[illegible]

Olfaction

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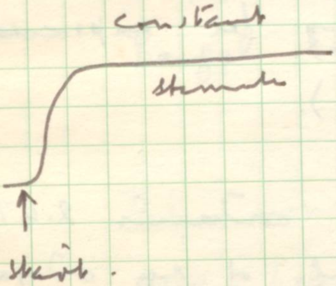
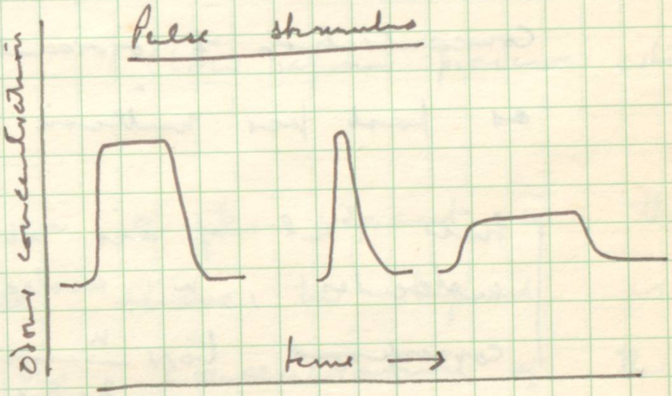
1. Instrumental aspects of olfactometry

A. Dravnieks
in
Methods in olfactory research

1. Principal physical dimensions of stimulus

1. Duration :-





Instrumentation.

Stuiver, M. (1960) An olfactometer with a wide range of possibilities.
Acta Oto-laryngol. 51, 135-142

Wenzel, B.M. (1948). Techniques in olfactometry
Psychol. Bull., 45, 231-247.

Engelmith, K. and Krueger, K. (1970). The construction of a programmable olfactometer. Behav. Res. Meth. Instr. 2, 19-22

2. Stimulus generation

Dilution : $w/w+V$ (w = odour vol ; V = diluent air)

may be expressed as pZ. $\left(Z = -\log_{10} \frac{w}{w+V} \right.$

$= \log_{10} \frac{w+V}{w}$)

Concentration of odorant may be expressed as part per million (ppm).

Since 1 ml of air at 25 °C contains 2.47×10^{19} molecules, n molecules/ml of an odorant correspond to $\frac{n}{2.5 \times 10^{19}}$

Other possible usages are microgram/litre or mole per litre of air.

Dilution methods:

(1) Odorant is diluted by liquid non odorous solvents.

(2) Odorant is vaporised and the vapours diluted with air.

SOLVENT DILUTION

(1) For liquid dilution a non-odorous solvent is required. Commonly used solvents are:

Water
Paraffin oil (highly refined medicinal)
Propylene glycol U.S.P.
Benzyl benzoate (low vapour pressure ester).

The concentration of the odorant in the air head-space above the liquid is proportional to the concentration of the odorant in the solution by an activity coefficient γ. This factor differs for different odorants and changes with the solvent (or even with concentration)

$$\boxed{p_i = (\gamma_i)(x_i)(p_i^o)} \qquad \text{I}$$

p_i = vapour pressure of odorant above solution.

p_i^o = vapour pressure of pure odorant at temperature of solution.

x_i = concentration in mol fraction units of odorant i in solution

γ_i = Activity coefficient which reflects the intermolecular interactions between odorant and the solvent.

{ For a hydrocarbon such as hexane in water $\gamma >> 1$ while for a solution of hexane in paraffin oil $\gamma << 1$.

Esters as solvents tend to exhibit a narrower range of $\underline{\gamma}$ values, giving a better proportionality between $\underline{p_i}$ and $\underline{p_i^\circ}$.

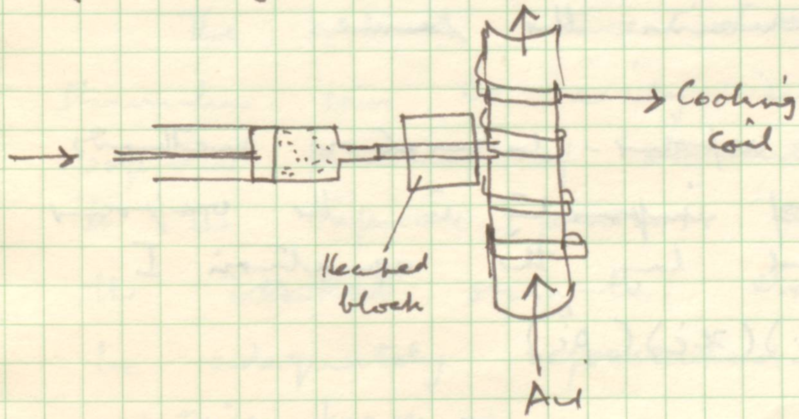
In addition to the thermodynamic difficulty (γ) - there is a kinetic difficulty. The pulse involves a removal of odorant in the gas phase (usually by introduction of a volume of air) - This ~~produces~~ results in gradual depletion in the liquid phase.

~~In addition~~ Evaporation and reestablishment of equilibrium requires time - It can be hastened by rapid mixing and bubbling through the liquid phase but this causes the formation of aerosol.

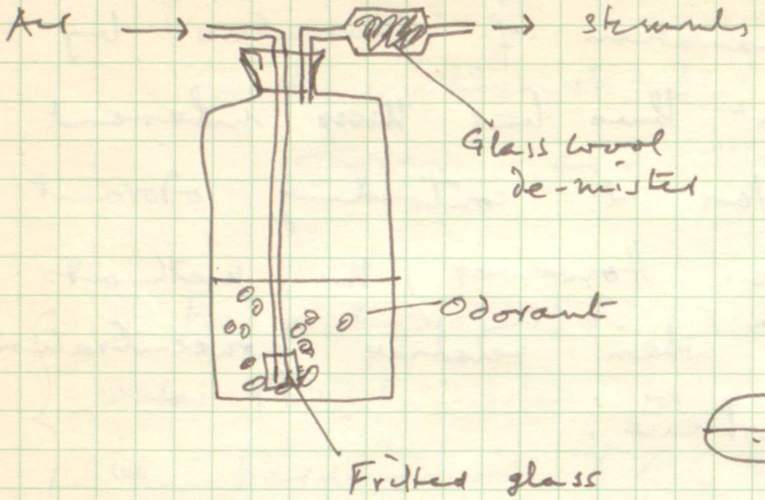
The preparation of stimulus by dilution in solvent thus has inherent limitations as far at controlling odorant concentration goes. However, the methods is convenient when relative concentration alone is important.

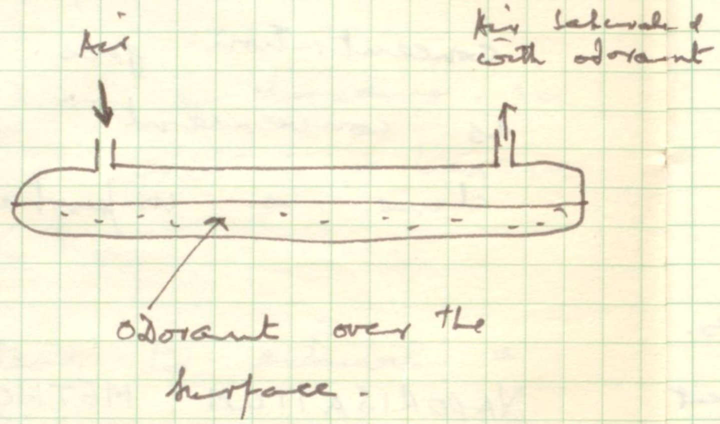
VAPORISATION METHODS

Two somewhat different techniques are possible. In complete direct vaporisation the odorant or its solution in non-odorous solvent is fed at a constant rate to a vaporiser — The vapour is then mixed with a constant flow vol. of air (Sehrberger et al 1958)



In saturated vapour method, air or other non-odorous gas is brought in contact with pure odorant and saturated with odorants vapour. The vapour-saturated air is then diluted to the desired extent.





Both of the above methods raise problems about impurities —

When odorant is totally vaporised the impurities co-vaporise — There is no change in the purity level of the remaining supply of odorant; the relative concentration of the impurities remains the same.

In the vapour-saturation methods the concentration of impurity in the vapour is determined by the equation I

$$p_i = (\gamma_i)(x_i)(p_i^0)$$

Two effects result. The impurity may be initially over-represented in the vapour but is gradually depleted from the supply. On the other hand if the impurity is less volatile than the odorant it will gradually accumulate in the supply.

For chemosensory work the usual conception of purity (i.e. 99+%) is not adequate — Much greater purification by gas chromatography or zone refining may be necessary and the vaporisation of impurity relative to odorant must be taken into account.

a) <u>Complete vaporisation method</u> (Scherberger et. al., 1958; Ind. Hyg. J. 19, 494-498).

The method is useful when very large volumes of air must be odorised. Preparation of higher dilutions presents problems

b) <u>Vapour saturation methods</u>:

The actual concentration of odorant in stimulus can be easily determined if the vapour pressure of odorant is known. If the vapour pressure is not known, the ~~[illegible]~~ stimulus strength then can be adequately represented in terms of a relative pressure

$$p_r = \frac{p_i}{p_i^0}$$

where p_i = vapour pressure of odorant in diluted stimulus.

p_c^0 = vapour pressure of odorant in saturator. (constant as long as temperature is constant).

p_r = relative vapour pressure $\equiv$ fraction of saturation.

Some substances eg. aliphatic acids dimerise in gas phase, so that two types of species will be present in vapour, single molecules and paired molecules. The ratio of the two is concentration dependent and only the total formed concentration can be calculated from the total vapour pressure tables. Ultimately at high dilutions the monomer will dominate

The saturation of a gas with vapour is done by sparging or by passing the gas over extended surface. The methods can be used with solids but one has to worry about particles being entrapped in the gas.

As vapour pressure increases with temperature, the saturator must be kept at constant temperature. The required constancy can be estimated from vapour-pressure tables (Handbook of Chemistry) - For instance for 1-butanol the vapour pressure at ambient increases 6% / °C

Passage of carrier gas through porous glass filter into liquid is a very efficient way of "sparging" - But this generates aerosol. These must be filtered effectively. Tightly packed glass wool is a suitable filter.

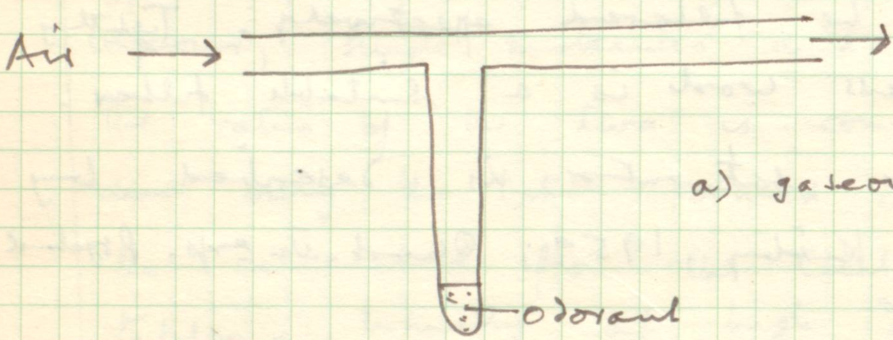
A simple saturator is described by Cheesmann + Kirby, 1959; Quart. J. exp. Psychol. 11, 115-123.

Squeeze flask technique

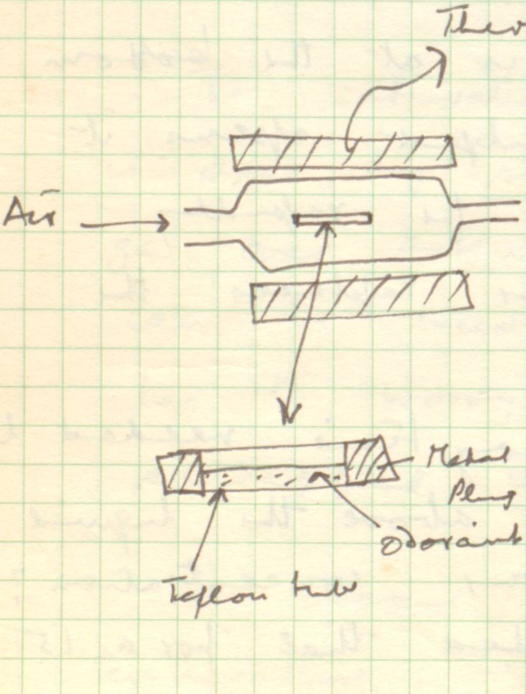
The odorant liquid is at the bottom of a plastic flask. The subject opens it and squeezes to sniff the rapidly expell the air - Fresh air replaces the expelled air:

What is the recovery time needed to restore the head space above the liquid to the original vapour concentration? Wuek (1971) has calculated that for a 15 cm high head space — in the absence of mixing 90% saturation will be reached in ~30 mins. If the liquid is shaken in a circular pattern much faster equilibration (fraction of a minute) takes place. Vigorous shaking should be avoided to prevent aerosol.

Diffusion method (Altshuller and Cohen, 1966; Anal. Chem, 32, 802-810)



a) gaseous diffusion



b) Permeation through teflon

Permeation method

(O'Keefe & Ortman, 1966)

(Martin and Dubrecht, 1970)

<Gas chromatograph may be as an olfactory stimulator. (Sniff at any peak) → by delivering through the stimulus port any given peak.

PURITY OF CARRIER GAS

Compressed air supplied by pumps is usually odorous.

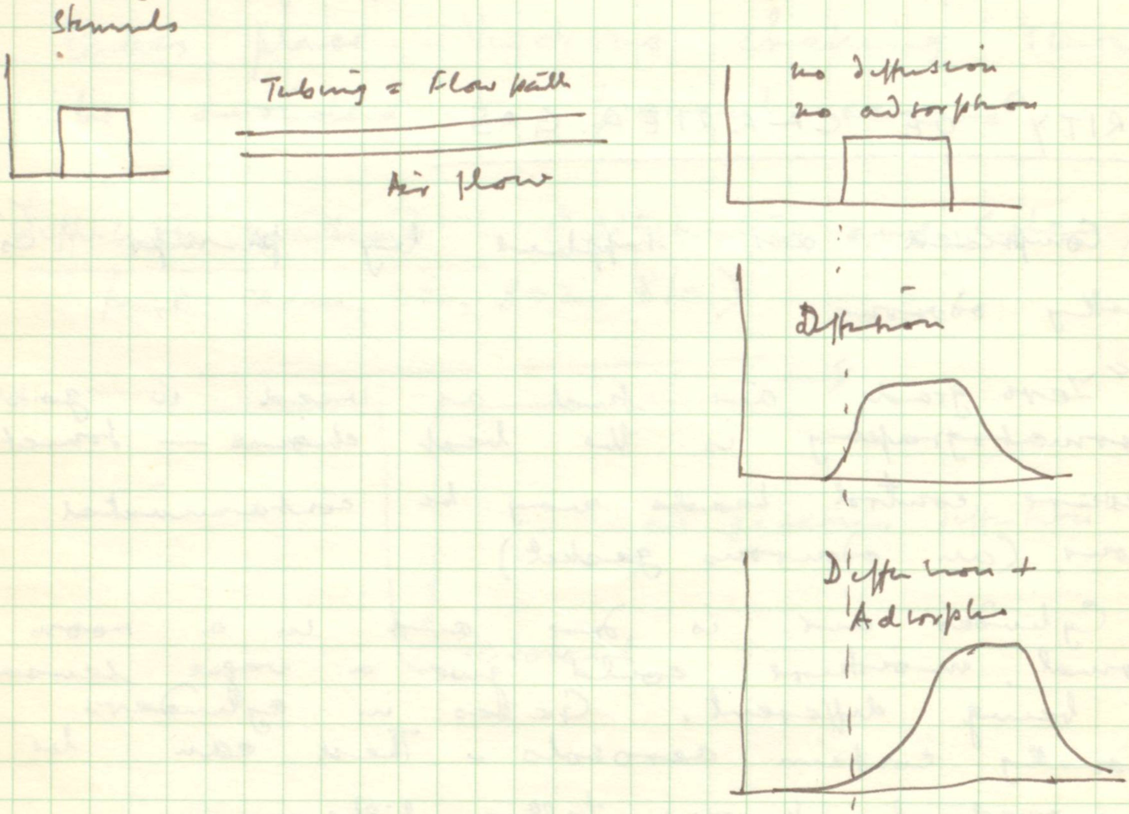
"Zero grade" air such as used in gas chromatography is the best choice — sometimes pressure control heads may be contaminated with odours (an odourous gasket)

Cylinder air is dry and in a room with normal moisture could give a vague sensation of being different. Gases in cylinders usually contain aerosols - These can be removed by porous teflon filters.

If the use of cylinders is not desirable air may be pumped into the olfactometer from free atmosphere or the "room" — An "aquarium pump" or a graphite vane pump will supply non odorous air. Intake must be away from possible sources of odour (hood exhausts, chemical storage etc) . It is important to remove particles by filteration.

Purification: Purification is usually carried out after compression. For a purification method see Valenta, 1970 (?).

TRANSITION TIME IN STIMULUS CHANGE



Turns in the flow path, cross-sectional changes, valves etc cause temporary turbulence which subsides after a distance of 10 to 20 diameters of the tube length.

(When two flows are to be mixed, turbulence is desirable)

WALL MATERIALS (Important)

Walls must be clean from grease and oil and preferably constructed from inorganic material

Plastics always contain volatile lower molecular monomers of the polymeric material and frequently contain plasticisers which are volatile.

Plastics dissolve organic vapours and are much more difficult to decontaminate

Probably the only plastics worth considering as permanent part of an olfactometric apparatus are various teflons which can be decontaminated with prolonged flushing (+ if necessary heating).

Polyethylene tubing is reasonably odourless, at least for humans - It cannot be heated beyond 100°C.

Tygon (vinyl) tubing especially formulated for use with food products (Formulation B-44-4X) is lower in odour than the usual laboratory variety.

Inorganic material such as glass or metal do not dissolve odorants but do adsorb them. The physically adsorbed amount increased with the molecular size of the odorant and depends upon the vapour pressure of the odorant. The ultimate amount of adsorbed material is on the order of 10^{15} molecules per cm^2.

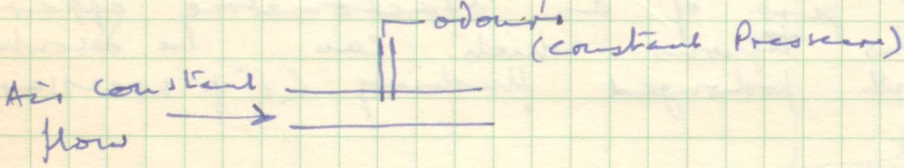
Stainless steel is probably is the best choice in materials for olfactometry. It can be joined by overlapping neoprene or Tygon tubing.

Stainless steel tubings in 1.6 mm (1/16 inches) and a range of internal diameters (0.1mm to 0.75mm) are available

Teflon coated steel & aluminium tubings are also available.

FLOW CONTROL

Splitters serve to reduce odour concentration by adding non-odorant carrier gas. The flow of carrier gas used for dilution at the downstream end of a capillary is fast.



The capillary stream and the dilution stream should meet at 90° angle to avoid a pushing or pulling effect.

Capillaries produce a constant flow when pressure is held constant.

Another system of flow-rate regulation is with constant flow valves (Brooks valves) widely used in gas chromatography. These valves supply a constant volumetric flow.

Flow rate measurements

The most accurate device for flow rate measurement is wet gasometer which is used for caliberating other flow-meters.

(For devices see Considine and Ross; 1964 and Gas Engineers handbook, 1965).

Considine, M. D. and Ross, S. D. (1964) Handbook of applied instrumentation. 5-12 + 5-21. Mc Graw Hill. Book Co. N. York.

Estimate of odour concentration

When stimulus is generated by saturating a clean carrier gas with the odorants vapour, the calculations are based on the vapour pressure of the odorant. For dilute vapours the vapour pressure is independent of total pressure and molecular concentration at reaching the equilibrium vapour pressure is:

$$n_i = \frac{6\times10^{23} \cdot 273\, p_i}{(22400)\, T\, 760} \approx 0.96 \cdot 10^{19} \frac{p_i}{T}$$

(Total = approximatly 3.2×10^{16} at $25^\circ C$)

n_i = molecules/ml

p_i = vapour pressure of odorant mm Hg at T

T = temperature Kelvin of odorant in generator

The total number of molecules of the odorant and the carrier gas per ml of vapour space at a reasonable pressure is:

$$n_t = \frac{6.10^{23} \cdot 273\, pt}{(22400)\, 760\, T}$$

or approximately $3.2.10^{16}\, pt$ at $25^{\circ}C$

nt = total number of molecules per ml

pt = total pressure mm, odorant and carrier gas in vapour space above the odorant.

Consequently the molecular concentration of the odorant in a stimulus leaving the pot is

$$n_a = \frac{ni\,(6.10^{23}) \cdot 273\, pa}{nt\,(22400)\, T\, 760} \approx \frac{ni}{nt} \times 0.96.10^{15} \cdot \frac{pa}{T}$$

$$= 10^{15} \frac{pa}{T} \left(\frac{ni}{nt}\right)$$

n_a = number of odorant molecules / ml

pa = barometric pressure in test room

T = temperature Kelvin of stimulus

For vapour pressure data look up Handbook of Chemistry and Physics (1970)

Perry, (1963) Chemical Engineers Handbook 3-213, 3-231. Mc Graw Hill - N. Y

Vapour pressures can be estimated for some compounds if those of its homologues are known. Vapour pressure varies systematically within a homologous series.

When vapour pressure at two temperatures is known its value for the intermediate temperature (if the melting point is not in this interval) can be obtained from a plot of the log of vapour pressure against $1/T$.

Methods of stimulus analysis

GC

Tracer methods.

Stimulus delivery systems:

For humans (see Köster, 1967, 1971 and others described by Dravnieks).

For animals (Moulton et al, 1978).
in Dravnieks.

Smell:

(Check Merck Index).

Methyl salycilate (Oil of winter green)

Amyl acetate (Oil of banana)

Odours to test (Volatile Chemicals).

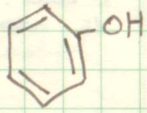
Alcohols

Monohydroxyhydric:

		Boiling Point	Structure
Methanol	CH_3OH		64.7
Ethanol	C_2H_5OH		
Propanol	C_3H_7OH		
n-butanol	$(CH_3)(CH_2)_3 \cdot OH$	117°C	
iso-butanol ✓ 3-methyl butanol	$(CH_3)_2 \cdot CH \cdot CH_2OH$	99°C	
Amyl alcohol	$C_5H_{11}OH$		
Octyl alcohol	$C_8H_{17}OH$ n-iso	184.6	
Dodecanol Lauryl alcohol	$C_{12}H_{25}OH$	259	
Geraniol	$(CH_3)_2 \cdot C \cdot CH \cdot CH_2 \cdot CH_2 \cdot C \cdot CH_3$ $\|\|$ $HC\,CH_2OH$ (230°C)		
3-octanol			

Remarks	Larval response	Adult	Source References
Tested (Veronica)	Strong	Attracts until 10^{-3}	
Tested (Veronica)	Strong	Attracts till 10^{-2} then repells	
Tested (Veronica)			
{stimulates. Pentanol receptor in cockroach – which responds als to Bannana, apples, oranges + fresh meat			Sass, H. (1978) Pentanol sensilum has 2 cells. The second cell responds to rotten meat
{Tested (Veronica) {Irritating			
Unpleasant odour		Unpleasant (Veronica)	
Sweet Rose Smell.			Dudai (1979). Buyers (1977)
{Octanol cell in cockroach responds weakly to fruits – The Octanol sensilum has 2 cells, the second cell responds to these + rotten meat.			Dudai (1979) Buyers (1977) Sass. H. (1978)

Alcohols

			Boiling Pt
Unsaturated			
Linalool (Isomer of) Geraniol			198°C
Aromatic			
Benzyl alcohol			204.7°C
Cyclohexanol			161°C
4-Methyl cyclohexanol			170°C - 180°C

Remarks		Source. References.
Found in orange flavour. (Veronica).		
Camphor odour		Sass (1979) see hexanol type cell
odour similar to cyclohexanol		Dodd (1979) Byers (1977

Alcohols (continued)

	Structure	VP / BP
Polyhydric: alcohols		197.6°C
Ethylene glycol	$CH_2OH \cdot CH_2OH$	
Propylene glycol	$CH_3 \cdot CHOH \cdot CH_2OH$	189°C
Triethylene glycol	$HO \cdot CH_2 \cdot CH_2 \cdot OCH_2 \cdot CH_2 \cdot OCH_2 \cdot CH_2OH$	218°C

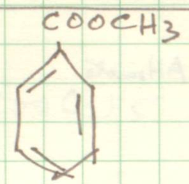
Remarks	Source

Acetates

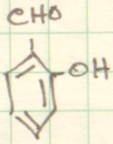
Ethyl acetate	$CH_3COOC_2H_5$	
Iso-amyl acetate	$(CH_3)_2CH.CH_2OH$	
Methyl acetate		
Butyl acetate		
Benzyl acetate		
Bornyl acetate		

Remarks	Drosophila: Larva	Drosophila: Adult	Source - Ref
Fruity	Strong	Attracts	
Pleasant fruity smell	Strong	Attracts	
			West (1961)
			West (1961). VISSER, 1979
			Visser, 1979
			Ryan's list

Possible Fruity smells.
Floral smells.

				BP.	Remarks	Larval Resp.	Adult Resp.	Sources.
Methyl benzoate				199.6° C	Mildly pleasant odour	Strong		
Methyl salicylate					Odours of Galitheria (oil of wintergreen)			

ALDEHYDES

Formaldehyde	HCHO		
Benzaldehyde			179°C
Salicylaldehyde			196°C
Acetaldehyde (Acetal)			
2-Decenal			
Dodecanal			
Heptanal			
Nonanal			
2-nonenal			
Octanal			
Propanal			
2,4. Decadienal			

Remarks	Larynx Resp.	Adult Response	Source - Reference
Pungent.	Med.	Att. ? Rep. ? Veronica	
Pungent, almond bitter odour,	Med	Rep. Veronica	
Bitter almond odour	Strong	Repellent Veronica	
		Attracts ?	West, A.S. (1961)
			M. Ryan's List
			"
			"
			"
			"
			"
			"
			"
			"
			"
			"
			"
			"
			"
			"

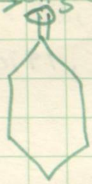
Aldehydes (continued)

Hexenal

Green odour - Receptors present in locust

{ Boeck, 1967
{ Kafka, 1970

Ketones

Acetone	$CH_3.CO.CH_3$		56.7
cyclohexanone -			156.7
4-methyl-3 heptanone			
3-Octanone			
2-methyl-5-octanone			
3-nonanone			
α Ionone			
β Ionone			
2-heptanone			

	Larval Response	Adult	
	Strong	Attracts	
Peppermint	Strong		
			(Anti) Kafka 1974
			"
			"
			"
			Ryan's list
			"
			Bee alarm pheromone

Acids

			B.P
Formic acid	HCOOH		100.5
Acetic acid	CH_3COOH		118.1
Propionic acid	CH_3CH_2COOH		102.5
Butyric acid			
Hexanoic acid			

	Larval Response	Adult Response	
Pungent	Week ~~Wea~~	Attracts till 10^{-3} then Repells.	
Vinegar smell	Week	Attracts till 10^{-3} then repells	
Rancid			
			Sass, 1979, Also Kafka. (*Periplaneta*)
			Sass, 1979 (Periplaneta).

Miscellaneous odorants

Pyridine

115.3

α-Pinene Coniferous odour

β-Pinene

Floral odours

Geraniol, neral, geranial, citronellol ~~nerol~~ nerol and eugenol

H_2S, NH_3, acetic acid & certain aliphatic aldehydes & Ketones

Larval Resp.

Adult resp.

Strong Repellent

(Hylobius) Pine weevil has receptors. for these

(Mustaparta, 1975)

Receptors in butterflies and flies

Boeckh, 1965

Kaib, 1974

Components of putrifying odours - receptors in Carrion beetle, Calliphora

Boeck, 1962

Waldow, 1973

Kaib, 1974

Amines:

Trimethylamine

diethylamine

1-aminobutane

Putrescine

aminocyclohexane.

Hydrocarbons

Biphenyl
Camphene
Caryophyllene
P. cymene
2.4. Dimethyl styrene
Dipentene
Isoprene
Limonene
α- Pinene
β- Pinene
α- Phellandrene
Sabinene

(West, 1961)

(Kafka, 1974)

Ants.

Ryans list -

Comparisons above

"

(Mustaberta)
1975.

α - Terpenene

γ - Terpinene

Terpinolene

γ - Bisabolene

Ethers

Methyl - iso - Eugenol.

Odorants against which Insects
have been tested. (& respond to)

West, A. S. 1961 — Attraction by - Diacetyl. (Attraction determined by trap-counts for 3 species)

Drosophila

Aerogenes culture

Acetaldehyde

Indole

Skatole

Trimethylamine

Methyl acetate

Butyl acetate ✓

Acetal ✓

Dudai, Y (1979)

Drosophila

3-Octanol

4-methylcyclohexanol

geraniol

benzaldehyde

Molin, C. (1978) ⟶ Peppermint essence elicits response from Drosophila.

Also Thorpe, 1939

Hershberger & Smith, 1967

Some general references on insect odorants

Jacobson, M. (1966) Chemical insect attractants and repellents. Ann Rev. Entomol.

Kafka, W. A. (1974) - Physico-chemical aspects of odour reception in insects
Ann. N.Y. Acad. Sci. 237, 115-128

Hansen, K (1978) - Insect chemoreception in Taxis and behaviour - Ed. G. L. Hazelbauer. pp 233-292.

PERIPLANETA

Cockroach (Receptor types) Responses to

Sass, H, 1979. 3-methyl butanol (Pentanol receptor)

Octanol

(Single units) responses Antenna

• The sense cells occur in certain fixed combinations (2-4 cells (sensillum) defining a "sensillum type".

(I). Pentanol sensillum (2-celled)

a) Bannana, apple, orange, lemon, lettuce, grass, bread fresh meat.

b). Rotten meat.

(II) Octanol sensillum (2-celled)

a) Octanol cell - broad spectrum of food odours - rotten meat.

b) cheese + rotten meat.

Hexanol types
Butyric acid
Hexanoic acid
Amine
Meat fresh
Meat old
Cheese
Bannana
Apples
Oranges.

(III) Hexanol sensillum (2-celled)

a) most food odours apple, banana, lemon (but not meat).

b) oil of cinnamon and cis-trans isoeugenol.

IV Alcohol-terpene sensillum (2-celled).

a) Strong response to lemon + orange.

b) food odours

V Butyric acid (3-celled)

a) stored cheese

(b + c) little response to food odours.

VI Cold-hexanoic acid (4-celled)

a) fatty acids

b) cold receptor

(c + d) meat odours

VII Amine sensillum (4-celled).

a) Stored meat remnies

b) fresh meat bannana apple, orange and bread.

c) old meat

• EAG Response (to general odours).

(Nishino et. al, 1979)

Alcohols (straight chain)

1- Pentanol
1- Hexanol
1- Heptanol
1- Octanol
1- Nonanol
1- Decanol
1- Dodecanol

~~Cyclic alcohol~~

Menthol (cyclic alcohol) strong response

Citronellol (straight chain) Medium

Nerol (straight chain) Medium

Carbonyl compounds

Citral

Camphor

Carvone

Citronellyl acetate

Neryl acetate

Camphene

α-pinene

Ketônes

2-hexanone

2-heptanone

2-Octanone

2-Nonanone

2-undecanone

2-tridecanone

Alkenés

1-nonene

1-undecene

1-Tridecene

Selzer, R, (1979). Single neurones in deuterocerebrum of Periplaneta tested against food odours and mixture of chemicals (CNS)

♀ odour

♂ odour

Apple

Aldehydes $C_3 - C_5$

Aldehydes $C_6 - C_{12}$

Alcohols $C_3 - C_5$

Alcohols $C_6 - C_{12}$

Amines

Banana

Bread

Cheese

Dog biscuit

Ester

Lemon

Meat

Orange

Potato

Fatty acids $C_1 - C_5$

Fatty acid $C_6 - C_{12}$

Terpenes.

Recording made extracellularly from neurons in deutocerebrum - Cells stained by iontophoresing cobalt.

Cells have broad spectra and could not be classified into specific types.

(Also see Boeckh, Seiss).

+ Nishino

Waldow, U. (1977) C.N.S units in Cockroach (Periplaneta americana) Specificity of responses to pheromones and other odour stimuli.

J. comp. Physiol 116 1-17 (1977).

Extracellular recordings from deutocerebral neurons against 28 odours (cockroach smells, meat, fruits and 17 chemicals) recorded.

- The neuron are classified in Type I and Type II. All single substances effective against type I are also effective against Type II but type II neurons do not respond to mixed odours.

- Single chemicals produce short bursts but type Ia neurons respond to various cockroach odours with a phasic tonic excitation

- It is suggested that odour quality is coded by the time course of the response — Strong "off responses" recorded to several stimuli

Chemicals

Cinnamaldehyde	10^{-2}	
Butyric acid	10^{-2}	
Terpeniol	10^{-2}	
1-Octanol	10^{-2}, 10^{-3}	
1-Decanol	10^{-2}	
Borneol	10^{-2}	{ D-bornyl acetate (mimic of sex pheromone
Santalol	concentrated	(mimic of sex pheromone)
α-Pinene	10^{-1}, 10^{-2}	
Theonaphthene	concentrated	
3-methyl 1-butanol	10^{-2}	
1-Hexanol	10^{-2}, 10^{-3}	
p-cresol	10^{-2}	(Repellent)
p-ethyl phenol	10^{-2}	(Repellent)
Undecane	concentrated	
Tridecane	10^{-1}	
n-Hexylamine	10^{-3}, 10^{-4}	

Colorado Beetle

Leptinotarsa

Visser, J. H. (1979) EAG responses to 53 chemicals. (See paper for list)

Good list of volatiles

Distinct responses to a set of related chemicals from certain plant species.

Coleoptera – Monochamus notatus (Butler)

- Dyer, L. J and Seabrook, W. D. (1978).

Single unit recording (tungsten electrode) against six terpenes shows that sensilla basiconica are olfactory receptors for these compounds – The cells are generalist (ie. respond to all terpenes albeit with varying spectra). No specialists were found.

Terpenes used

α-pinene, Limonene, Geraniol, Camphene.

Responses varied from excitation to inhibition.

My own smell sense

Alcohols

1-Octanol - 10^{-6} (Detectable)

10^{-5} (Detectable - Pleasant).

10^{-4} (Pleasant - recognizable) floral ?

Amyl

10^{-4} strong - chemical - somewhat unpleasant.

Cyclohexanol

10^{-4} Somewhat unpleasant (recognizably distinct) from amyl alcohol

Geraniol

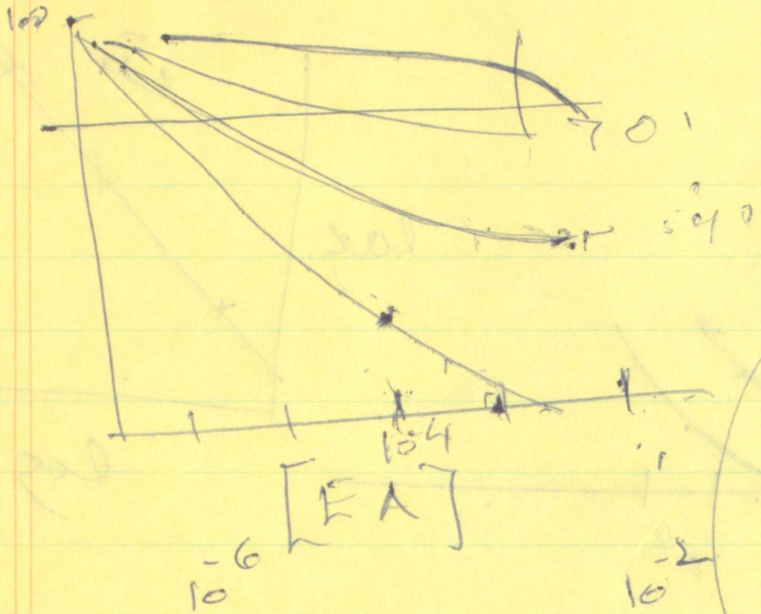
10^{-4} - Mildly floral

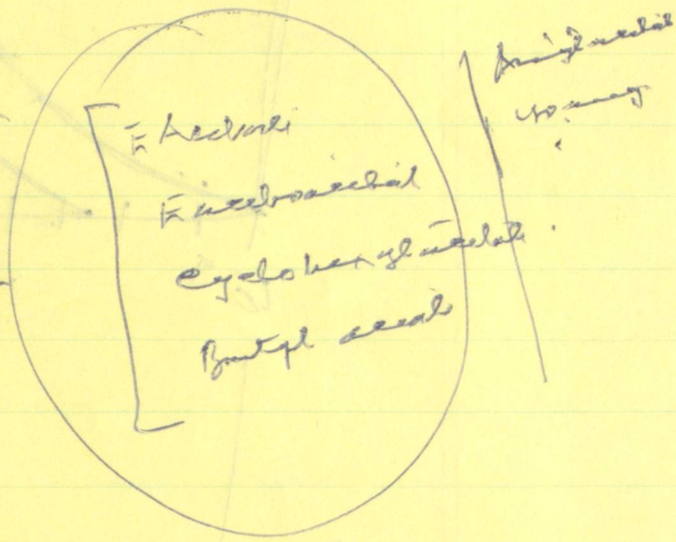
10^{-3} strongly floral, pleasant

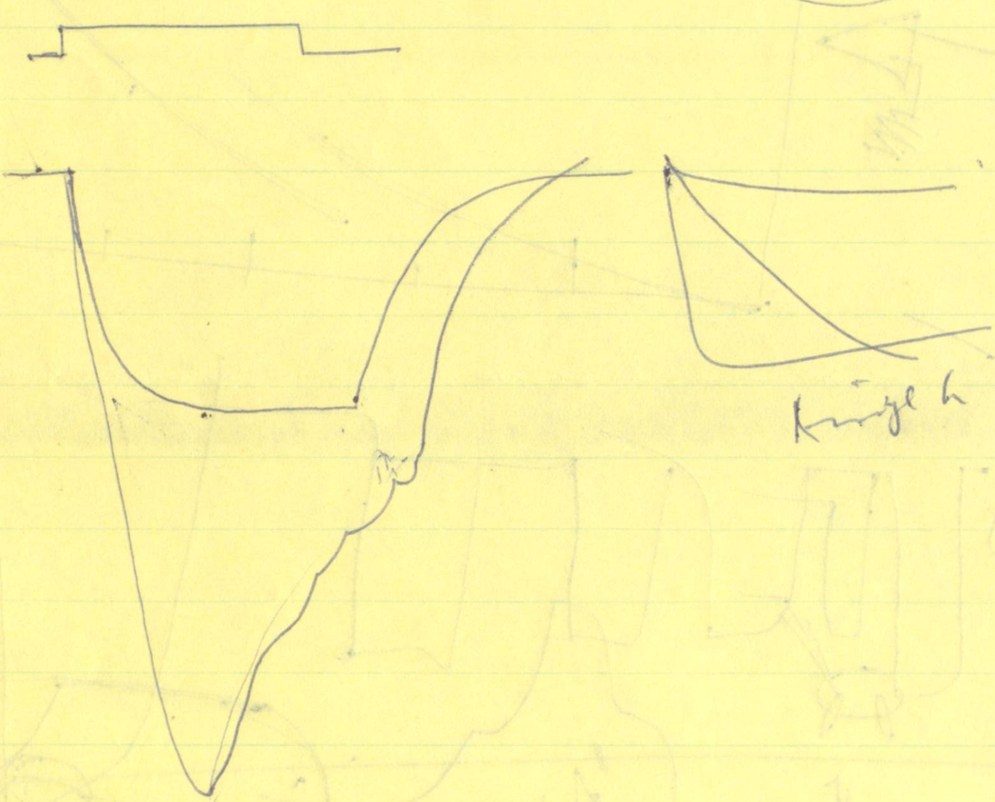
TABLE 1 Responses of
reported from

COMPOUND
ALCOHOLS
Borneol
Linalool
Nopol
α-Terpineol
4-Terpineol
Carotol
ALDEHYDES
2-Decenal
Dodecanal
Heptanal
Nonanal
2-Nonenal
Octanal
Propanal
2,4 Decadienal
ESTERS
Bornyl acetate
ETHERS
Methyl-ISO-Eugenol
HYDROCARBONS
Biphenyl
Camphene
Caryophyllene
P-cymene
2,4-Dimethyl styrene
Dipentene
Isoprene
Limonene
Myrcene
α-Pinene
β-Pinene
α-Phellandrene
Sabinene
α-Terpinene
γ-Terpinene
Terpinolene
γ-Bisabolene
KETONES
α-Iconone
β-Iconone

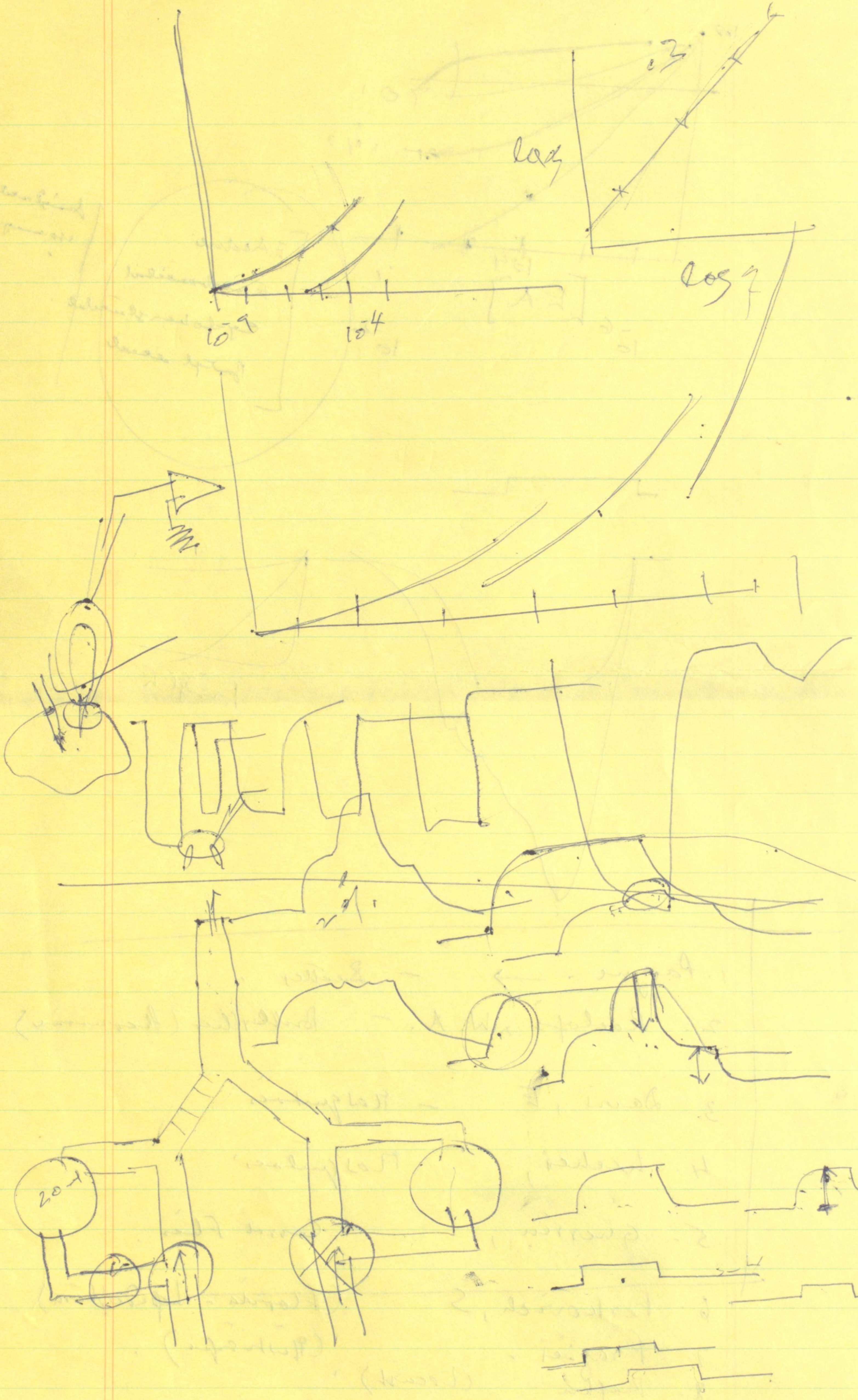
NUMBER	SHEET COUNT	RULING
53-008	60	WIDE
53-108	60	5 x 5 QUAD
53-208	60	PLAIN
53-010	96	WIDE
53-110	96	5 x 5 QUAD
53-210	96	PLAIN
53-012	96	WIDE & MARGIN







1. Payne → – Beetles.
2. Roelofs, W. A. – Butterflies (Pheromones)
3. Davis, E. – Mosquitoes.
4. Lacher, Mosquitoes
5- Guerrin, Carrot Flies.
6. Ferkovich, S. (Florida – Lepidoptera)
7. Frazier – (Mississippi).
8- Kafka (Locust)



10^{-9}
10^{-4}
log

- Friendly smell

1. – Acetals

– Alcohols

1. Pyrazines :–

2. Aldehydes

NUMBER	SHEET COUNT	RULING
53-008	60	WIDE
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