil [α-*naphthylurethane*, m. p. 114° (Found: C, 73·4; H, 4·9; N, 3·95. $C_{21}H_{15}NO_2S$ requires C, 73·0; H, 4·4; N, 4·1%)]; 1-p-*dimethylaminophenylhexa*-2,4-*diyn*-1-*ol* (63%), needles, m. p. 110—111° (from aqueous ethanol) (Found: C, 78·6; H, 7·3; N, 6·8. $C_{14}H_{15}NO$ requires C, 78·8; H, 7·1; N, 6·6%); 1-*phenyl*-6-(NN-*dimethylamino*)-6-*methylhepta*-2,4-*diyn*-1-*ol* (93%), needles, m. p. 137° (from aqueous ethanol) (Found: C, 79·7; H, 8·0; N, 5·7. $C_{16}H_{19}NO$ requires C, 79·6; H, 7·9; N, 5·8%); 1-p-*carboxyphenylhexa*-2,4-*diyn*-1-*ol* (78%, isolated by acidification of the ether-washed, basified reaction mixture), needles, m. p. 159—161° (from aqueous ethanol), $\lambda_{max.}$ 235 mμ (ε 24,400) (Found: C, 73·1; H, 4·9. $C_{13}H_{10}O_3$ requires C, 72·9; H, 4·7%); 1-*phenylhexa*-1,3-*diyn*-5-*ol* (50%, after chromatography on silica), needles, m. p. 32—34° (from benzene) (Found: C, 84·4; H, 6·05. $C_{12}H_{10}O$ requires C, 84·7; H, 5·9%).

1-*Phenylhexa*-2,4-*diyn*-1-*one* (*Capillin*).—1-Phenylhexa-2,4-diyn-1-ol (1·00 g.) in chloroform (100 ml.) was stirred for 2½ hr. with freshly powdered manganese dioxide [6] (10 g.) at room temperature. The oxidation was followed by thin-layer chromatography. The manganese dioxide was filtered off and washed with chloroform, and the filtrate and washings were evaporated under reduced pressure. Recrystallisation of the residue from hexane (10 ml.) gave capillin (760 mg., 76%) as clusters of pale cream needles, m. p. 82·5—83·5° (lit.,[3a] m. p. 81°), $\lambda_{max.}$ 265—266, 279, 295 mμ (ε 15,700, 18,100, 14,500). The 2,4-dinitrophenylhydrazone (orange needles from ethanol containing a little ethyl acetate) had m. p. 225° (decomp.) (Found: C, 62·1; H, 3·5; N, 16·0; O, 18·5. Calc. for $C_{18}H_{12}N_4O_4$: C, 62·1; H, 3·5; N, 16·0; O, 18·5%). From a 20-g. oxidation in ethyl acetate the yield of capillin, m. p. 81—82°, was 92%.

The following ketones were similarly prepared in chloroform; oxidation was for the time specified. 1-p-*Chlorophenylhexa*-2,4-*diyn*-1-*one* (20 min., 54%), needles, m. p. 125—126° (decomp.) (from hexane), $\lambda_{max.}$ 283, 300 mμ (ε 20,900, 18,700) (Found: C, 70·6; H, 3·1; Cl, 17·4. $C_{12}H_7ClO$ requires C, 71·1; H, 3·45; Cl, 17·5%) [2,4-*dinitrophenylhydrazone* (orange needles from ethyl acetate), m. p. 210° (decomp.) (Found: C, 56·9; H, 2·9; Cl, 9·2. $C_{18}H_{11}ClN_4O_4$ requires C, 56·6; H, 2·9; Cl, 9·3%)]; 1-*p*-methoxyphenylhexa-2,4-diyn-1-one (45 min., 60%), needles, m. p. 114—115° (from hexane), $\lambda_{max.}$ 314—316 mμ (ε 17,600) [2,4-*dinitrophenylhydrazone* (orange-red needles from ethyl acetate), m. p. 220° (decomp.) (Found: C, 60·0; H, 3·8; N, 14·8. $C_{19}H_{14}N_4O_5$ requires C, 60·3; H, 3·7; N, 14·8%)]; 1,5-diphenylpenta-2,4-diyn-1-one (3 hr., 35%) pale brown needles which rapidly darkened, m. p. 38—39° (from aqueous methanol), $\lambda_{max.}$ 269, 315, 336 mμ (ε 5410, 3780, 3400) [2,4-*dinitrophenylhydrazone* (deep orange needles from ethanol containing a little ethyl acetate), m. p. 225° (decomp.) (Found: C, 67·0; H, 3·45; N, 13·55. $C_{23}H_{14}N_4O_4$ requires C, 67·3; H, 3·4; N, 13·7%)]; 1-(1-naphthyl)hexa-2,4-diyn-1-one (3 hr., 54%) m. p. 95—95·5° (from aqueous ethanol) (lit.,[3b] m. p. 94—94·5°), $\lambda_{max.}$ 252·5—256·5, 290, 350 mμ (ε 6800, 2960, 6010); 1-(*2-furyl*)*hexa*-2,4-*diyn*-1-*one* (30 min. in acetone, 92%) needles, m. p. 75—77° (from light petroleum, b. p. 60—80°), $\lambda_{max.}$ 310 mμ (ε 21,330) (Found: C, 76·0; H, 3·9. $C_{10}H_6O_2$ requires C, 75·9; H, 3·8%); 1-(2-thienyl)hexa-2,4-diyn-1-one (2 hr., 95%), pale brown needles which rapidly darkened, m. p. *ca.* 60° [2,4-*dinitrophenylhydrazone* (dark red needles from ethyl acetate), m. p. 208° (decomp.) (Found: C, 54·6; H, 3·05; N, 15·6; S, 8·6. $C_{16}H_{10}N_4O_4S$ requires C, 54·2; H, 2·85; N, 15·8; S, 9·0%)]; 1-p-*dimethylaminohexa*-2,4-*diyn*-1-*one* (1 hr., 89%), orange needles (from ethanol), m. p. 134—136°, $\lambda_{max.}$ 255, 289, 310 mμ (ε 13,870, 5180, 1960) (Found: C, 79·4; H, 6·1; N, 6·3. $C_{14}H_{13}NO$ requires C, 79·6; H, 6·1; N, 6·6%), which did not react with methyl iodide; 1-*phenyl*-6-(NN-*dimethylamino*)-6-*methylhepta*-2,4-*diyn*-1-*one* (1 hr., 90%) needles, m. p. 33—35° (from light petroleum, b. p. 80—100°), $\lambda_{max.}$ 269, 281, 305 mμ (ε 17,090, 19,210, 12,750) (Found: C, 80·1; H, 7·3; N, 5·8. $C_{16}H_{17}NO$ requires C, 80·3; H, 7·2; N, 5·85%), which formed a *methiodide* [prepared in 50% yield by refluxing the ketone (1 g.) in ether (10 ml.) with methyl iodide (2 ml.) for 30 min.], m. p. 200—202° (decomp.) (Found: C, 53·3; H, 5·4; I, 33·4; N, 3·7. $C_{17}H_{20}INO$ requires C, 53·55; H, 5·3; I, 33·3; N, 3·7%), and a *methochloride* [prepared in 29% yield by heating the ketone with methyl chloride and ether in a sealed tube at 90° for 40 hr.], m. p.

209—211° (decomp.) (from ethanol–ethyl acetate) (Found: C, 70·3; H, 7·0; Cl, 12·2; N, 4·7. $C_{17}H_{20}ClNO$ requires C, 70·45; H, 7·0; Cl, 12·2; N, 4·8%); 6-phenylhexa-3,5-diyn-2-one (30 min., 93%) colourless crystals, m. p. *ca.* 45°, which became almost black on exposure to air for <1 min. [2,4-*dinitrophenylhydrazone* (orange needles from ethanol containing a little ethyl acetate), m. p. 170° (decomp.) (Found: C, 61·9; H, 3·6; N, 15·8. $C_{18}H_{12}N_4O_4$ requires C, 62·1; H, 3·4; N, 16·1%)].

2-*Methylpent*-2-*en*-4-*yne*.—2-Methylpent-4-yn-2-ol [10] (9·8 g.) in pyridine (20 ml.) was stirred and cooled, and phosphoryl chloride (7 ml.) in pyridine (7 ml.) was added at <20° during 45 min. The mixture was stirred for 15 min. more, than gradually warmed, and finally distilled, giving the crude hydrocarbon (7·05 g.). This was mixed with the crude hydrocarbon from a similar run and redistilled, giving 2-methylpent-2-en-4-yne (9·2 g., 61%), b. p. 70—71° (lit.,[8] b. p. 73—75°). The *mercury derivative* had m. p. 64·5—65° (from ethanol) (Found: C, 40·3; H, 4·0. $C_{12}H_{14}Hg$ requires C, 40·2; H, 3·9%).

1-*Phenylhex*-4-*en*-2-*yn*-1-*ol*.—Pent-2-en-4-yne [11] (3·30 g.) in ether (6 ml.) was added dropwise at room temperature, with stirring, to ethylmagnesium bromide prepared from magnesium (1·2 g.). The mixture was stirred for 1 hr. more, left overnight, and refluxed for 1 hr., then cooled to 20°. Benzaldehyde (5·30 g.) in ether (10 ml.) was added to the stirred mixture, and stirring continued for 1 hr.; then saturated ammonium chloride solution was added at 5—10°. The mixture was worked up to give an oil (7·15 g.). Distillation gave the pale yellow carbinol (5·1 g., 60%), b. p. 112—114°/0·4 mm., n_D^{20} 1·5689; this contained a trace of benzaldehyde (i.r. spectrum). The α-*naphthylurethane* had m. p. 96—100° (Found: C, 80·85; H, 5·9; N, 4·0. $C_{23}H_{19}NO_2$ requires C, 80·9; H, 5·6; N, 4·1%).

The following compounds were similarly prepared. 7-Phenylhept-6-en-4-yn-3-ol (from styrylacetylene [12]) (44%), b. p. 150—157°/0·1 mm., n_D^{20} 1·5988, $\lambda_{max.}$ 284 mμ (ε 28,200) [α-*naphthylurethane*, m. p. 112—114° (Found: C, 80·7; H, 6·1; N, 4·2. $C_{24}H_{21}NO_2$ requires C, 81·1; H, 6·0; N, 3·9%)]; 5-methyl-1-phenylhex-4-en-2-yn-1-ol (77%, after chromatography on alumina), pale yellow oil, which could not be distilled n_D^{20} 1·5580, $\lambda_{max.}$ 231 mμ (ε 13,800); 1,5-*diphenylpent*-4-*en*-2-*yn*-1-*ol* (69%, after chromatography on alumina), m. p. 60—61° (from ether–hexane), $\lambda_{max.}$ 221·5, 228—229, 280—283, 305 mμ (ε 15,000, 11,300, 19,200, 14,300) (Found: C, 87·1; H, 6·6. $C_{17}H_{14}O$ requires C, 87·1, H, 6·0%); 4-methyl-1-phenylpent-4-en-2-yn-1-ol (with Mr. M. V. Burge) (85%), b. p. 120° (bath)/0·1 mm., n_D^{24} 1·5493 [α-*naphthylurethane*, m. p. 113—114° (Found: C, 80·8; H, 5·7; N, 3·8. $C_{23}H_{19}NO_2$ requires C, 80·9; H, 5·6; N, 4·1%)]; 1-(2-furyl)hex-4-en-2-yn-1-ol (with Mr. M. V. Burge) (74%), b. p. 120° (bath)/0·2 mm., n_D^{24} 1·5305 [α-*naphthylurethane*, m. p. 92—96° (Found: C, 76·0; H, 5·1; N, 4·3. $C_{21}H_{17}NO_3$ requires C, 76·1; H, 5·2; N, 4·2%)]; 1-(2-*thienyl*)*hex*-4-*en*-2-*yn*-1-*ol* (with Mr. M. V. Burge) (73%, based on aldehyde; 2 equiv. of Grignard reagent were used), b. p. 102—104°/0·1 mm., n_D^{24} 1·5800 (Found: C, 67·7; H, 5·7; S, 17·4. $C_{10}H_{10}OS$ requires C, 67·4; H, 5·7; S, 17·9%); 5-*methyl*-1-(2-*thienyl*)*hex*-4-*en*-2-*yn*-1-*ol* (49%), b. p. 120° (bath)/0·2 mm., n_D^{18} 1·5757, $\lambda_{max.}$ 234—236 mμ (ε 17,300) (Found: S, 16·4. $C_{11}H_{12}OS$ requires S, 16·7%).

1-*Phenylhex*-4-*en*-2-*yn*-1-*one*.—1-Phenylhex-4-en-2-yn-1-ol (1·0 g.) in chloroform (100 ml.) was stirred for 2½ hr. with manganese dioxide (10 g.), when chromatography showed that the reaction was complete. The manganese dioxide was filtered off and washed with chloroform, and the filtrates were distilled, giving 1-phenylhex-4-en-2-yn-1-one (610 mg., 61%), b. p. 150° (bath)/0·05 mm., $\lambda_{max.}$ 269—271, 282 mμ (ε 16,800, 1700). The 2,4-*dinitrophenylhydrazone* (red needles from ethyl acetate) had m. p. 150° (decomp.) (Found: C, 61·8; H, 4·0; N, 16·3. $C_{18}H_{14}N_4O_4$ requires C, 61·7; H, 4·0; N, 16·9%).

The following compounds were similarly prepared; oxidation was for the time specified. 7-Phenylhept-6-en-4-yn-3-one (1 hr., 34%), b. p. 75—90°/10^{-3} mm., n_D^{22} 1·6205, $\lambda_{max.}$ 296—298 mμ (ε 16,600) [2,4-*dinitrophenylhydrazone* (orange needles from ethyl acetate), m. p. 169—171° (decomp.) (Found: C, 62·9; H, 4·4; N, 15·6. $C_{19}H_{16}N_4O_4$ requires C, 62·6; H, 4·4; N, 15·4%)]; 5-methyl-1-phenylhex-4-en-2-yn-1-one (30 min., 68%) b. p. 100° (bath)/0·05 mm., n_D^{19} 1·6000, $\lambda_{max.}$ 261, 289, 305 mμ (ε 13,300, 15,000, 14,300) [2,4-*dinitrophenylhydrazone* (red needles from ethyl acetate), m. p. 196° (decomp.) (Found: C, 62·3; H, 4·35; N, 15·1. $C_{19}H_{16}N_4O_4$ requires C, 62·6; H, 4·4; N, 15·4%)]; 1,5-*diphenylpent*-4-*en*-2-*yn*-1-*one* (1 hr., 57%), plates, m. p. 59—60° (from ether–hexane), $\lambda_{max.}$ 262—265, 321 mμ (ε 17,900, 27,100) (Found: C, 87·7;

[10] H. B. Henbest, E. R. H. Jones, and I. M. S. Walls, *J.*, 1950, 3646.
[11] G. Eglinton and M. C. Whiting, *J.*, 1950, 3650.
[12] M. Akhtar, T. A. Richards, and B. C. L. Weedon, *J.*, 1959, 933.

H, 5·3. $C_{17}H_{12}O$ requires C, 87·9; H, 5·2%) [2,4-*dinitrophenylhydrazone* (dark red needles from chloroform), m. p. 240—241° (decomp.) (Found: C, 67·2; H, 4·0; N, 13·4. $C_{23}H_{16}N_4O_4$ requires C, 67·0; H, 3·9; N, 13·6%)]; 4-methyl-1-phenylpent-4-en-2-yn-1-one (1·5 hr., 83%), b. p. 110°/0·3 mm., n_D^{20} 1·5657, $\lambda_{max.}$ 267 mμ (ε 7250) [2,4-*dinitrophenylhydrazone* (red needles from ethyl acetate), m. p. 175° (decomp.) (Found: C, 62·1; H, 4·3; N, 16·4. $C_{18}H_{14}N_4O_4$ requires C, 61·7; H, 4·0; N, 16·0%)]; 1-(2-thienyl)hex-4-en-2-yn-1-one (with Mr. M. V. BURGE) (1 hr., 90%), b. p. 140—160°/0·05 mm., n_D^{22} 1·6287, $\lambda_{max.}$ 313 mμ (ε 13,400) [2,4-*dinitrophenylhydrazone* (dark red needles from ethyl acetate), m. p. 170° (decomp.) (Found: C, 53·8; H, 3·5; N, 15·6; S, 8·8. $C_{16}H_{12}N_4O_4S$ requires C, 54·0; H, 3·4; N, 15·75, S, 9·0%)]; 5-methyl-1-(2-thienyl)hex-4-en-2-yn-1-one (5 min., 56%), pale yellow oil (after chromatography on silica gel) which could not be distilled, n_D^{17} 1·6280, $\lambda_{max.}$ 272, 302, 314 mμ (ε 11,700, 18,500, 18,700) [2,4-*dinitrophenylhydrazone* (red needles from ethyl acetate), m. p. 196—197° (decomp.) (Found: C, 55·3; H, 3·6; N, 14·8; S, 8·6. $C_{17}H_{14}N_4O_4S$ requires C, 55·1; H, 3·8; N, 15·1; S, 8·6%)].

1-(2-*Furyl*)*hex*-4-*en*-2-*yn*-1-*one*.—1-(2-Furyl)hex-4-en-2-yn-1-ol (1·0 g.) in dry benzene (200 ml.) was stirred under nitrogen at room temperature with "nickel peroxide" [8] (50 g.) for 1 hr., when chromatography showed that oxidation was complete. The filtered solution was concentrated and distilled, giving the ketone (740 mg., 74%), b. p. 130° (bath)/0·05 mm., n_D^{23} 1·5924, $\lambda_{max.}$ 310 mμ (ε 18,000). The 2,4-*dinitrophenylhydrazone* (red needles from ethyl acetate) had m. p. 178—180° (decomp.) (Found: C, 56·6; H, 3·9; N, 16·0. $C_{16}H_{12}N_4O_5$ requires C, 56·5; H, 3·6; N, 16·4%).

We thank Professor Sir Ewart Jones, F.R.S., for discussions.

[*Added in proof.*—Reisch and Walker (*Arch. Pharm.*, 1964, **297**, 628) have now prepared capillin by coupling 3-bromo-1-phenylprop-2-yn-1-one with propane; they have similarly prepared the alcohol (I) from 3-bromo-1-phenylprop-2-yn-1-ol.]

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