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4-Chloro-1,2-phenylenediamine *[95-83-0]* **M 142.6, m 69-70°, pK_1^{25} -0.27 (aq H_2SO_4), pK_2^{25} 3.35 (3.67).** Recrystd from pet. ether.

4-Chlorophenyl isocyanate *[104-12-1]* **M 153.6, m 28-31°, 31-32°, 32°, 32.5°, b 80.6-80.9°/9.5mm, 115-117°/45mm.** Purified by recrystn from pet ether (b 30-40°) or better by fractional distn. **TOXIC irritant.**

4-Chlorophenyl isothiocyanate *[2131-55-7]* **M 169.6, m 44°, 43-45°, 45°, 46°, 47°, b 110-115°/4mm, 135-136°/24mm.** Check the IR first. Triturate with pet ether (b 30-60°) and decant the solvent. Repeat 5 times. The combined extracts are evap under reduced press to give almost pure compound as a readily crystallisable oil with a pleasant anise odour. It can be recrystd from the minimum vol of EtOH at 50° (do not boil too long in case it reacts). It can be purified by vac distn. **IRRITANT.** [*Org Synth* Coll Vol V 223 *1973*.]

4-Chlorophenyl 2-nitrobenzyl ether *[109669-56-9]* **M 263.7, m 69°.** Crystd from EtOH.

4-Chlorophenyl 4-nitrobenzyl ether *[5442-44-4]* **M 263.7, m 102°.** Crystd from EtOH.

9-Chloro-9-phenylxanthene (Pixyl chloride) *[42506-03-6]* **M 292.8, m 105-106°.** Possible impurity is 9-hydroxy-9-phenylxanthene. If material contains a lot of the hydroxy product then boil 10g in $CHCl_3$ (50mL) with redistd acetyl chloride (1mL) until liberation of HCl is complete. Evapn leaves the chlorophenylxanthene as the hydrochloride which on heating with *benzene loses HCl; and on adding pet ether prisms of chlorophenylxanthene separate and contain 0.5mol of *benzene. The *benzene-free compound is obtained on drying and melts to a colourless liquid. [*Justus Liebigs Ann Chem* **370** 142 *1909*.] The 9-phenylxanthyl group is called pixyl. [*J Chem Soc, Chem Commun* 639 *1978*.]

Chlorophyll ***a*** *[479-61-8]* **M 983.5, m 117-120°, 150-153°, 178-180° (sinters at ~150°), $[\alpha]_D^{20}$ -262° (Me_2CO).** Forms green crystals from Me_2CO, Et_2O + H_2O, Et_2O + hexane + H_2O or Et_2O + pentane + H_2O. It is sparingly soluble in MeOH and insol in pet ether. In alkaline soln it gives a blue-green colour with deep red fluorescence. A very crude chlorophyll mixture has been purified by chromatography on low melting polyethylene (MI 0.044; 'Dow' melting index MI <2) and developed with 70% aq Me_2CO. The order of effluent from the bottom of the column is: xanthophylls, chlorophyll *b*, chlorophyll *a*, phaeophytins and carotenes. A mixture of chlorophylls *a* and *b* is best separated by chromatography on sugar and the order is chlorophyll *b* elutes first followed by chlorophyll *a*. To an Me_2CO-H_2O soln of chlorophylls 200mL of iso-octane is added and the mixt shaken in a separating funnel and the H_2O is carefully removed. The iso-octane layer is dried (Na_2SO_4) and applied to a glass column (5cm diameter) dry packed with 1000mL of powdered sucrose which has been washed with 250mL of iso-octane. Elution with 0.5% of isopropanol in iso-octane gives chlorophyll *a*. Keeping the eluate overnight at 0° yields micro crystals which are collected by filtration or centrifugation (Yield 40mg). UV_{EtOH} has λ_{max} **660**, 613, 577, 531, 498, **429** and 409 nm. [Anderson and Calvin *Nature* **194** 285 *1962*; Stoll and Weidemann *Helv Chim Acta* **16** 739 757 *1933*; NMR: Katz et al. *J Am Chem Soc* **90** 6841 *1968*, **85** 3809 *1963* for *a* and *b*; ORD: Inhoffen et al. *Justus Liebigs Ann Chem* **704** 208 *1967*; Willstätter and Isler *Justus Liebigs Ann Chem* **390** 269, 233 *1912*.]

Chlorophyll ***b*** *[519-62-0]* **M 907.52, sinters at 86-92°, sinters at 170°, dec at 160-170°, m 183-185°, 190-195°, $[\alpha]_D^{20}$ -267° (Me_2CO + MeOH), $[\alpha]_{720}^{25}$ -133° (MeOH + Pyridine 95:5).** See purification of chlorophyll *a*, and is separated from "*a*" by chromatography on sucrose [UV, IR: Stoll and Weidemann *Helv Chim Acta* **42** 679, 681 *1959*]. It forms red-black hexagonal bipyramids or four sided plates from dilute EtOH and has been recrystd from $CHCl_3$-MeOH. It is soluble in MeOH, EtOH, EtOAc and insoluble in pet ether. [*J Am Chem Soc* **88** 5037 *1966*.]

Chloropicrin (trichloronitromethane) *[76-06-2]* **M 164.5, b 112°.** Dried with $MgSO_4$ and fractionally distd. **EXTREMELY NEUROTOXIC, use appropriate precautions.**

***RS*-2-Chloropropionic acid** *[598-78-7]* **M 108.5, b 98°/3mm, d 1.182, n 1.453 pK^{25} 2.89.** Dried with P_2O_5 and fractionally distd under vacuum.

***S*-(-)-2-Chloropropionic acid** *[29617-66-1]* **M 108.5, b 77°/10mm, 80.7°/10mm, 185-188°/atm, d_4^{25} 1.2485, n_D^{25} 1.436, $[\alpha]_D^{25}$ -14.6° (neat).** Purified by twice fractionating through a 115cm Podbielniak column (calcd 50 theoretical plates at atm pressure, see p. 141) using a take-off ratio of 1:5. Ths *acid chloride* is prepared by dissolving the acid in $SOCl_2$ adding a few drops of PCl_3, refluxing and then distilling through a 30 cm column, **b** 53°/100mm, $[\alpha]_D^{25}$ - 4.6° (neat), d_4^{25} 1.2689, n_D^{25} 1.4368. [Fu et al. *J Am Chem Soc* **76** 6954 *1954*].

3-**Chloropropionic acid** *[107-94-8]* **M 108.5, m 41°, pK^{25} 4.08.** Crystd from pet ether or *benzene.

3-**Chloropropyl bromide (1-bromo-3-chloropropane)** *[109-70-6]* **M 157.5, b 142-145°, n^{25} 1.4732.** Washed with conc H_2SO_4, water, 10% Na_2CO_3 soln, water again and then dried with $CaCl_2$ and fractionally distd just before use [Akagi, Oae and Murakami *J Am Chem Soc* **78** 4034 *1956*].

6-Chloropurine *[87-42-3]* **M 154.6, m 179°(dec), pK_1^{20} 0.45, pK_2^{20} 7.88.** Crystd from water.

2-Chloropyrazine *[14508-49-7]* **M 114.5, b 62-63°/31mm, 153-154°/atm, d_4^{20} 1.302, n_D^{26} 1.535, pK_{Est} <0.** Fractionally distil through a short column packed with glass helices. It has a penetrating mildly pungent odour with a high vapour pressure at room temperature. [Erickson and Spoerri *J Am Chem Soc* **68** 400 *1946*; *J Org Chem* **28** 1682 *1963*.]

2-Chloropyridine *[109-09-1]* **M 113.6, b 49.0°/7mm, d 1.20, n 1.532, pK^{20} 0.49 (0.72).** Dried with NaOH for several days, then distd from CaO under reduced pressure.

3-Chloropyridine *[626-60-8]* **M 113.6, b 148°, d 1.194, n 1.5304, pK^{25} 2.84.** Distd from KOH pellets.

4-Chloropyridine *[626-61-9]* **M 113.6, b 85-86°/100mm, 147-148°/760mm, pK^{20} 3.84.** Dissolved in distilled water and excess of 6M NaOH was added to give pH 12. The organic phase was separated and extracted with four volumes of diethyl ether. The combined extracts were filtered through paper to remove water and the solvent evaporated. The dark brown residual liquid was kept under high vacuum [Vaidya and Mathias *J Am Chem Soc* **108** 5514 *1986*]. It can be distd but readily darkens and is best kept as the *hydrochloride [7379-35-3]* **M** 150.1, **m** 163-165°(dec).

2-Chloropyrimidine *[1722-12-9]* **M 114.5, m 63-65°, 66°, b 91°/26mm, pK^{20} -1.90.** It has been recrystd from *C_6H_6, pet ether or a mixture of both. It sublimes at 50°/18mm and can be distd in a vacuum. [IR: Short and Thompson *J Chem Soc* 168 *1952*; Boarland and McOmie *J Chem Soc* 1218 *1951*.]

2-Chloroquinoline *[612-62-4]* **M 163.6, m 34°, b 147-148°/15mm, d^{35} 1.235, n^{25} 1.629, pK_{Est} ~0.3.** Purified by crystn of its picrate to constant melting point (123-124°) from *benzene, regenerating the base and distilling under vacuum [Cumper, Redford and Vogel *J Chem Soc* 1183 *1962*]. 2-Chloroquinoline can be crystd from EtOH. Its *picrate* has **m** 122° (from EtOH).

4-Chloroquinoline *[611-35-8]* **M 163.6, m 29-32°, 31°, b 130°/15mm, 261°/744mm, pK 3.72.** Possible impurities include the 2-isomer. Best purified by converting to the *picrate* (**m** 212-213° dec) in EtOH and recryst from EtOH (where the picrate of the 2-chloroquinoline stays in soln) or EtOAc . The picrate is decomposed with 5% aqueous NaOH, extracted in $CHCl_3$, washed with H_2O, dried ($MgSO_4$), evapd and distd in a vacuum. It can be steam distd from slightly alkaline aqueous solns, the aqueous distillate is extracted with Et_2O, evaporated and distd. The distillate solidifies on cooling. [Bobránski *Chem Ber* **71** 578 *1938*.]

8-Chloroquinoline *[611-33-6]* **M 163.6, b 171-171.5°/24mm, d 1.278, n 1.644, pK^{25} 3.12.** Purified by crystn of its $ZnCl_2$ complex (**m** 228°) from aqueous EtOH.

4-Chlororesorcinol *[95-88-5]* **M 144.6, m 105°, $pK_{Est(1)}$~9.2, $pK_{Est(2)}$ ~10.1.** Crystd from boiling CCl_4 (10g/L, charcoal) and air dried.

5-Chlorosalicaldehyde *[635-93-8]* **M 156.6, m 98.5-99°.** Steam distd, then crystd from aq EtOH.

***N*-Chlorosuccinimide** *[128-09-6]* **M 133.5, m 149-150°.** Rapidly crystd from *benzene, or glacial acetic acid and washed well with water then dried *in vacuo*. [Phillips and Cohen *J Am Chem Soc* **108** 2023 *1986*.]

2-Chlorothiophene (2-thienyl chloride) *[96-43-5]* **M 118.6, b 126-128°, d 1.285, n 1.551.** Purified by fractional distn at atmospheric pressure or by gas chromatography.

8-Chlorotheophylline *[85-18-7]* **M 214.6, m 311°(dec), $pK_{Est(1)}$~5.4, $pK_{Est(2)}$ ~9.1.** Crystd from H_2O.

4-Chlorothiophenol *[106-54-7]* **M 144.6, m 51-52°, pK^{25} 6.14.** Recrystd from aqueous EtOH [D'Sousa et al. *J Org Chem* **52** 1720 *1987*].

2-Chlorotoluene *[95-49-8]* **M 126.6, b 159°, d 1.083, n 1.5255.** Dried for several days with $CaCl_2$, then distd from Na using a glass helices-packed column.

3-Chlorotoluene *[108-41-8]* **M 126.6, m -48°, b 161-163°, d 1.072, n 1.522.** Purified as for 2-chlorotoluene above.

4-Chlorotoluene *[106-43-4]* **M 126.6, f 7.2°, b 162.4°, d 1.07, n 1.521.** Dried with BaO, fractionally distd, then fractionally crystd by partial freezing.

2-Chlorotriethylamine hydrochloride *[869-24-9]* **M 172.1, m 208-210°, pK_{Est} ~8.6 (free base).** Crystd from absolute MeOH (to remove highly coloured impurities).

Chlorotrifluoroethylene *[79-38-9]* **M 116.5, b -26 to -24°.** Scrubbed with 10% KOH soln, then 10% H_2SO_4 soln to remove inhibitors, and dried. Passed through silica gel.

Chlorotrifluoromethane *[75-72-9]* **M 104.5, m -180°, b -81.5°.** Main impurities were CO_2, O_2, and N_2. The CO_2 was removed by passage through saturated aqueous KOH, followed by conc H_2SO_4. The O_2 was removed using a tower packed with activated copper on Kieselguhr at 200°, and the gas dried over P_2O_5.

Chlorotriphenylmethane see **triphenylmethyl chloride (trityl chloride).**

5-Chlorouracil (5-chloro-2,4(6)-dihydroxypyrimidine) *[1820-81-1]* **M 146.5, m 314-418° dec, 324-325° dec, pK_1^{25} 7.95, pK_2^{25} >13.** Recrystallised from hot H_2O (4g/500mL) using charcoal. [McOmie et al. *J Chem Soc* 3478 *1955;* West and Barrett *J Am Chem Soc* **76** 3146 *1954*.]

5β-Cholanic acid *[25312-65-6]* **M 360.6, m 164-165°, $[\alpha]_D^{14}$ +21.7° ($CHCl_3$), pK_{Est} ~4.9.** Crystd from EtOH. The *Ethyl ester* has **m** 93-94° (from 80% EtOH), **b** 273°/12mm, $[\alpha]_D^{20}$ +21° ($CHCl_3$).

Cholanthrene (1,2,-dihydrobenz[*j*]aceanthrylene) *[479-23-2]* **M 254.3, m 173°.** Crystd from *benzene/diethyl ether.

5α-Cholestane *[481-21-0]* **M 372.7, m 80°, $[\alpha]_{546}^{20}$ +29.5° (c 2, $CHCl_3$).** Crystd from diethyl ether/EtOH.

5α-Cholestan-3ß-ol *[80-97-7]* **M 388.7, m 142-143°(monohydrate), $[\alpha]_{546}^{20}$ +28° (c 1, $CHCl_3$), $[\alpha]_D$ +27.4° (in $CHCl_3$).** Crystd from EtOH or slightly aqueous EtOH, or MeOH. [Mizutani and Whitten *J Am Chem Soc* **107** 3621 *1985*.]

Cholest-2-ene *[15910-23-3]* **M 370.6, m 75-76°, $[\alpha]_D^{24}$ +64°.** Recrystd from MeOH or diethyl ether/acetone. [Berzbrester and Chandran *J Am Chem Soc* **109** *174 1987*.]

Cholesterol *[57-88-5]* **M 386.7, m 148.9-149.4°, $[\alpha]_D^{25}$ -35° (hexane).** Crystd from ethyl acetate, EtOH or isopropyl ether/MeOH. [Hiromitsu and Kevan *J Am Chem Soc* **109** 4501 *1987*.] For extensive details of purification through the dibromide, see Fieser [*J Am Chem Soc* **75** 5421 *1953*] and Schwenk and Werthessen [*Arch Biochem Biophys* **40** 334 *1952*], and by repeated crystn from acetic acid, see Fieser [*J Am Chem Soc* **75** 4395 *1953*].

Cholesteryl acetate *[604-35-3]* **M 428.7, m 112-115°, $[\alpha]_{546}^{20}$ -51° (c 5, $CHCl_3$).** Crystd from *n*-pentanol.

Cholesteryl myristate *[1989-52-2]* **M 597.0.** Crystd from *n*-pentanol. Purified by column chromatography with MeOH and evaporated to dryness. Recrystd and finally, dried in vacuum over P_2O_5. [Malanik and Malat *Anal Chim Acta* **76** 464 *1975*].

Cholesteryl oleate *[303-43-5]* **M 651.1, m 48.8-49.4°.** Purified by chromatography on silica gel.

Cholic acid *[81-25-4]* **M 408.6, m 198-200°, $[\alpha]_{546}$ +41° (c 0.6, EtOH), pK^{20} 4.98.** Crystd from EtOH. Dried under vacuum at 94°.

Choline chloride *[67-48-1]* **M 139.6, m 302-305°(dec).** *Extremely deliquescent.* Purity checked by $AgNO_3$ titration or by titration of free base after passage through an anion-exchange column. Crystd from absolute EtOH, or EtOH-diethyl ether, dried under vacuum and stored in a vacuum desiccator over P_2O_5 or $Mg(ClO_4)_2$.

4-Chromanone *[491-37-2]* **M 148.2, m 35-37°, 39°, 41°, b 92-93°/3mm, 130-132°/15mm, 160°/50mm.** It has been recryst from pet ether, or purified by dissolving in $*C_6H_6$ washing with H_2O, drying ($MgSO_4$), evaporate and dist in a vacuum, then recryst the residue. The liquid has a pleasant lemon-like odour. The *semicarbazone* has **m** 227°. [Loudon and Razdan *J Chem Soc* 4299 *1954*.] The *oxime* is prepared from 3g of chromanone, 3g $NH_2OH.HCl$ in EtOH (50mL), 6g K_2CO_3 and refluxed on a water bath for 6h. The soln is poured into H_2O, the solid is filtered off, dried and dissolved in hot $*C_6H_6$ which on addition of pet ether yields the oxime as glisteneing needles **m** 140°. Decomposition of this gives very pure chromanone. The *benzal derivative* is prepared from 3g of chromanone, 4g PhCHO in 50mL EtOH, heated to boiling, 10mL of conc HCl are added dropwise and set aside for several days. The derivative separates and is recrystd from EtOH to give yellow needles, **m** 112° [*J Am Chem Soc* **45** 2711 *1923*]. Reaction with $Pb(OAc)_4$ yields the *3-acetoxy derivative* **m** 74° (from pet ether + trace of EtOAc) [Cavill et al. *J Chem Soc* 4573 *1954*].

Chrysene *[218-01-9]* **M 228.3, m 255-256°.** Purified by chromatography on alumina from pet ether in a darkened room. Its soln in $*C_6H_6$ was passed through a column of decolorising charcoal, then crystd by concentration of the eluate. Also purified by crystn from $*C_6H_6$ or $*C_6H_6$-pet ether , and by zone refining. [Gorman et al. *J Am Chem Soc* **107** 4404 *1985*]. It was freed from 5*H*-benzo[*b*]carbazole by dissolving in *N,N*-dimethylformamide and successively adding small portions of alkali and iodomethane until the fluorescent colour of the carbazole anion no longer appeared when alkali was added. The chrysene (and alkylated 5*H*-benzo[*b*]carbazole) separated on addition of water. Final purification was by crystn from ethylcyclohexane and from 2-methoxyethanol [Bender, Sawicki and Wilson *Anal Chem* **36** 1011 *1964*]. It can be sublimed in a vacuum.

Chrysoidine G (4-phenylazo-1,3-benzenediamine monohydrochloride) *[532-82-1]* **M 248.7, m 118-118.5°, pK_1 3.32, pK_2 5.21.** Red-brown powder which is recrystd from H_2O. It gives a yellow soln in conc H_2SO_4 which turns orange on dilution. Its solubility at 15° is 5.5% (H_2O), 4.75% (EtOH), 6.0% (cellosolve), 9.5% (ethylene glycol), 0.005% (xylene) and insol in $*C_6H_6$. The *hydroiodide* has **m** 184° (from EtOH) and the *picrate* forms red needles **m** 196°. [*Bull Chem Soc Jpn* **31** 864 *1958*; *Chem Ber* **10** 213 *1877*.]

1,8-Cineole (1,8-epoxy-*p*-menthane) *[470-82-6]* **M 154.2, f 1.3°, b 176.0°, d 0.9251.** See eucaliptol on p. 242.

***trans*-Cinnamaldehyde** *[14271-10-9]* **M 132.2, m -4°, -7.5°, -9°, b 80°/0.4mm, 85.8°/1.1mm, 125-128°/11mm, 152.2°/40mm, 163.7°/60mm, 199.3°/200mm, 246°/760mm dec, d_4^{20} 1.0510, n_D^{20} 1.623.** Purified by steam distn (sol 1 in 700 parts H_2O) followed by distn *in vacuo*. The *cis*-isomer has **b** 67-69°/40mm and d_4^{20} 1.0436 and n_D^{20} 1.5937. The *trans-semicarbazone* has **m** 210° dec from $CHCl_3$-MeOH (*cis-semicarbazone* has **m** 196°); the *trans-phenylsemicarbazone* has **m** 177° from $CHCl_3$-MeOH (the *cis-phenylsemicarbazone* has **m** 146°); the *trans-2,4-dinitrophenylhydrazone* has **m** 250° dec from MeOH as the *cis*-isomer [Gamboni et al. *Helv Chim Acta* **38** 255 *1955*; Peine *Chem Ber* **17** 2117 *1884*; *J Org Chem* **26** 4814 *1961*; *J Am Chem Soc* **86** 198 *1964*].

***cis*-Cinnamic acid (*Z*-3-phenyl-2-propenoic acid)** *[102-94-3]* **M 148.2, m 68° (for *allo*-form), pK^{25} 3.93.** The *cis*-acid is prepared by catalytic reduction of phenylpropiolic acid and after distn in high vacuum at ~95° gives the most stable *allo*-isomer **m** 68°. Recrystn from pet ether yields **Liebermann's *iso*-cinnamic acid m 58°**. When the *allo*-acid (**m** 68°) is heated at 20° above its melting point in a sealed capillary for 0.5h and allowed to cool slowly **Erlenmyer's *iso*-cinnamic acid m** 42° is formed. This form can also be obtained in larger amounts by heating the *allo*-acid at 80° for 3h and on cooling it remains liquid for several weeks but gives the 42° acid on innoculation with the crystals from the capillary tube. This form is unchanged in 6 weeks when kept in a dark cupboard. All three forms have the same pK values and the same rate of bromination. There is also a very labile form with **m** 32°. [Liebermann, *Chem Ber* **26** 1572 *1893*; Claisen and Crismer *Justus Liebigs Ann Chem* **218** 135 *1883*; Robinson and James *J Chem Soc* 1453 *1933*; Berthoud and Urech *Helv Chim Acta* **13** 437 *1930*; McCoy and McCoy *J Org Chem* **33** 2354 *1968*.]

***trans*-Cinnamic (*E*-3-phenyl-2-propenoic) acid** *[140-10-3; 621-82-9 for E-Z mixture]* **M 148.2, m 134.5-135°, pK^{25} 4.42 (4.50).** Crystd from *benzene, CCl_4, hot water, water/EtOH (3:1), or 20% aqueous EtOH. Dried at 60° *in vacuo*. Steam volatile.

Cinnamic anhydride *[538-56-7]* **M 278.4, m 136°.** Crystd from *C_6H_6 or toluene/pet ether (b 60-80°).

***N*-Cinnamoyl-*N*-phenylhydroxylamine** *[7369-44-0]* **M 239.3, m 158-163°.** Recrystd from EtOH.

Cinnamyl alcohol *[104-54-1]* **M 134.2, m 33°, b 143.5°/14mm, λ_{max} 251nm (ε 18,180M^{-1} cm^{-1}).** Crystd from diethyl ether/pentane.

Cinnoline *[253-66-7]* **M 130.2, m 38°, pK^{20} 2.37.** Crystd from pet ether. Kept under N_2 in sealed tubes in the dark at 0°.

Citraconic acid *[498-23-7]* **M 130.1, m 91°, pK_1^{25} 2.2, pK_2^{25} 5.60 (cis).** Steam distd and crystd from EtOH/ligroin.

Citraconic anhydride *[616-02-4]* **M 112.1, m 8-9°, b 47°/0.03mm, 213°/760mm, d_4^{20} 1.245, n_D^{20} 1.472.** Possible contamination is from the acid formed by hydrolysis. If the IR has OH bands then reflux with Ac_2O for 30 min, evaporate then distil the residue in a vacuum; otherwise distil in a vacuum. Store in a dry atmosphere. [*Biochem J* **191** 269 *1980*.]

Citrazinic acid (2,6-dihydroxyisonicotinic acid) *[99-11-6]* **M 155.1, m >300°, pK_1 3.0, pK_2 4.76.** Yellow powder with a greenish shade, but is white when ultra pure and turns blue on long standing. It is insoluble in H_2O but slightly soluble in hot HCl and soluble in alkali or carbonate solutions. Purified by precipitation from alkaline solutions with dilute HCl, and dry in a vacuum over P_2O_5. The *ethyl ester* has **m** 232° (evacuated tube) and a pKa of 4.81 in $MeOCH_2CH_2OH$ [IR: Pitha *Coll Czech Chem Comm* **28** 1408 *1963*].

Citric acid (H_2O) *[5949-29-1; 77-92-9 (anhydr)]* **M 210.1, m 156-157°, 153° (anhyd), pK_1^{25} 2.96, pK_2^{25} 4.38, pK_3^{25} 5.68.** Crystd from water.

Citronellal (3,7-dimethyloctan-6-al) *[R(+): 2385-77-5; S(-): 5949-05-3]* **M 154.3, b 67°/4mm, 89°/14mm, 104-105°/21mm, 207°/760mm, $[\alpha]_{546}^{20}$ (+) and (-) 20°, $[\alpha]_D^{20}$ (+) and (-) 16.5° (neat).** Fractionally distd. Alternatively extracted with $NaHSO_3$ solution, washed with Et_2O then acidified to decompose the bisulfite adduct and extracted with Et_2O, dried (Na_2SO_4), evaporated and distd. Check for purity by hydroxylamine titration. The ORD in MeOH (c 0.167) is: $[\alpha]_{700}$ +9°, $[\alpha]_{589}$ +11°, $[\alpha]_{275}$ +12° and $[\alpha]_{260}$ 12°. The *semicarbazone* has **m** 85°, and the *2,4-dinitrophenylhydrazone* has **m** 79-80°. [IR: *J Chem Soc* 3457 *1950*; ORD: Djerassi and Krakower *J Am Chem Soc* **81** 237 *1959*.]

β-Citronellene (2,6-dimethylocta-2,7-diene) *[S-(+): 2436-90-0; R-(-): 10281-56-8]* **M 138.3, b 153-154°/730mm, 155°/atm, d_4^{22} 0.757, n_D^{22} 1.431, $[\alpha]_{546}^{20}$ (+) and (-) 13°, $[\alpha]_{546}^{20}$ (+) and (-) 10° (neat).** Purified by distillation over Na three times and fractionation. [(-) Arigoni and Jeager *Helv Chim Acta* **37** 881 *12954*; (+) Eschenmoser and Schinz *Helv Chim Acta* **33** 171 *1950*.]

β-Citronellol (3,7-dimethyloctan-6-ol) *[R-(+): 11171-61-9; S-(-): 106-22-9]* **M 156.3, b 47°/1mm, 102-104(110°)°/10mm, 112-113°/12mm, 221-224°/atm, 225-226°/atm, d_4^{24} 0.8551, n_D^{24} 1.4562, $[\alpha]_{546}^{20}$ (+) and (-) 6.3°, $[\alpha]_D^{20}$ (+) and (-) 5.4° (neat).** Purified by distn through a cannon packed (Ni) column and the main cut collected at 84°/14mm and redistd. Also purified *via* the benzoate. [IR: Eschenazi *J Org Chem* **26** 3072 *1961*; *Bull Soc Chim Fr* 505 *1951*.]

***S*-Citrulline (2-amino-5-ureidopentanoic acid)** *[372-75-8]* **M 175.2, m 222°, $[\alpha]_D^{20}$ +24.2° (in 5M HCl), pK^{25} 9.71.** Likely impurities are arginine, and ornithine. Crystd from water by adding 5 volumes of EtOH. Also crystd from water by addn of MeOH.

Clofazimine [2-(4-chloroanilino)-3-isopropylimino-5-(4-chlorophenyl)-3,4-dihydrophenazine] *[2030-63-9]* **M 473.5, m 210-212°.** Recrystd from acetone.

Coenzyme Q_0 (2,3-Dimethoxy-5-methyl-1,4-benzoquinone, 3,4-dimethoxy-2,5-toluquinone, fumigatin methyl ether), colchicine and **colchicoside** see entries in Chapter 6.

Conessine *[546-06-5]* **M 356.6, m 125°, 127-128.5°, $[\alpha]_D^{20}$ -1.9° (in $CHCl_3$) and +25.3° (in EtOH), $pK_{Est(1)}$~10.4 , $pK_{Est(2)}$~10.7,.** Crystd from acetone. The *dihydrochloride* has **m** >340° and $[\alpha]_D^{20}$ +9.3° (c 0.9, H_2O).

Coniferyl alcohol [4-hydroxy-3-methoxy-cinnamyl alcohol, 3-(4-hydroxy-3-methoxyphenyl)-2-propen-1-ol] *[458-35-5]* **M 180.2, m 73-75°, b 163-165°/3mm, pK^{25} 9.54.** It is soluble in EtOH and insoluble in H_2O. It can be recrystd from EtOH and distd in a vacuum. It polymerises in dilute acid. The *benzoyl derivative* has **m** 95-96° (from pet ether), and the *tosylate* has **m** 66°. [Derivatives: Freudenberg and Achtzehn *Chem Ber* **88** 10 *1955*; UV: Herzog and Hillmer *Chem Ber* **64** 1288 *1931*.]

Congo Red *[573-58-0]* **M 696.7, λ_{max} 497nm, pK_2^{28} 4.19.** Crystd from aq EtOH (1:3). Dried in air.

(-)-α-Copaene {*1R,2S,6S,7S,8S*-8-isopropyl-1,3-dimethyltricyclo[4.4.0.$0^{2,7}$]dec-3-ene} *[3856-25-5]* **M 204.4, b 119-120°/10mm, 246-251°, d 0.908, n 1.489, $[\alpha]_D^{20}$ -6.3° (c 1.2, $CHCl_3$).** Purified by distn, preferably under vacuum.

4,5-Coprosten-3-ol (cholest-4-ene-3ß-ol) *[517-10-2]* **M 386.7, m 132°.** Crystd from MeOH/diethyl ether.

Coprosterol (5α-cholestan-3ß-ol, dihydrocholesterol) *[80-97-7]* **M 388.7, m 101°, 139-140°, $[\alpha]_D^{20}$ +24° (c 1, $CHCl_3$).** See entry on p. 169.

Coronene *[191-07-1]* **M 300.4, m 438-440°, λ_{max} 345nm (log ε 4.07).** Crystd from *benzene or toluene, then sublimed in vacuum.

Cortisol, corticosterone, cortisone and **cortisone-21-acetate** see entries in Chapter 6.

Coumalic acid (2-pyrone-5-carboxylic acid) *[500-05-0]* **M 140.1, m 205-210°(dec), pK_{Est} ~0.** Crystd from MeOH. *Methyl ester* , from pet ether, has **m** 74-74° and **b** 178-180°/60 mm.

Coumarin *[91-64-5]* **M 146.2, m 68-69°, b 298°, pK -4.97 (aq H_2SO_4).** Crystd from ethanol or water and sublimed *in vacuo* at 43° [Srinivasan and deLevie *J Phys Chem* **91** 2904 *1987*].

Coumarin-3-carboxylic acid *[531-81-7]* **M 190.2, m 188°(dec), pK_{Est} ~1.5.** Crystd from water.

Creatine (H_2O) and **creatinine** see entries in Chapter 6.

***o*-Cresol** *[95-48-7]* **M 108.1, m 30.9°, b 191°, n^{41} 1.536, n^{46} 1.534, pK^{25} 10.22.** Can be freed from *m*- and *p*-isomers by repeated fractional distn, Crystd from *benzene by addition of pet ether. Fractional crystd by partial freezing of its melt.

***m*-Cresol** *[108-39-4]* **M 108.1, f 12.0°, b 202.7°, d 1.034, n 1.544, pK^{25} 10.09.** Separation of the *m*- and *p*-cresols requires chemical methods, such as conversion to their sulfonates [Brüchner *Anal Chem* **75** 289 *1928*]. An equal volume of H_2SO_4 is added to *m*-cresol, stirred with a glass rod until soln is complete. Heat for 3h at 103-105°. Dilute carefully with 1-1.5 vols of water, heat to boiling point and steam distil until all unsulfonated cresol has been removed. Cool and extract residue with ether. Evaporate the soln until the boiling point reaches 134° and steam distil off the *m*-cresol. Another purification involves distn, fractional crystn from the melt, then redistn. Freed from *p*-cresol by soln in glacial acetic acid and bromination by about half of an equivalent amount of bromine in glacial acetic acid. The acetic acid was distd off, then fractional distn of the residue under vac gave bromocresols from which 4-bromo-*m*-cresol was obtained by crystn from hexane. Addn of the bromocresol in glacial acetic acid slowly to a reaction mixture of HI and red phosphorus or (more smoothly) of HI and hypophosphorus acid, in glacial acetic acid, at reflux, removed the bromine. After an hour, the soln was distd at atmospheric pressure until layers were formed. Then it was cooled and diluted with water. The cresol was extracted with ether, washed with water, $NaHCO_3$ soln and again with water, dried with a little $CaCl_2$ and distd [Baltzly, Ide and Phillips *J Am Chem Soc* **77** 2522 *1955*].

***p*-Cresol** *[106-44-5]* **M 108.1, m 34.8°, b 201.9°, n^{41} 1.531, n^{46} 1.529, pK^{25} 10.27.** Can be separated from *m*-cresol by fractional crystn of its melt. Purified by distn, by pptn from *benzene soln with pet ether, and *via* its benzoate, as for phenol. Dried under vacuum over P_2O_5. Has also been crystd from pet ether (b 40-60°) and by conversion to sodium *p*-cresoxyacetate which, after crystn from water was decomposed by heating with HCl in an autoclave [Savard *Ann Chim (Paris)* **11** 287 *1929*].

***o*-Cresolphthalein complexon** *[2411-89-4]* **M 636.6, m 186°(dec), λmax 575nm, pK_1 2.2, pK_2 2.9, pK_3 7.0, pK_4 7.8, pK_5 11.4, pK_6 12.0.** *o*-Cresolphthalein (a complexone precursor without the two bis-carboxymethylamino groups) is a contaminant and is one of the starting materials. It can be removed by dissolving the reagent in water and adding a 3-fold excess of sodium acetate and fractionally precipitating it by dropwise addition of HCl to the clear filtrate. Wash the ppte with cold H_2O and dry the monohydrate at 30° in a vacuum. The pure material gives a single spot on paper chromatography (eluting solvent EtOH/water/phenol, 6:3:1; and developing with NaOH). [Anderegg et al. *Helv Chim Acta* **37** 113 *1954*.] Complexes with Ba, Ca, Cd, Mg and Sr.

***o*-Cresol Red** *[1733-12-6]* **M 382.4, m 290°(dec), pK^{25} 1.26.** Crystd from glacial acetic acid. Air dried. Dissolved in aqueous 5% $NaHCO_3$ soln and ppted from hot soln by dropwise addition of aqueous HCl. Repeated until extinction coefficients did not increase.

***o*-Cresotic acid (methylsalicylic acid)** *[83-40-9]* **M 152.2, m 163-164°, pK_1^{25} 3.32.** Crystd from water.

***m*-Cresotic acid** *[50-85-1]* **M 152.2, m 177°, pK_1^{25} 3.15, pK_2^{25} 13.35.** Crystd from water.

***p*-Cresotic acid** *[89-56-5]* **M 152.2, m 151°, pK_1^{25} 3.40, pK_2^{25} 13.45.** Crystd from water.

Crocetin diethyl ester *[5056-14-4]* **M 384.5, m 218-219°, 222.5°, $A^{1\%}_{1cm}$ (λmax) 2340 (400nm), 3820 (422nm), 3850 (450nm) in pet ether.** Purified by chromatography on a column of silica gel G. Crystd from *benzene. Stored in the dark, under an inert atmosphere, at 0°.

Crotonaldehyde (2-butenal) *[123-73-9]* **M 70.1, b 104-105°, d 0.851, n 1.437.** Fractionally distd under N_2, through a short Vigreux column. Stored in sealed ampoules. Stabilised with 0.01% of 2,6-di-tert-butyl-*p*-cresol

***trans*-Crotonic acid** *[107-93-7]* **M 86.1, m 72-72.5°, pK_1^{25}-6.17 (aq H_2SO_4), pK_2^{18} 4.71.** Distd under reduced pressure. Crystd from pet ether (b 60-80°) or water, or by partial freezing of the melt.

***E*- and *Z*-Crotonitrile (mixture)** *[4786-20-3]* **M 67.1, b 120-121°, d 1.091, n 1.4595.** Separated by preparative GLC on a column using 5% FFAP on Chromosorb G. [Lewis et al. *J Am Chem Soc* **108** 2818 *1986*.]

γ-Crotonolactone [2(5*H*)-furanone] *[497-23-4]* **M 84.1, m 3-4°, 76-77°/3.5mm, 90.5-91°/11.5mm, 92-93°/14mm, 107-109°/24mm, 212-214°/760mm, d_4^{20} 1.197, n_D^{20} 1.470.** Fractionally distd under reduced pressure. IR: (CCl_4) 1784 and 1742 cm^{-1}, UV no max above 205nm (ε 1160 cm^{-1} M^{-1}) and ^1H NMR: (CCl_3) τ: 2.15 (pair of triplets 1H), 3.85 (pair of triplets 1H) and 5.03 (triplet 2H). [*Org Synth* Coll Vol V 255 *1973*; Smith and Jones *Can J Chem* **37** 2007, 2092 *1959*].

Crotyl bromide *[29576-14-5]* **M 135.0, b 103-105°/740mm, n^{25} 1.4792.** Dried with $MgSO_4$, $CaCO_3$ mixture. Fractionally distd through an all-glass Todd column. [**Todd column.** A column (which may be a Dufton type, fitted with a Monel metal rod and spiral, or a Hempel type, fitted with glass helices) which is surrounded by an open heating jacket so that the temperature can be adjusted to be close to the distillation temperature (Todd *Ind Eng Chem (Anal Ed)* **17** 175 *1945*)].

15-Crown-5 *[33100-27-5]* **M 220.3, b 93-96°/0.1mm, d 1.113, n 1.465.** Dried over 3A molecular sieves.

18-Crown-6 *[17455-13-9]* **M 264.3, m 37-39°.** Recrystd from acetonitrile and vacuum dried. Purified by pptn of 18-crown-6/nitromethane 1:2 complex with Et_2O/nitromethane (10:1 mixture). The complex is decomposed in vacuum and distilled under reduced pressure. Also recrystd from acetonitrile and vacuum dried.

Cryptopine *[482-74-6]* **M 369.4, m 220-221°.** Crystd from *benzene.

Cryptoxanthin *[472-70-8]* **M 552.9, $A^{1\%}_{1cm}$ 2370 (452nm), 2080 (480nm) in pet ether.** Purified by chromatography on MgO, $CaCO_3$ or deactivated alumina, using EtOH or diethyl ether to develop the column. Crystd from $CHCl_3$/EtOH. Stored in the dark, under inert atmosphere, at -20°.

Crystal Violet Chloride {Gentian violet, *N*-4[bis[4-(dimethylaminophenyl)methylene]-2,5-cyclohexadien-1-ylidene]-*N*-methylmethaninium chloride} *[548-62-9]* **M 408.0, pK 9.36.** Crystd from water (20mL/g), the crystals being separated from the chilled soln by centrifugation, then washed with chilled EtOH (sol 1g in 10 mL of hot EtOH) and diethyl ether and dried under vac. It is sol in $CHCl_3$ but insol in Et_2O. The carbinol was ppted from an aqueous soln of the HCl dye, using excess NaOH, then dissolved in HCl and recrystd from water as the chloride [UV and kinetics: Turgeon and La Mer *J Am Chem Soc* **74** 5988 *1952*]. The *carbinol base* has **m** 195° (needles from EtOH). The *diphthalate* (blue and turns red in H_2O) crystallises from H_2O, **m** 153-154° (dec 185-187°)[Chamberlain and Dull *J Am Chem Soc* **50** 3089 *1928*].

Cumene (isopropyl benzene) *[98-82-8]* **M 120.2, b 69-70°/41mm, 152.4°/760mm, d 0.864, n 1.49146, n^{25} 1.48892.** Usual purification is by washing with several small portions of conc H_2SO_4 (until the acid layer is no longer coloured), then with water, 10% aq Na_2CO_3, again with water, and drying with $MgSO_4$, $MgCO_3$ or Na_2SO_4, followed by fractional distn. It can then be dried with, and distd from, Na, NaH or CaH_2. Passage through columns of alumina or silica gel removes oxidation products. Has also been steam

distd from 3% NaOH, and azeotropically distd with 2-ethoxyethanol (which was subsequently removed by washing out with water).

Cumene hydroperoxide *[80-15-9]* **M 152.2, b 60°/0.2mm, d 1.028, n^{24} 1.5232.** Purified by adding 100mL of 70% material slowly and with agitation to 300mL of 25% NaOH in water, keeping the temperature below 30°. The resulting crystals of the sodium salt were filtered off, washed twice with 25 mL portions of *benzene, then stirred with 100mL of *benzene for 20min. After filtering off the crystals and repeating the washing, they were suspended in 100mL of distilled water and the pH was adjusted to 7.5 by addn of 4M HCl. The free hydroperoxide was extracted into two 20mL portions of *n*-hexane, and the solvent was evaporated under vacuum at room temperature, the last traces being removed at 40-50° and 1mm [Fordham and Williams *Canad J Res* **27B** 943 *1949*]. Petroleum ether, **but not diethyl ether**, can be used instead of *benzene, and powdered solid CO_2 can replace the 4M HCl. *The material is potentially* **EXPLOSIVE.**

Cuminaldehyde (4-isopropylbenzaldehyde) *[122-03-2]* **M 148.2, b 82-84°/3.5mm, 120°/23mm, 131-135°/35mm, 235-236°/760mm, d^{20} 0.978, n_D^{20} 1.5301.** Likely impurity is the benzoic acid. Check the IR for the presence of OH from CO_2H and the CO frequencies. If acid is present then dissolve in Et_2O, wash with 10% $NaHCO_3$ until effervescence ceases, then with brine, dry over $CaCl_2$, evap and distil the residual oil, preferably under vacuum. It is almost insoluble in H_2O, but soluble in EtOH and Et_2O. The *thiosemicarbazone* has **m** 147° after recrystn from aqueous EtOH, or MeOH or *C_6H_6. [Crounse *J Am Chem Soc* **71** 1263 *1949*; Bernstein et al. *J Am Chem Soc* **73** *906* 1951; Gensler and Berman *J Am Chem Soc* **80** 4949 *1958*.]

Cuprein (6'-hydroxycinchonidine) *[524-63-0]* **M 310.4, m 202°, $[\alpha]_D^7$ -176° (in MeOH), pK^{15} 7.63.** Crystd from EtOH.

Curcumin [bis-(4-hydroxy-3-methoxycinnamoyl)methane] *[458-37-7]* **M 368.4, m 183°.** Crystd from EtOH or acetic acid.

Cyanamide *[420-04-2]* **M 42.0, m 41°, pK_1^{25} -0.36, pK_2^{25} 10.27.** See cyanamide on p. 416 in Chapter 5.

Cyanoacetamide *[107-91-5]* **M 84.1, m 119.4°.** Crystd from MeOH/dioxane (6:4), then water. Dried over P_2O_5 under vacuum.

Cyanoacetic acid *[372-09-8]* **M 85.1, m 70.9-71.1°, pK^{25} 2.47.** Crystd to constant melting point from *benzene/acetone (2:3), and dried over silica gel.

Cyanoacetic acid hydrazide *[140-87-4]* **M 99.1, m 114.5-115°.** Crystd from EtOH.

***p*-Cyanoaniline** *[873-74-5]* **M 118.1, m 85-87°.** See *p*-aminobenzonitrile on p. 104.

9-Cyanoanthracene (anthracene-9-carbonitrile) *[1210-12-4]* **M 203.2, m 134-137°.** Purified by crystn from EtOH or toluene, and vacuum sublimed in the dark and in an inert atmosphere [Ebied et al. *J Chem Soc, Faraday Trans 1* **76** 2170 *1980*; Kikuchi et al. *J Phys Chem* **91** 574 *1987*].

9-Cyanoanthracene photodimer *[33998-38-8]* **M 406.4, dec to monomer above ~147°.** Purified by dissolving in the minimum amount of $CHCl_3$ followed by addition of EtOH at 5° [Ebied et al. *J Chem Soc, Faraday Trans 1* **75** 1111 *1979*; **76** 2170 *1980*].

***p*-Cyanobenzoic acid** *[619-65-8]* **M 147.1, m 219°, pK^{25} 3.55.** Crystd from water and dried in vacuum desiccator over Sicapent.

4-Cyanobenzoyl chloride *[6068-72-0]* **M 165.6, m 68-70°,69-70°, 73-74°, b 132°/8mm, 150-151°/25mm.** If the IR shows presence of OH then treat with $SOCl_2$ boil for 1h, evaporate and distil in

vacuum. The distillate solidifies and can be recrystallised from pet ether. It is moisture sensitive and is an **IRRITANT.** [Ashley et al. *J Chem Soc* 103 *1942*; Fison et al. *J Org Chem* **16** 648 *1951*.]

Cyanoguanidine (dicyanodiamide) *[461-58-5]* **M 84.1, m 209.5°, pK -0.4.** Crystd from water or EtOH.

5-Cyanoindole *[15861-24-2]* **M 142.2, m 106-108°, 107-108°, pK <0.** Dissolve in 95% EtOH boil in the presence of charcoal, filter, evaporate to a small volume and add enough H_2O to cause crystallisation and cool. Recrystd directly from aqueous EtOH and dried in a vacuum. UV: λ_{max} 276 nm (log ε 3.6) in MeOH. [Lindwall and Mantell *J Org Chem* **18** 345 *1953*, **20** 1458 *1955*; Thesing at al. *Chem Ber* **95** 2205 *1962*; NMR: Lallemend and Bernath *Bull Soc Chim Fr* 4091 *1970*.]

***p*-Cyanophenol** *[767-00-0]* **M 119.1, m 113°, pK^{25} 7.97.** Crystd from pet ether, *benzene or water and kept under vacuum over P_2O_5. [Bernasconi and Paschelis *J Am Chem Soc* **108** 2969 *1986*.]

3-Cyanopyridine *[100-54-9]* **M 104.1, m 50°, pK^{25} 1.38.** Crystd to constant melting point from *o*-xylene/hexane.

4-Cyanopyridine *[100-48-1]* **M 104.1, m 76-79°, pK^{25} 1.86.** Crystd from dichloromethane/diethyl ether mixture.

Cyanuric acid (2,4,6-trichloro-1,3,5-triazine) *[108-80-5]* **M 120.1, m >300°, pK 6.78.** Crystd from water. Dried at room temperature in a desiccator under vacuum.

Cyanuric chloride (TCT, 2,4,6-trichloro-1,3,5-triazine) *[108-77-0]* **M 184.4, m 146-149°, 154°, b 190°.** Crystd from CCl_4 or pet ether (b 90-100°), and dried under vacuum. Recrystd twice from anhydrous *benzene immediately before use [Abuchowski et al. *J Biol Chem* **252** 3582 *1977*].

Cyclobutane carboxylic acid *[3721-95-7]* **M 100.1, m 3-4°, -5.4°, b 84-84.5°/10mm, 110°/25mm, 135-138°/110mm, 194°/760mm, d_4^{20} 1.061, n_D^{20} 1.453, pK^{25} 4.79.** Dissolve in aqueous HCO_3^- and acidify with HCl and extract into Et_2O, wash with H_2O, dry (Na_2SO_4), concentrate to a small volume, then distil through a glass helices packed column. The *S-benzylthiouronium salt* has ***m*** *176°* (from EtOH), and the *anilide* has **m** 112.5-113°, and the *p-toluide* has **m** 123°. [Payne and Smith *J Org Chem* **22** 1680 *1957*; Kantaro and Gunning *J Am Chem Soc* **73** 480 *1951*.]

***trans*-Cyclobutane-1,2-dicarboxylic acid** *[1124-13-6]* **M 144.1, m 131°, pK_1^{25} 4.11, pK_2^{25} 5.15.** Crystd from *benzene.

Cyclobutanone *[1191-95-3]* **M 70.1, b 96-97°, d 0.931, n^{52} 1.4189.** Treated with dilute aqueous $KMnO_4$, dried with molecular sieves and fractionally distd. Purified *via* the semicarbazone, then regenerated, dried with $CaSO_4$, and distd in a spinning-band column. Alternatively, purified by preparative gas chromatography using a Carbowax 20-M column at 80°. (This treatment removes acetone).

Cyclobutylamine *[2516-34-9]* **M 71.1, b 82-83°/atm, 83.2-84.2°/760mm, d_4^{20} 0.839, n_D^{20} 1.437, pK^{25} 10.04 (9.34 in 50% aq EtOH).** It has been purified by steam distn. The aqueous distillate (e.g. 2L) is acidified with 3N HCl (90mL) and evapd to dryness in a vacuum. The *hydrochloride* is treated with a few mL of H_2O, cooled in ice and a slush of KOH pellets ground in a little H_2O is added slowly in portions and keeping the soln very cold. The amine separates as an oil from the strongly alkaline soln. The oil is collected dried over solid KOH and distd using a vac jacketed Vigreux column and protected from CO_2 using a soda lime tube. The fraction boiling at 79-83° is collected, dried over solid KOH for 2 days and redistd over a few pellets of KOH (**b** 80.5-81.5°). Best distil in a dry N_2 atmosphere. The purity can be checked by GLC using a polyethylene glycol on Teflon column at 72°, 15 psi, flow rate of 102 mL/min of He. The sample can appear homogeneous but because of tailing it is not possible to tell if H_2O is present. The NMR in CCl_4 should show no signals less than 1 ppm from TMS. The *hydrochloride* has a multiplet at *ca* 1.5-2.6ppm (H 2,2,4,3,3,4,4), a quintet at 3.8 ppm (H 1) and a singlet at 4.75 for NH_2 [Roberts and Chambers *J Am Chem*

Soc **73** 2509 *1951*]. The *benzenesulfonamide* has **m** 85-86° (from aq MeOH) and the *benzoyl derivative* has **m** 120.6-121.6° [Roberts and Mazur *J Am Chem Soc* **73** 2509 *1951*; Iffland et al. *J Am Chem Soc* **75** 4044 *1953*; *Org* Synth Coll Vol V 273 *1973*.]

Cyclodecanone *[1502-06-3]* **M 154.2, m 21-24°, b 100-102°/12mm.** Purified by sublimation in a vac.

***cis*-Cyclodecene** *[935-31-9]* **M 138.3, m -3°, -1°, b 73°/15mm, 90.3°/33mm, 194-195°/740mm, 197-199°/atm, d_4^{20} 0.8770, n_D^{20} 1.4854.** Purified by fractional distn. It forms an $AgNO_3$ complex which crystallises from MeOH, **m** 167-187° [Cope et al. *J Am Chem Soc* **77** 1628 *1955*; IR: Blomqvist et al. *J Am Chem Soc* **74** 3636 *1952*; Prelog et al. *Helv Chim Acta* **35** 1598 *1952*].

α-Cyclodextrin (H_2O) *[10016-20-3]* **M 972.9, m >280°(dec), $[\alpha]_{546}^{20}$ +175° (c 10, H_2O).** See entry on p. 524 in Chapter 6.

β-Cyclodextrin (H_2O) *[7585-39-9, 68168-23-0]* **M 1135.0, m >300°(dec), $[\alpha]_{546}^{20}$ +170° (c 10, H_2O).** See entry on p. 524 in Chapter 6.

***trans-cis-cis*-1,5,9-Cyclododecatriene (cyclododec-1c,5c,9t-triene)** *[2765-29-9]* **M 162.3, m -9°, -8°, b 117.5°/2mm, 237-239°/atm, 244°/760mm, d_4^{20} 0.907, n_D^{20} 1.5129.** Purified by fractional distn, preferably in a vacuum under N_2, and forms an insoluble $AgNO_3$ complex. [Breil et al. *Makromol Chemie* **69** 28 *1963*.]

Cyclododecylamine *[1502-03-0]* **M 183.3, m 27-29°, b 140-150°/*ca* 18mm, 280°/atm, pK 9.62 (in 80% methyl cellosolve).** It can be purified *via* the *hydrochloride salt* **m** 274-275° (from EtOH) or the *picrate* **m** 232-234°, and the free base is distd at water-pump vacuum [Prelog et al. *Helv Chim Acta* **33** 365 *1950*].

1,3-Cycloheptadiene *[4054-38-0]* **M 94.2, b 55°/75mm, 71.5°/150mm, 120-121°/atm, d_4^{20} 0.868, n_D^{20} 1.4972.** It was purified by dissolving in Et_2O, wash with 5% HCl, H_2O, dry ($MgSO_4$), evap and the residue is distd under dry N_2 through a semi-micro column (some foaming occurs) [Cope et al. *J Am Chem Soc* **79** 6287 *1957;* UV: Pesch and Friess *J Am Chem Soc* **72** 5756 *1950*].

Cycloheptane *[291-64-5]* **M 98.2, b 114.4°, d 0.812, n 1.4588.** Distd from sodium, under nitrogen.

Cycloheptanol *[502-41-0]* **M 114.2, b 77-81°/11mm, 185°/atm, d 0.951, n 1.477.** Purified as described for cyclohexanol.

Cycloheptanone *[502-42-1]* **M 112.2, b 105°/80mm, 172.5°/760, d 0.952, n^{24} 1.4607.** Shaken with aq $KMnO_4$ to remove material absorbing around 230-240nm, then dried with Linde type 13X molecular sieves and fractionally distd.

Cycloheptatriene *[544-25-2]* **M 92.1, b 114-115°, d 0.895, n 1.522.** Washed with alkali, then fractionally distd.

Cycloheptylamine *[5452-35-7]* **M 113.2, b 50-52°/11mm, 60°/18mm, d_4^{20} 0.887, n_D^{20} 1.472, pK_{Est} ~10.5 (H_2O), pK^{24} 9.99 (in 50% aq methyl cellosolve).** It can be purified by conversion to the *hydrochloride* **m** 242-246°, and the free base is distd under dry N_2 in a vacuum [Cope et al. *J Am Chem Soc* **75** 3212 *1953*; Prelog et al. *Helv Chim Acta* **33** 365 *1950*].

1,3-Cyclohexadiene *[592-57-4]* **M 80.1, b 83-84°/atm, d_4^{20} 0.840, n_D^{20} 1.471.** Distd from $NaBH_4$.

1,4-Cyclohexadiene *[628-41-1]* **M 80.1, b 83-86°/714mm, 88.3°/741mm, 86-88°/atm, 88.7-89°/760mm, d_4^{20} 0.8573, n_4^{20} 1.4725.** Dry over $CaCl_2$ and distil in a vacuum under N_2. [Hückel and Wörffel *Chem Ber* **88** 338 *1955*; Giovannini and Wegmüller *Helv Chim Acta* **42** 1142 *1959*.]

Cyclohexane *[110-82-7]* **M 84.2, f 6.6°, b 80.7°, d^{24} 0.77410, n 1.42623, n^{25} 1.42354.** Commonly, washed with conc H_2SO_4 until the washings are colourless, followed by water, aq Na_2CO_3 or 5% NaOH, and again water until neutral. It is next dried with P_2O_5, Linde type 4A molecular sieves, $CaCl_2$, or $MgSO_4$ then Na and distd. Cyclohexane has been refluxed with, and distd from Na, CaH_2, $LiAlH_4$ (which also removes peroxides), sodium/potassium alloy, or P_2O_5. Traces of *benzene can be removed by passage through a column of silica gel that has been freshly heated: this gives material suitable for ultraviolet and infrared spectroscopy. If there is much *benzene in the cyclohexane, most of it can be removed by a preliminary treatment with nitrating acid (a cold mixture of 30mL conc HNO_3 and 70mL of conc H_2SO_4) which converts *benzene into nitrobenzene. The impure cyclohexane and the nitrating acid are placed in an ice bath and stirred vigorously for 15min, after which the mixture is allowed to warm to 25° during 1h. The cyclohexane is decanted, washed several times with 25% NaOH, then water dried with $CaCl_2$, and distd from sodium. Carbonyl-containing impurities can be removed as described for chloroform. Other purification procedures include passage through columns of activated alumina and repeated crystn by partial freezing. Small quantities may be purified by chromatography on a Dowex 710-Chromosorb W gas-liquid chromatographic column.
Rapid purification: Distil, discarding the forerun. Stand distillate over Grade I alumina (5% w/v) or 4A molecular sieves.

Cyclohexane butyric acid *[4441-63-8]* **M 170.3, m 31°, 26.5-28.5°, b 136-139°/4mm. 169°/20mm, 188.8°/46mm, pK^{25} 4.95.** Distil through a Vigreux column, and the crystalline distillate is recrystd from pet ether. The *S-benzylthiouronium salt* has **m** 154-155° (from EtOH) [*Acta Chem Scand* **9** 1425 *1955*; English and Dayan *J Am Chem Soc* **72** 4187 *1950*].

Cyclohexane-1,2-diaminetetraacetic acid (H_2O; CDTA) *[13291-61-7]* **M 364.4, pK_1 1.34, pK_2 3.20, pK_3 5.75 (6.12), pK_4 9.26 (12.35).** Dissolved in aq NaOH as its disodium salt, then pptd by adding HCl. The free acid was filtered off and boiled with distd water to remove traces of HCl [Bond and Jones *Trans Faraday Soc* **55** 1310 *1959*]. Recrystd from water and dried under vacuum.

***trans*-Cyclohexane-1,2-dicarboxylic acid** *[2305-32-0]* **M 172.2, m 227.5-228°, 228-230.5°, pK_1^{25} 4.30, pK_2^{25} 6.06 [*cis* , pK_1^{25} 4.25, pK_2^{25} 6.74].** It is purified by recrystn from EtOH or H_2O. The *dimethyl ester* has **m** 95-96° (from *C_6H_6-pet ether). [Abell *J Org Chem* **22** 769 *1957*; Smith and Byrne *J Am Chem Soc* **72** 4406 *1950*; Linstead et al. *J Am Chem Soc* **64** 2093 *1942*.]

(±)-*trans*-1,2-Cyclohexanediol *[1460-57-7]* **M 116.2, m 104°, 105°, 120°/14mm.** Crystd from Me_2CO and dried at 50° for several days. It can also be recrystd from CCl_4 or EtOAc and can be distilled. The *2,4-dinitrobenzoyl derivative* has **m** 179°. [Winstein and Buckles *J Am Chem Soc* **64** 2780 *1942*.]

***trans*-1,2-Cyclohexanediol** *[1R,2R-(-)- 1072-86-2; 1S,2S-(+)- 57794-08-8]* **M 116.2, m 107-109°, 109-110.5°, 109-111°, 111-112°, 113-114°, $[\alpha]_D^{22}$ (-) and (+) 46.5° (c 1, H_2O).** The enantiomers have been recrystd from *C_6H_6 or EtOAc. The (±) diol has been resolved as the distrychnine salt of the hemisulfate [Hayward, Overton and Whitham *J Chem Soc Perkin Trans 1* 2413 *1976*]; or the *l-menthoxy acetates*. {l-trans- diastereoisomer has **m** 64°, $[\alpha]_D$ -91.7° (c 1.4 EtOH) from pet ether or aqueous EtOH and yields the (-)-*trans*-diol } and {d-trans-diastereoisomer has **m** 126-127°, $[\alpha]_D$ -32.7° (c 0.8 EtOH) from pet ether or aq EtOH and yields the (+)-trans diol}. The bis-*4-nitrobenzoate* has **m** 126.5° $[\alpha]_D$ (-) and (+) 25.5° (c 1.1 $CHCl_3$), and the bis-*3,5-dinitrobenzoate* has **m** 160° $[\alpha]_D$ ± -83.0° (c 1.8 $CHCl_3$) [Wilson and Read *J Chem Soc* 1269 *1935*].

***cis*-1,3-Cyclohexanediol** *[823-18-7]* **M 116.2, m 86°.** Crystd from ethyl acetate and acetone.

***trans*-1,3-Cyclohexanediol** *[5515-64-0]* **M 116.2, m 117°.** Crystd from ethyl acetate.

***cis*-1,4-Cyclohexanediol** *[556-58-9]* **M 116.2, m 102.5°.** Crystd from acetone (charcoal), then dried and sublimed under vacuum.

Cyclohexane-1,3-dione *[504-02-9]* **M 112.1, m 107-108°.** Crystd from *benzene.

Cyclohexane-1,4-dione *[637-88-7]* **M 112.1, m 76-77°, 78°, 79.5°, 79-80°, b 130-133°/20mm, d_4^{91} 1.0861, n_D^{102} 1.4576.** Crystd from water, then *benzene. It can also be recrystd from $CHCl_3$/pet ether or Et_2O. It has been purified by distn in a vacuum and the pale yellow distillate which solidified is then recrystd from CCl_4 (14.3 g/100 mL) and has **m** 77-79°. The *di-semicarbazone* has **m** 231°, the *dioxime HCl* has **m** 150° (from MeOH-*C_6H_6) and the bis-*2,4-dinitrophenylhydrazone* **m** 240° (from $PhNO_2$). [*Org Synth* Coll Vol V 288 *1973*; IR: LeFevre and LeFevre *J Chem Soc* 3549 *1956*.]

Cyclohexane-1,2-dione dioxime (Nioxime) *[492-99-9]* **M 142.2, m 189-190°, pK_1^{25} 10.68, pK_2^{25} 11.92.** Crystd from alcohol/water and dried in a vacuum at 40°.

1,4-Cyclohexanedione monoethylene acetal (1,4-dioxa-spiro[4.5]decan-8-one) *[4746-97-8]* **M 156.2, m 70-73°, 73.5-74.5°.** Recrystd from pet ether and sublimes slowly on attempted distillation. Also purified by dissolving in Et_2O and adding pet ether (b 60-80°) until turbid and cool. [Gardner et al. *J Am Chem Soc* **22** 1206 *1957*; Britten and Lockwood *J Chem Soc Perkin Trans 1* 1824 *1974*.]

***cis,cis*-1,3,5-Cyclohexane tricarboxylic acid** *[16526-68-4]* **M 216.2, m 216-218°, $pK_{Est(1)}$~4.1, $pK_{Est(2)}$ ~5.4, $pK_{Est(3)}$ ~6.8.** Purified by recrystn from toluene + EtOH or H_2O. It forms a *1.5 hydrate* with **m** 216-218°, and a *dihydrate* at 110°. Purified also by conversion to the *triethyl ester* **b** 217-218°/10mm, 151°/1mm and distillate solidifies on cooling, **m** 36-37° and is hydrolysed by boiling in aq HCl. The *trimethyl ester* can be distd and recrystd from Et_2O, **m** 48-49°. [Newman and Lawrie *J Am Chem Soc* **76** 4598 *1954*, Lukes and Galik *Coll Czech Chem Comm* **19** 712 *1954*.]

Cyclohexanol *[108-93-0]* **M 100.2, m 25.2°, b 161.1°, d 0.946, n 1.466, n^{25} 1.437, n^{30} 1.462.** Refluxed with freshly ignited CaO, or dried with Na_2CO_3, then fractionally distd. Redistd from Na. Further purified by fractional crystn from the melt in dry air. Peroxides and aldehydes can be removed by prior washing with ferrous sulfate and water, followed by distillation under nitrogen from 2,4-dinitrophenylhydrazine, using a short fractionating column: water distils as the azeotrope. Dry cyclohexanol is *very hygroscopic*.

Cyclohexanone *[108-94-1]* **M 98.2, f -16.4°, b 155.7°, d 0.947, n^{15} 1.452. n 1.451, pK^{25} -6.8 (aq H_2SO_4), pK^{25} 11.3 (enol), 16.6 (keto).** Dried with $MgSO_4$, $CaSO_4$, Na_2SO_4 or Linde type 13X molecular sieves, then distd. Cyclohexanol and other oxidisable impurities can be removed by treatment with chromic acid or dil $KMnO_4$. More thorough purification is possible by conversion to the bisulfite addition compound, or the semicarbazone, followed by decompn with Na_2CO_3 and steam distn. [For example, equal weights of the bisulfite adduct (crystd from water) and Na_2CO_3 are dissolved in hot water and, after steam distn, the distillate is saturated with NaCl and extracted with *benzene which is then dried and the solvent evaporated prior to further distn.]

Cyclohexanone oxime *[100-64-1]* **M 113.2, m 90°.** Crystd from water or pet ether (b 60-80°).

Cyclohexanone phenylhydrazone *[946-82-7]* **M 173.3, m 77°.** Crystd from EtOH.

Cyclohexene *[110-83-8]* **M 82.2, b 83°, d 0.810, n 1.4464, n^{25} 1.4437.** Freed from peroxides by washing with successive portions of dil acidified ferrous sulfate, or with $NaHSO_3$ soln then with distd water, dried with $CaCl_2$ or $CaSO_4$, and distd under N_2. Alternative methods of removing peroxides include passage through a column of alumina, refluxing with sodium wire or cupric stearate (then distilling from sodium). Diene is removed by refluxing with maleic anhydride before distg under vac. Treatment with 0.1moles of MeMgI in 40mL of diethyl ether removes traces of oxygenated impurities. Other purification procedures include washing with aq NaOH, drying and distg under N_2 through a spinning band column; redistg from CaH_2; storage with sodium wire; and passage through a column of alumina, under N_2, immediately before use. Stored in a

refrigerator under argon. [Woon et al. *J Am Chem Soc* **108** 7990 *1986*; Wong et al. *J Am Chem Soc* **109** 3428 *1987*.]

(±)-2-Cyclohexen-1-ol (3-hydroxycyclohex-1-ene) *[822-67-3]* **M 242.2, b 63-65°/12mm, 65-66°/13mm, 67°/15mm, 74°/25mm, 85°/35mm, 166°/atm, d_4^{20} 0.9865, n_D^{20} 1.4720.** Purified by distillation through a short Vigreux column. The *2,4-dinitrobenzoyl derivative* has **m** 120.5°, and the *phenylurethane* has **m** 107°. [*Org Synth* **48** 18 *1968*, Cook *J Chem Soc* 1774 *1938*; Deiding and Hartman *J Am Chem Soc* **75** 3725 *1953*.]

Cyclohexene oxide *[286-20-4]* **M 98.2, b 131-133°/atm, d_4^{20} 0.971, n_D^{20} 1.452.** Fractionated through an efficient column. The main impurity is probably H_2O. Dry over $MgSO_4$, filter and distil several times (**b** 129-134°/atm). The residue is sometimes hard to remove from the distilling flask. To avoid this difficulty, add a small amount of a mixture of ground NaCl and Celite (1:1) to help break the residue particularly if H_2O is added. [*Org Synth* Coll Vol I 185 *1948*.]

Cycloheximide *[68-81-9]* **M 281.4, m 119.5-121°, $[\alpha]_{546}^{20}$ +9.5° (c 2, H_2O).** Crystd from water/MeOH (4:1), amyl acetate, isopropyl acetate/isopropyl ether or water.

Cyclohexylamine *[108-91-8]* **M 99.2, b 134.5°, d 0.866, d^{25} 0.863, n 1.4593, n^{25} 1.456, pK^{25} 10.63.** Dried with $CaCl_2$ or $LiAlH_4$, then distd from BaO, KOH or Na, under N_2. Also purified by conversion to the hydrochloride, several crystns from water, then liberation of the amine with alkali and fractional distn under N_2.

Cyclohexylbenzene *[827-52-1]* **M 160.3, f 6.8°, b 237-239°, d 0.950, n 1.5258.** Purified by fractional distn, and fractional freezing.

Cyclohexyl bromide *[108-85-0]* **M 156.3, b 72°/29mm, d 0.902, n^{25} 1.4935.** Shaken with 60% aqueous HBr to remove the free alcohol. After separation from excess HBr, the sample was dried and fractionally distd.

Cyclohexyl chloride *[542-18-7]* **M 118.6, b 142-142.5°, d 1.000, n 1.462.** See chlorocyclohexane on p. 162.

1-Cyclohexylethylamine *[S-(+): 17430-98-7; R-(-): 5913-13-3]* **M 127.2, b 177-178°/atm, d_4^{20} 0.866, n_D^{20} 1.446, $[\alpha]_D^{15}$ (-) and (+) 3.2° (neat), pK_{Est} ~10.6.** Purified by conversion to the *bitartrate salt* (**m** 172°), then decomposing with strong alkali and extracting into Et_2O, drying (KOH), filtering, evaporating and distilling. The *hydrochloride salt* has **m** 242° (from EtOH-Et_2O), $[\alpha]_D^{15}$ -5.0° (c 10 H_2O; from (+) amine). The *oxalate salt* has **m** 132° (from H_2O). The *(±)-base* has **b** 176-178°/760mm, and *HCl* has **m** 237-238°. [Reihlen, Knöpfle and Sapper *Justus Liebigs Ann Chem* **532** 247 *1938*; *Chem Ber* **65** 660 *1932*.]

Cyclohexylidene fulvene *[3141-04-6]* **M 134.2.** Purified by column chromatography and eluted with *n*-hexane [Abboud et al. *J Am Chem Soc* **109** 1334 *1987*].

Cyclohexyl mercaptan (cyclohexane thiol) *[1569-69-3]* **M 116.2, b 38-39°/12mm, 57°/23mm, 90°/100mm, 157°/763mm, d_4^{20} 0.949, n_D^{20} 1.493, pK_{Est} ~10.8.** Possible impurities are the sulfide and the disulfide. Purified by conversion to the Na salt by dissolving in 10% aq NaOH, extract the sulfide and disulfide with Et_2O, and then acidify the aq soln (with cooling and under N_2) with HCl, extract with Et_2O, dry $MgSO_4$, evaporate and distil in a vacuum (**b** 41°/12mm). The *sulfide* has **b** 74°/0.2mm, $n_D^{18.5}$ 1.5162 and the *disulfide* has **b** 110-112°/0.2mm, $n_D^{18.5}$ 1.5557. The *Hg-mercaptide* has **m** 77-78° (needles from EtOH). [Naylor *J Chem Soc* 1532 *1947*.]

Cyclohexyl methacrylate *[101-43-9]* **M 168.2, b 81-86°/0.1mm, d 0.964, n 1.458.** Purification as for methyl methacrylate.

1-Cyclohexyl-5-methyltetrazole *[7707-57-5]* **M 166.2, m 124-124.5°.** Crystd from absolute EtOH, then sublimed at 115°/3mm.

Cyclononanone *[3350-30-9]* **M 140.2, m 142.0-142.8°, b 220-222°.** Repeatedly sublimed at 0.05-0.1mm pressure.

***cis,cis*-1,3-Cyclooctadiene** *[29965-97-7]* **M 108.2, m -5°, -49°, b 55°/34mm, 142-144°/760mm, d_4^{20} 0.8690, n_D^{20} 1.48921.** Purified by GLC. Fractionally distd through a Widmer column [as a mobile liquid and redistilled with a Claisen flask or through a semi-micro column [Gould, Holzman and Neiman *Anal Chem* **20** 361 *1948*]. **NB:** It has a strong characteristic disagreeable odour detectable at low concentrations and causes headaches on prolonged exposure. [IR: Cope and Estes *J Am Chem Soc* **72** 1128 *1950*; UV: Cope and Baumgardner *J Am Chem Soc* **78** 2812 *1956*.] **[Widmer column.** A Dufton column, modified by enclosing within two concentric tubes the portion containing the glass spiral. Vapour passes up the outer tube and down the inner tube before entering the centre portion. In this way flooding of the column, especially at high temperatures, is greatly reduced (Widmer *Helv Chim Acta* **7** 59 *1924*).]

***cis-cis*-1,5-cyclooctadiene,** *[1552-12-1]* **M 108.2, m -69.5°, -70°, b 51-52°/25mm, 97°/144mm, 150.8°/757mm, d_4^{20} 0.880, n_D^{20} 1.4935, .** Purified by GLC. It has been purified *via* the $AgNO_3$ salt. This is prepared by shaking with a soln of 50% aq $AgNO_3$ w/w several times (e.g. 3 x 50 mL and 4 x 50 mL) at 70° for *ca* 20min to get a good separation of layers. The upper layers are combined and further extracted with $AgNO_3$ at 40° (2 x 20 mL). The upper layer (19 mL) of original hydrocarbon mixture gives colourless needles $AgNO_3$ complex on cooling. The adduct is recrystd from MeOH (and cooling to 0°). The hydrocarbon is recovered by steam distilling the salt. The distillate is extracted with Et_2O, dried ($MgSO_4$), evap and distd. [Jones *J Chem Soc* 312 *1954*.]

Cyclooctanone *[502-49-8]* **M 126.2, m 42°.** Purified by sublimation after drying with Linde type 13X molecular sieves.

1,3,5,7-Cyclooctatetraene *[629-20-9]* **M 104.2, b 141-141.5°, d 1.537, n^{25} 1.5350.** Purified by shaking 3mL with 20mL of 10% aqueous $AgNO_3$ for 15min, then filtering off the silver nitrate complex as a ppte. The ppte was dissolved in water and added to cold conc ammonia to regenerate the cyclooctatetraene which was fractionally distd under vacuum onto molecular sieves and stored at 0°. It was passed through a dry alumina column before use [Broadley et al. *J Chem Soc, Dalton Trans* 373 *1986*].

***cis*-Cyclooctene** *[931-88-4]* **M 110.2, b 32-34°/12mm, 66.5-67°/60mm, 88°/141mm, 140°/170mm, 143°/760mm, d_4^{20} 0.84843, n_D^{20} 1.4702, .** The *cis*-isomer was freed from the *trans*-isomer by fractional distn through a spinning-band column, followed by preparative gas chromatography on a Dowex 710-Chromosorb W GLC column. It was passed through a short alumina column immediately before use [Collman et al. *J Am Chem Soc* **108** 2588 *1986*]. It has also been distd in a dry nitrogen glove box from powdered fused NaOH through a Vigreux column and then passed through activated neutral alumina before use [Wong et al. *J Am Chem Soc* **109** 4328 *1987*]. Alternatively it can be purified *via* the $AgNO_3$ salt. This salt is obtained from crude cyclooctene (40 mL) which is shaken at 70-80° with 50% w/w $AgNO_3$ (2 x 15 mL) to remove cyclooctadienes (aq layer). Extraction is repeated at 40° (4 x 20 mL, of 50% $AgNO_3$). Three layers are formed each time. The middle layer contains the $AgNO_3$ adduct of cyclooctene which crystallises on cooling the layer to room temperature. The adduct (complex 2:1) is highly soluble in MeOH (at least 1g/mL) from which it crystallises in large flat needles when cooled at 0°. It is dried under slight vacuum for 1 week in the presence of $CaCl_2$ and paraffin wax soaked in the cyclooctene. It has **m** 51° and loses hydrocarbon on exposure to air. *cis*-Cyclooctene can be recovered by steam distn of the salt, collected, dried ($CaCl_2$) and distilled in vacuum. [Braude et al. *J Chem Soc* 4711 *1957*; $AgNO_3$: Jones *J Chem Soc* 1808 *1954*; Cope and Estes *J Am Chem Soc* **72** 1128 *1950*.]

***cis*-Cyclooctene oxide {(1r,8c)-9-oxabicyclo[6.1.0]nonane}** *[286-62-4]* **M 126.7, m 56-57°, 57.5-57.8°,50-60°, b 85-88°/17mm, 82.5°/22mm, 90-93°/37mm, 189-190°/atm.** It can be distd in vacuum and the solidified distillate can be sublimed in vacuum below 50°. It has a characteristic odour.

[IR: Cope et al. *J Am Chem Soc* **74** 5884 *1952*, **79** 3905 *1957*; Reppe et al. *Justus Liebigs Ann Chem* **560** 1 *1948*].

Cyclopentadecanone *[502-72-7]* **M 224.4, m 63°.** Sublimation is better than crystn from aq EtOH.

Cyclopentadiene *[542-92-7]* **M 66.1, b 41-42°.** Dried with $Mg(ClO_4)_2$ and distd.

Cyclopentane *[287-92-3]* **M 70.1, b 49.3°, d 0.745, n 1.40645, n^{25} 1.4340.** Freed from cyclopentene by two passages through a column of carefully dried and degassed activated silica gel.

Cyclopentane carbonitrile *[4254-02-8]* **M 95.2, m -75.2°, -76°, b 43-44°/7mm, 50-62°/10mm, 67-68°/14mm, 74.5-75°/30mm, d_4^{20} 0.912, n_D^{20} 1.441.** Dissolve in Et_2O, wash thoroughly with saturated aqueous K_2CO_3, dry ($MgSO_4$) and distil through a 10 cm Vigreux column. [McElvain and Stern *J Am Chem Soc* **77** 457 *1955*, Bailey and Daly *J Am Chem Soc* **81** 5397 *1959*.]

Cyclopentane-1,1-dicarboxylic acid *[5802-65-3]* **M 158.1, m 184°, pK_1 3.23, pK_2 4.08.** Recrystd from water.

1,3-Cyclopentanedione *[3859-41-4]* **M 98.1, m 149-150°, 151-152.5°, 151-154°, 151-153°.** Purified by Soxhlet extraction with $CHCl_3$. The $CHCl_3$ is evaporated and the residue is recrystd from EtOAc and/or sublimed at 120°/4mm. It has an acidic pKa of 4.5 in H_2O. [IR: Boothe et al. *J Am Chem Soc* **75** 1732 *1953*; DePuy and Zaweski *J Am Chem Soc* **81** 4920 *1959*.]

Cyclopentanone *[120-92-3]* **M 84.1, b 130-130.5°, d 0.947, n 1.4370, n^{25} 1.4340.** Shaken with aq $KMnO_4$ to remove materials absorbing around 230 to 240nm. Dried with Linde type 13X molecular sieves and fractionally distd. Has also been purified by conversion to the $NaHSO_3$ adduct which, after crystallising four times from EtOH/water (4:1), was decomposed by adding to an equal weight of Na_2CO_3 in hot H_2O. The free cyclopentanone was steam distd from the soln. The distillate was saturated with NaCl and extracted with *benzene which was then dried and evaporated; the residue was distd [Allen, Ellington and Meakins *J Chem Soc* 1909 *1960*].

Cyclopentene *[142-29-0]* **M 68.1, b 45-46°, d 0.772, n 1.4228.** Freed from hydroperoxide by refluxing with cupric stearate. Fractionally distd from Na. Chromatographed on a Dowex 710-Chromosorb W GLC column. Methods for **cyclohexene** should be applicable here. Also washed with 1M NaOH soln followed by water. It was dried over anhydrous Na_2SO_4, distd over powdered NaOH under nitrogen, and passed through neutral alumina before use [Woon et al. *J Am Chem Soc* **108** 7990 *1986*]. It was distd in a dry nitrogen atmosphere from powdered fused NaOH through a Vigreux column, and then passed through activated neutral alumina before use [Wong et al. *J Am Chem Soc* **109** 3428 *1987*].

1-Cyclopentene-1,2-dicarboxylic anhydride *[3205-94-5]* **M 138.1, m 42-54°, 46-47°, b 130°/5mm, 133-135°/5mm, n_D^{20} 1.497.** If IR has OH peaks then some hydrolysis to the diacid (**m** 178°) must have occurred. In this case reflux with an appropriate volume of Ac_2O for 30min, evaporate the Ac_2O and distil *in vacuo*. The distillate solidifies and can be recrystd from EtOAc-hexane (1:1). The diacid distils without dec due to formation of the anhydride. The *dimethyl ester* has **m** 120-125°/11mm. [Askain *Chem Ber* **98** 2322 *1965*.]

Cyclopentylamine *[1003-03-8]* **M 85.2, m -85.7°, b 106-108°/760mm, 108.5°/760mm, d_4^{20} 0.869, n_D^{20} 1.452, pK^{25} 10.65, (pK^{25} 4.05 in 50% aq EtOH).** May contain H_2O or CO_2 in the form of carbamate salt. Dry over KOH pellets and then distil from a few pellets of KOH. Store in a dark, dry CO_2-free atmosphere. It is characterised as the *thiocyanate salt* **m** 94.5°. The *benzenesulfonyl derivative* has **m** 68.5-69.5°. [Roberts and Chambers *J Am Chem Soc* **73** 5030 *1951*; Bollinger et al. *J Am Chem Soc* **75** 1729*1953*.]

Cyclopropane *[75-19-4]* **M 42.1, b -34°.** Washed with a soln of $HgSO_4$, and dried with $CaCl_2$, then $Mg(ClO_4)_2$.

Cyclopropanecarbonyl chloride *[4023-34-1]* **M 104.5, b 117.9-118.0°/723mm, 119.5-119.6°/760mm, d_4^{20} 1.142, n_4^{20} 1.453.** If the IR shows OH bands then some hydrolysis to the free acid must have occurred. In this case heat with oxalyl chloride at 50° for 2h or $SOCl_2$ for 30min, then evap and distil three times using a Dufton column. Store in an inert atm, preferably in sealed tubes. Strong **IRRITANT.** If it is free from OH bands then just distil *in vacuo* and store as before. [Jeffrey and Vogel *J Chem Soc* 1804 *1948.*]

Cyclopropane-1,1-dicarboxylic acid *[598-10-7]* **M 130.1, m 140°, pK_1^{25} 1.8, pK_2^{25} 5.42.** Recrystd from $CHCl_3$.

Cyclopropylamine *[765-30-0]* **M 57.1, b 49-49.5°/760mm, 48-50°/atm, 49-50°/750mm, d_4^{20} 0.816, n_D^{20} 1.421, pK^{25} 9.10 (pK^{25} 5.33 in 40% aq EtOH).** It has been isolated as the *benzamide* **m** 100.6-101.0° (from aqueous EtOH). It forms a *picrate* **m** 149° (from EtOH-pet ether) from which the free base can be recovered using a basic ion exchange resin and can then be distd through a Todd column (see p. 174) using an automatic still head which only collects products boiling below 51°/atm. Polymeric materials if present will boil above this temperature. The *hydrochloride* has **m** 85-86° [Roberts and Chambers *J Am Chem Soc* **73** 5030 *1951*; Jones *J Org Chem* **9** 484 *1944*; Emmons *J Am Chem Soc* **79** 6522 *1957*].

Cyclopropyldiphenylcarbinol *[5785-66-0]* **M 224.3, m 86-87°.** Crystd from *n*-heptane.

Cyclopropyl methyl ketone *[765-43-5]* **M 84.1, b 111.6-111.8°/752mm, d 0.850, n 1.4242.** Stored with anhydrous $CaSO_4$, distd under nitrogen. Redistd under vacuum.

Cyclotetradecane *[295-17-0]* **M 192.3, m 56°.** Recrystd twice from aq EtOH then sublimed *in vacuo* [Dretloff et al. *J Am Chem Soc* **109** 7797 *1987*].

Cyclotetradecanone *[3603-99-4]* **M 206.3, m 25°, b 145°/10mm, d 0.926, n 1.480.** It was converted to the semicarbazone which was recrystd from EtOH and reconverted to the free cyclotetradecanone by hydrolysis [Dretloff et al. *J Am Chem Soc* **109** 7797 *1987*].

Cyclotrimethylenetrinitramine (RDX, 1,3,5-trinitrohexahydro-1,3,5-triazine) *[121-82-4]* **M 222.2, m 203.8°(dec).** Crystd from acetone. **EXPLOSIVE.**

***p*-Cymene** *[99-87-6]* **M 134.2, b 177.1°, d 0.8569, n 1.4909, n^{25} 1.4885.** Washed with cold, conc H_2SO_4 until there is no further colour change, then repeatedly with H_2O, 10% aqueous Na_2CO_3 and H_2O again. Dried with Na_2SO_4, $CaCl_2$ or $MgSO_4$, and distd. Further purification steps include steam distn from 3% NaOH, percolation through silica gel or activated alumina, and a preliminary refluxing for several days over powdered sulfur. Stored over CaH_2.

Cystamine dihydrochloride, *S,S*-(L,L)-Cystathionine, Cysteamine, Cysteamine hydrochloride, (±)-Cysteic acid, *S*-Cysteic acid (H_2O), L-Cysteine hydrochloride (H_2O), (±)-Cysteine hydrochloride and **L-Cystine, Cytidine,** see entries in Chapter 6.

Cytisine (7*R*,9*S*-7,9,10,11,12,13-hexahydro-7,9-methano-12*H*-pyrido[1,2-*a*][1,5]diazocin-8-one, Laburnine, Ulexine) *[485-35-8]* **M 190.3, m 152-153°, 155°, b 218°/2mm, $[\alpha]_D^{17}$ -120° (H_2O), $[\alpha]_D^{25}$ -115° (c 1, H_2O), pK_1^{15} 1.20, pK_2^{15} 8.12 [also stated are pK_1 6.11, pK_2 13.08].** Crystd from acetone and sublimed in a vacuum. Its solubilities are: 77% (H_2O), 7.7% (Me_2CO), 28.6% (EtOH), 3.3% (*C_6H_6), 50% ($CHCl_3$) but is insoluble in pet ether. The *tartrate* has **m** 206-207° $[\alpha]_D^{24}$ +45.9°, the *N-tosylate* has **m** 206-207°, and the *N-acetate* has **m** 208°. [Bohlmann et al. *Angew Chem* **67** 708 *1955*; van Tamelen and Baran *J Am Chem Soc* **77** 4944 *1955*; Isolation: Ing *J Chem Soc* 2200 *1931*; Govindachari et al. *J Chem Soc* 3839 *1957*; Abs config: Okuda et al. *Chem Ind (London)* 1751 *1961.*] **TOXIC.**

Cytosine see entry in Chapter 6.

cis-Decahydroisoquinoline *[2744-08-3]* M 139.2, b 97-98°/15mm, 208-209°/730mm, pK^{20} 11.32.

The free base is treated with satd aq picric acid, allowed to stand for 12h, filtd, washed with MeOH to remove the more soluble *trans* isomer and recrystd from MeOH to give pure cis-*picrate* **m** 149-150°. The picrate (~5g) is shaken with 5M aq NaOH (50mL) and Et_2O (150mL) while H_2O is added to the aq phase to dissolve insoluble Na picrate. The Et_2O extract is dried over solid NaOH and then shaken with Al_2O_3 (Merck for chromatography) until the yellow color of traces of picric acid disappears (this color cannot be removed by repeated shaking with 5-10 M aq NaOH). The extract is concentrated to 50mL and dry HCl is bubbled through until separatn of the white crysts of the cis-*HCl* is complete. These are washed with Et_2O, dried at 100° and recrystd from EtOH + EtOAc to yield pure cis-*Hydrochloride* **m** 182-183° (dried in a vac desiccator over KOH) with IR (KBr) ν_{max} 2920, 2820, 1582, 1470, 1445, 1410, 1395, 1313, 1135, 1080, 990, 870 cm^{-1}. The pure *free base* is prepared by dissolving the *hydrochloride* in 10 M aq NaOH, extracted with Et_2O, dried over solid KOH, filtd and distd in vac. It has IR (film) ν_{max} 2920, 2820, 2720, 2560, 1584, 1470, 1445, 1415, 1395, 1315, 1300, 1135, 1080, 1020, 990, 873 cm^{-1}. The ^1H NMR in $CDCl_3$ is characteristically different from that of the *trans*-isomer. [Armarego *J Chem Soc (C)* 377 *1967*; Gray and Heitmeier *J Am Chem Soc* **80** 6274 *1958*; Witkop *J Am Chem Soc* **70** 2617 *1948;* Skita *Chem Ber* **57** 1982 *1924*; Helfer *Helv Chim Acta* **6** 799*1923*.]

trans-Decahydroisoquinoline *[2744-09-4]* M 139.2, b 106°/15mm, pK^{20} 11.32.

This is purified as the *cis*-isomer above. The trans-*picrate* has **m** 175-176°, and the trans-*hydrochloride* has **m** 221-222° and has IR (KBr) ν_{max} 2930, 3800, 1589, 1450, 1400, 1070, 952, 837 cm^{-1}. The pure *free base* was prepared as above and had IR (film) ν_{max} 2920, 2820, 2720, 2560, 1584, 1470, 1445, 1415, 1395, 1315, 1300, 1135, 1080, 1020, 990, 873 cm^{-1}. The ^1H NMR in $CDCl_3$ is characteristically different from that of the *cis*-isomer. (references as above and Helfer *Helv Chim Acta* **9** 818 *1926*).

Decahydronaphthalene (decalin, mixed isomers) *[91-17-8]* M 138.2, b 191.7°, d 0.886, n 1.476.

Stirred with conc H_2SO_4 for some hours. Then the organic phase was separated, washed with water, saturated aqueous Na_2CO_3, again with water, dried with $CaSO_4$ or CaH_2 (and perhaps dried further with Na), filtered and distd under reduced pressure (**b** 63-70°/10mm). Also purified by repeated passage through long columns of silica gel previously activated at 200-250°, followed by distn from $LiAlH_4$ and storage under N_2. Type 4A molecular sieves can be used as a drying agent. Storage over silica gel removes water and other polar substances.

cis-Decahydronaphthalene *[493-01-6]* M 138.2, f -43.2°, b 195.7°, d 0.897, n 1.48113.

Purification methods described for the mixed isomers are applicable. The individual isomers can be separated by very efficient fractional distn, followed by fractional crystn by partial freezing. The *cis*-isomer reacts preferentially with $AlCl_3$ and can be removed from the *trans*-isomer by stirring the mixture with a limited amount of $AlCl_3$ for 48h at room temperature, filtering and distilling.

trans-Decahydronaphthalene *[493-02-7]* M 138.2, f -30.6°, b 187.3°, d 0.870, n 1.46968.

See purification of *cis*-isomer above.

cis-Decahydroquinoline *[10343-99-4]* M 139.2, b 207-208°/708mm , pK^{20} 11.29.

It is available as a *cis-trans*-mixture (**b** 70-73°/10mm, Aldrich, ~ 18% *cis*-isomer *[2051-28-7]*), but the isomers can be fractionated in a spinning band column (1~1.5 metre, type E) at atmospheric pressure and collecting 2mL fractions with a distillation rate of 1 drop in 8-10sec. The lower boiling fraction solidifies and contains the *trans*-isomer (see below, **m** 48°). The higher boiling fraction **b** 207-208°/708mm, remains liquid and is mostly the *cis*-isomer. This is reacted with PhCOCl and M aq NaOH to yield the *N-benzoyl derivative* **m** 96° after recrystn from pet ether (b 80-100°). It is hydrolysed with 20% aq HCl by refluxing overnight. $PhCO_2H$ is filtd off, the filtrate is basified with 5M aq NaOH and extracted with Et_2O. The dried extract (Na_2SO_4) is satd with dry HCl gas and the *cis-decahydroquinoline hydrochloride* which separates has **m** 222-224° after washing with Et_2O and drying at 100°; and has IR (KBr) ν_{max} 2900, 2780, 2560, 1580, 1445, 1432, 1403, 1165, 1080,

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