Introduction to Food Additives

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Food additives

- There are over 2000 compounds approved as food additives in the US (list is continuously changing due to additions and deletions)
- Necessary for meeting the demands of a continuous, adequate supply of a substantial variety of food items

Broad categories of food additives

- Pesticide residues
- Unavoidable contaminants
- Colouring additives
- Intentional food additive

Food Additives

- Functions
  - Enhance food appearance and consumer acceptance
  - Improve shelf life
  - Enhance nutrition
  - Functional property provision & improvement (e.g. texture improvement)
  - Aid in processing

Food additives

- Chemicals, both natural and synthetic, added intentionally to foods to bring desired change in physical, chemical and sensory properties
- Classified according to the functionality or desired purpose
- Antioxidants, preservatives, flavouring agents, colouring agents, emulsifiers

Food additives

- Acids / Acidity regulators / Alkalis
  - help to maintain a constant acid level in food. This is important for taste, as well as to influence how other substances in the food function. For example, an acidified food can retard the growth of some micro-organisms.
- Anti-caking agents
  - reduce the tendency of individual food particles to adhere and improve flow characteristics. For example, seasoning with an added anti-caking agent flows freely and doesn't clump together.

http://www.foodstandards.gov.au/

Food additives

- Antioxidants
  - retard or prevent the oxidative deterioration of foods. For example, in fats and oils, rancid flavours can develop when they are exposed to oxygen. Antioxidants prevent this from happening.
- Bulking agents
  - contribute to the volume of the food, without contributing significantly to its available energy. For example, sugar often contributes to the volume of lollies, while some low-joule foods need bulking agents added to them to replace the bulk normally provided by sugar.

http://www.foodstandards.gov.au/

Food additives

- Colourings
  - add or restore colour to foods. For example, icing mixture is coloured to make it more attractive on cakes.
- Emulsifiers
  - facilitate or maintain oil and water from separating into layers. For example, emulsifiers may be used in margarine to prevent oil forming a layer on top of the margarine.
- Firming agents / Stabilisers
  - maintain the uniform dispersion of substances in solid and semi-solid foods.

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Food additives

- Flavour enhancers
  - enhance the existing taste and/or odour of a food.
- Foaming agents
  - maintain the uniform dispersion of gases in aerated foods.
- Gelling agents
  - modify the texture of the food through gel formation.
- Glazing agents
  - impart a coating to the external surface of the food, for example a wax coating on fruit to improve its appearance.

http://www.foodstandards.gov.au/

Food additives

- Humectants
  - reduce moisture loss in foods. For example, glycerine may be added to icing to prevent it from drying out.
- Preservatives
  - retard or prevent the deterioration of food by micro-organisms, and thus prevent spoilage of foods.
- Raising agents
  - liberate gases, thereby increasing the volume of a food. Raising agents are often used in baked goods.

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Food additives

- Sweeteners
  - replace the sweetness normal provided by sugars in foods without contributing significantly to their available energy.
- Thickeners
  - increase the viscosity of a food. For example, a sauce might contain a thickener to give it the desired consistency

http://www.foodstandards.gov.au/

Use of food additives in Australia

- Food Standards Australia New Zealand is the regulatory body which ensures the following
  - Is the food additive safe (at the requested level in that particular food)?
  - Are there good technological reasons for the use of the food additive?
  - Will consumers be clearly informed about its presence?

Examples of functional properties in food processing

Property/functionality	Ingredient
Water binding	Protein, phosphates
Emulsification	Lecithin
Whippability	Albumin
Buffering	phosphates
Heat gelation	proteins
O_2 scavenging	BHA

Acids

- Inorganic
  - Phosphoric and its derivatives
- Organic
  - Acetic, lactic, citric, malic, succinic, fumaric

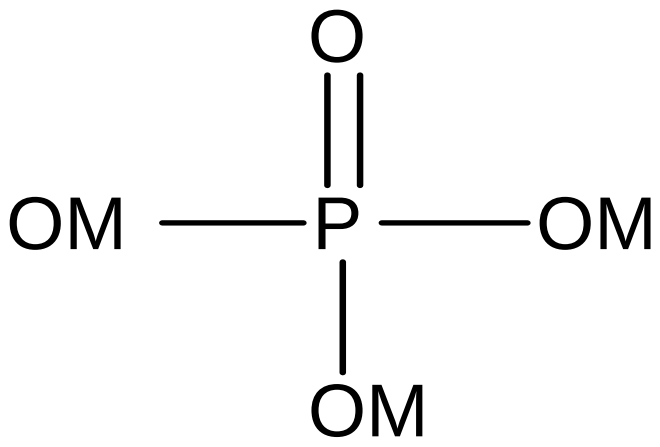
Acids

- General attributes & functions
  - Reduction in pH
  - Buffering
  - Taste
  - Gel formation: pectin, casein, cultured dairy products
  - Chemical leavening

Phosphates

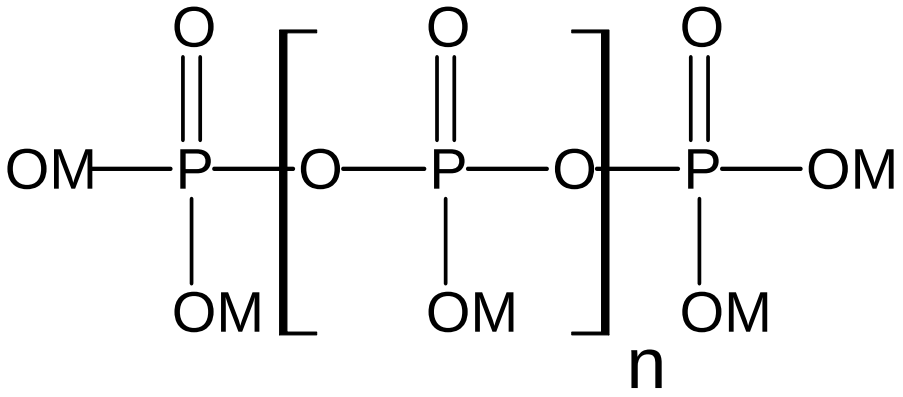
- Classes
  - Orthophosphates
  - Condensed phosphates
    - Polyphophates (straight chain)
    - Metaphosphates (cyclic)

Orthophosphates



Orthophosphates

Polyphosphates



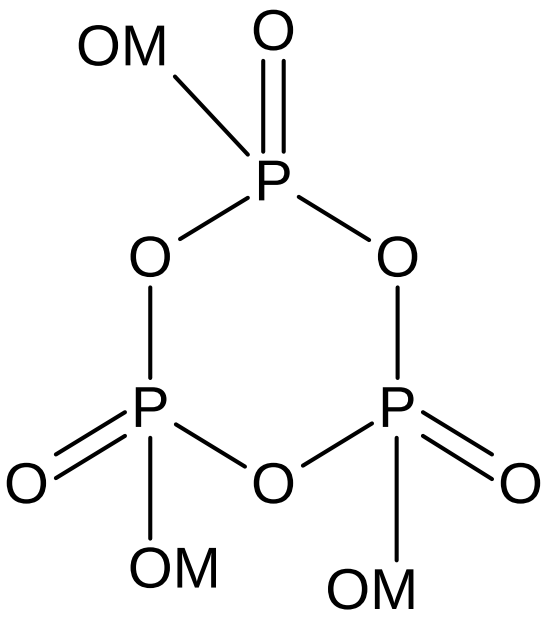
n=0 pyrophosphate

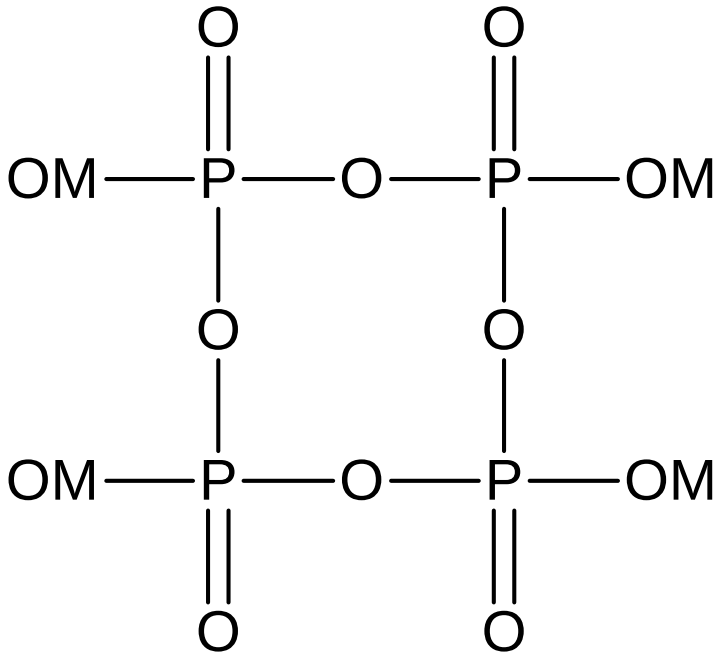
n=1 triphosphate

n>1 long chain phosphate

Straight chain polyphosphates

Polyphosphates





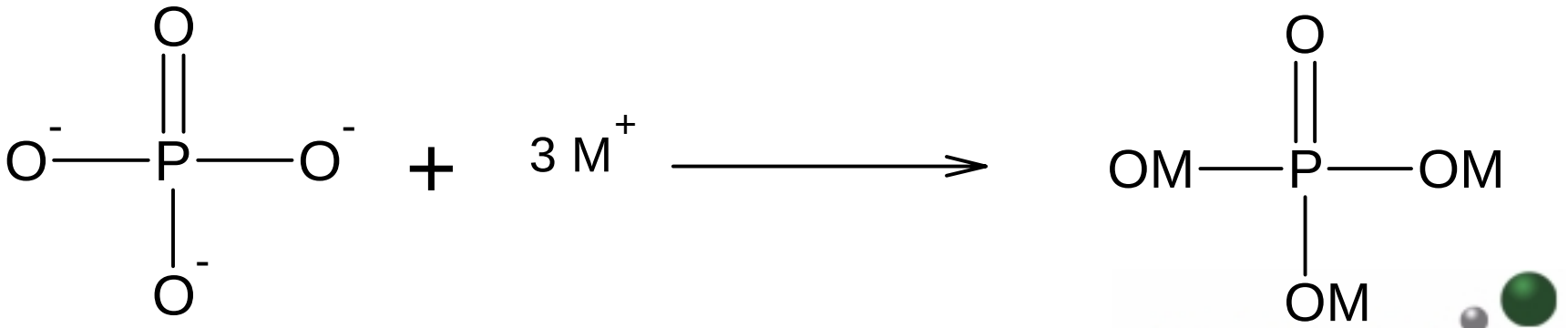
Cyclic metaphophates

Functions of phosphates

- Sequestering agent
- Water holding capacity
- Stabilising emulsion
- Leavening
- Buffering

Phosphate-sequestering

- Sequestering action is due to phosphate acting as an anion to bind cations which are metals in the presence of other complexing or precipitating anions



Phosphate-sequestering

- Action depends on
  - pH (higher the pH lesser is sequestering)
  - Long chain phosphates are stronger anion than short chain or orthophosphates

Phosphate-Water holding capacity

- Used in processed meat, poultry, seafood for retaining juiciness and tenderness
- Combination of phosphates are utilised for optimum functionality, eg sodium tri-polyphosphates and sodium dexa-meta-phosphates are used together

Phosphate-Water holding capacity

- Phosphates are hydrolysed to pyrophosphates, which are active principles to control WHC
- Functions
  - Increasing pH
  - Increase in ionic strength
  - Sequestering of metal ions

Phosphate-WHC in meat products

- Mechanism in meat products
  - Phosphates and chlorides cause interfibrillar volume to expand due to
    - Depolymerisation of myosin filament
    - Dissociation of actomyosin complex

Phosphate:emulsion stabiliser

- Used in processed cheese to stabilise emulsion of butterfat in protein-water matrix
- Na salts of orthophosphate are often used

Phosphate:emulsion stabiliser

Phosphate	Use
Polyphosphate eg Na-acid pyrophosphates and Na-hexametaphosphates	Processed cheese-smooth texture and melt down with no fat separation
Alkaline pyrophosphates	Soft texture & low melting point
Acid phophates & polyphophates	Hard texture & high melting point

Phosphates-leavening

- Reaction with bicarbonates to produce CO_2 in leavened bakery products
- Anhydrous mono-calcium phosphate, dicalcium phosphate dihydrate, sodium aluminium phosphate & sodium acid pyrophosphates are most common

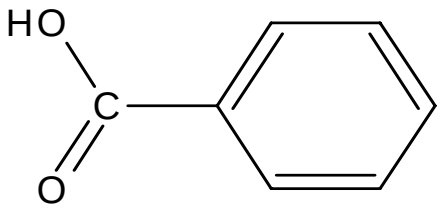
Citric acid

- Acidification
- Buffering
- Flavour enhancing
- Sequestering

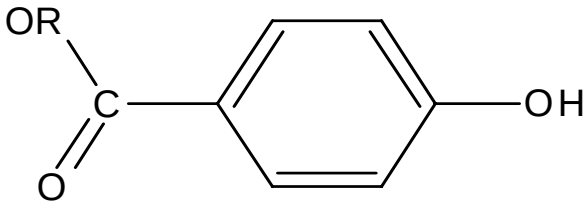
Antimicrobials

- Sodium benzoates
- Alkyl esters of p-hydroxybenzoates
- sorbates and it salts
- Propionates
- Sulfites

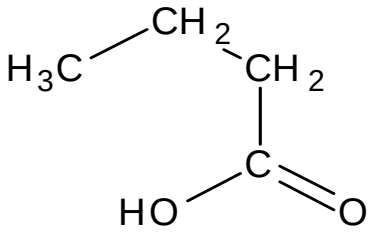
Antimicrobial short chain acid derivatives



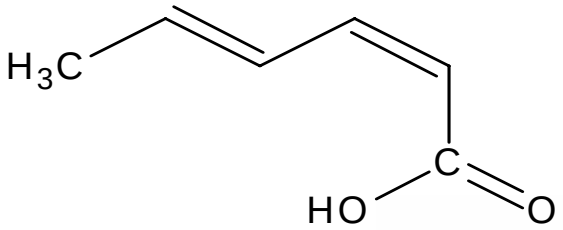
Benzoic acid



Paraben



Propionic acid



Sorbic acid

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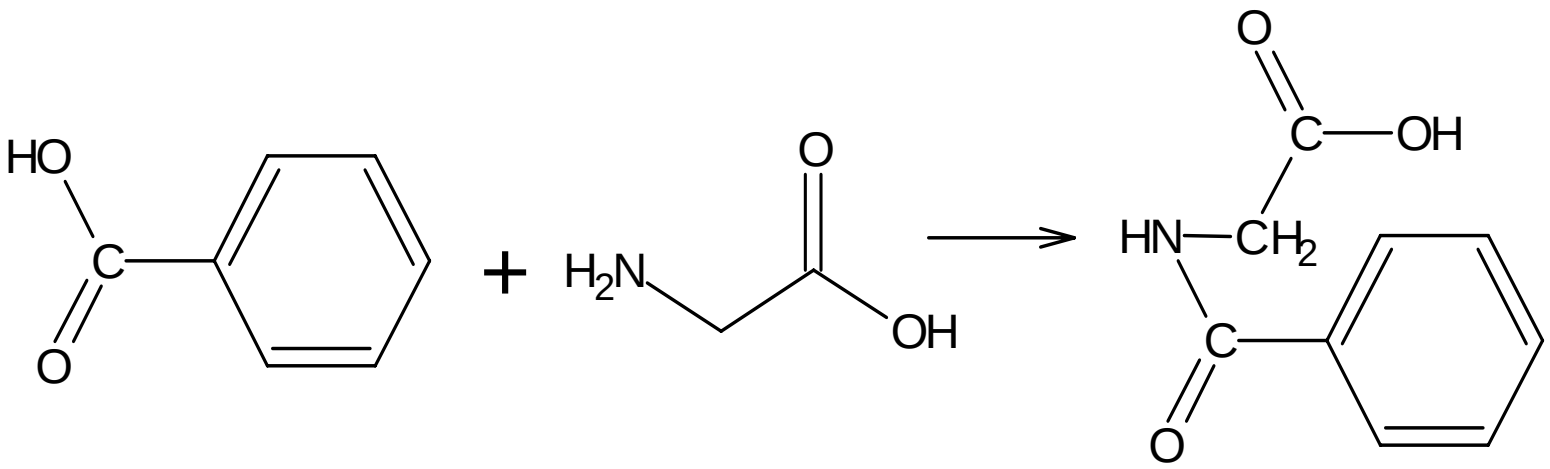
Benzoic acids

- Naturally found in berries *e.g.* cranberries (ca 5%)
- Effective
  - against most microorganisms, particularly yeasts, bacteria
  - Ineffective against molds
- Opt activity 2.5-4 pH

Benzoic acids

- Used as preservative in jams, jellies & preserves, fruit juices
- Use in combination with sorbic acid and parabens
- Safe in low amounts

Detoxification of benzoic acid



Glycine

Hippuric acid

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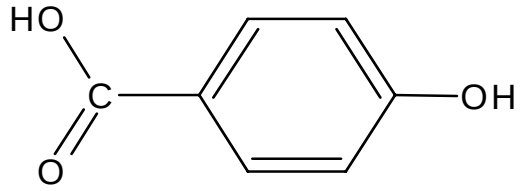
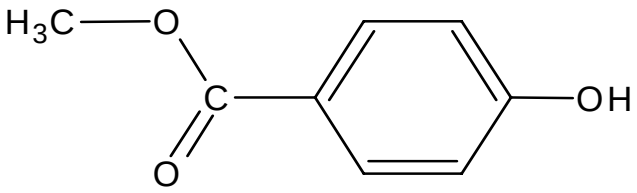
Parabens

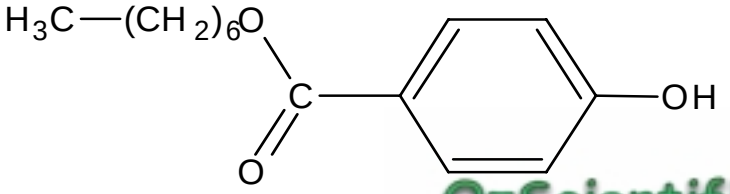
- Group of alkyl esters of p-hydroxy benzoic acid



p-hydroxybenzoic acid



Methyl paraben



Heptyl paraben

Parabens

- Used in baked products, soft drinks, beer, olives, pickles, jams, jellies & syrups
- Effective against yeasts & moulds (0.05 to 0.1% by wt)
- Ineffective against gram -ve bacteria
- Active at neutral pH

Parabens

- Remain un-dissociated at higher pH
- Efficiency depends on
  - Increase in chain length
  - Increase in chain length reduces the water solubility
- Safe as hydrolysed and excreted in urine

Sorbic acid

- Short chain monocarboxylic acid are Antimycotic, effective against yeast & moulds
- Used in cheese, baked products, fruit juices, pickles or applied on the packaging material

Sorbic acid

- Contributes little flavour at conc up to 0.3% by wt
- Activity
  - Decreases as pH increases, effective at 6.5
  - Against mould is due to inability to metabolise the diene aliphatic structure which interferes with the cellular dehydrogenase

Sorbic acid

- Metabolised through β- oxidation in the same manner as other fatty acids and therefore safe for humans
- Effective against some bacteria & found to be effective in inhibiting toxin production by *Clostridium botulinum* and useful in poultry, fish and bacon
- Used as K salt as well

Propionic acid

- Acid and its Ca and Na salts are effective against moulds and few bacteria in bakery products
- Occurs naturally in swiss cheese, produced by *Propionibacterium shermanii*
- Effective up to pH of 5

Propionic acid

- Toxicity of bacteria and moulds is due to inability of these to metabolise 3-C containing skeletons
- In humans metabolism similar to that of fatty acids

Glyceryl esters

- MAG effective against gram +ive bacteria and yeasts
- Used in cured meats, refrigerated fresh fish
- Mechanism facilitate conduction of protons thro cell membranes destroying the proton-motive force need for cellular transport

Sulphites and SO_2

- Used as gas or Na and K salts

$$SO_2 + H_2O \rightleftharpoons H_2SO_3$$

$$2H_2SO_3 \rightleftharpoons H^+, HSO_3^- + 2H^+, SO_3^{2-}$$

Sulphites and SO_2

- Relative proportion of the forms depend on pH
- Most effective under acidic conditions (pH<3.0)
- undissociated sulphurous acid form is the most effective as antimicrobial as it penetrates the cell wall

Sulphites and SO_2

- Effective against bacteria, yeasts and moulds as it
  - Reaction of bisulphite with aldehydes in cell wall
  - Inhibition of sulphur containing enzymes
  - Formation of addition compounds which interfere with respiration

Sulphites and SO_2

- Effective against NEB by
  - Reversible binding of reducing sugars and aldehyde intermediates
  - Bleaching effect of SO_2 on melanoidin pigments
- Effective against EB by
  - Inhibition of oxidation of phenolic compounds

Sulphites and SO_2

- Effective as antioxidant to prevent oxidative flavour defects in beer
- Effective as bread improver to cleave the disulphide bonds
- Effective in bleaching of anthocyanins
- Safety: metabolised to sulphates and excreted in urine, asthmatic reaction and mutagenacity

Nitrite and nitrate salts

- Used in curing mix to:
  - Enhance colour of meat
  - Inhibit MO
  - Develop characteristic flavour
- Effective at 5-5.5 pH
- Nitrosamine formation

Artificial sweeteners

Artificial sweeteners

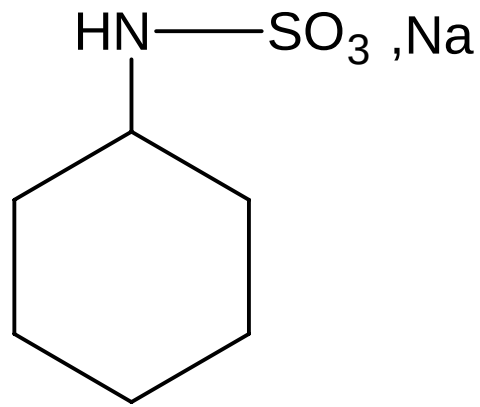
- Substances or groups thereof evoking a sweet taste or enhance the perception of sweet taste

Artificial sweeteners

- Provide low calories than sugar & non nutritive
- Used in beverages
- Have no body & filling capacity
- Types
  - Cyclamates: Na & Ca salts, not used due to suspected carcinogen

Sweetener

- Cyclamates

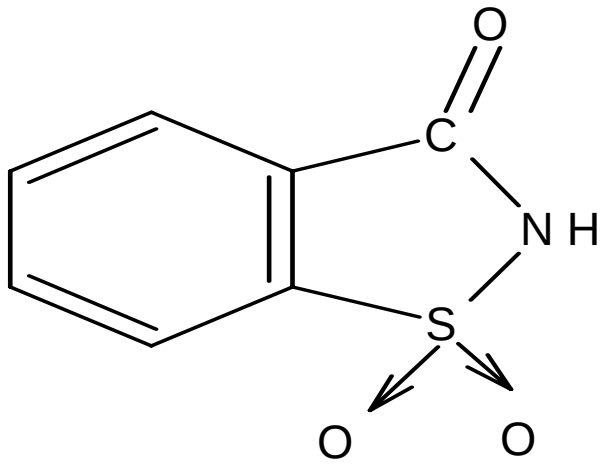


Sodium cyclamate

- Cyclamates
  - Potential carcinogen suspect as hydrolysis of sulphamates yields cyclohexylamine, a known carcinogen
  - Not used

Artificial sweeteners

- Types
  - Saccharin



Saccharine

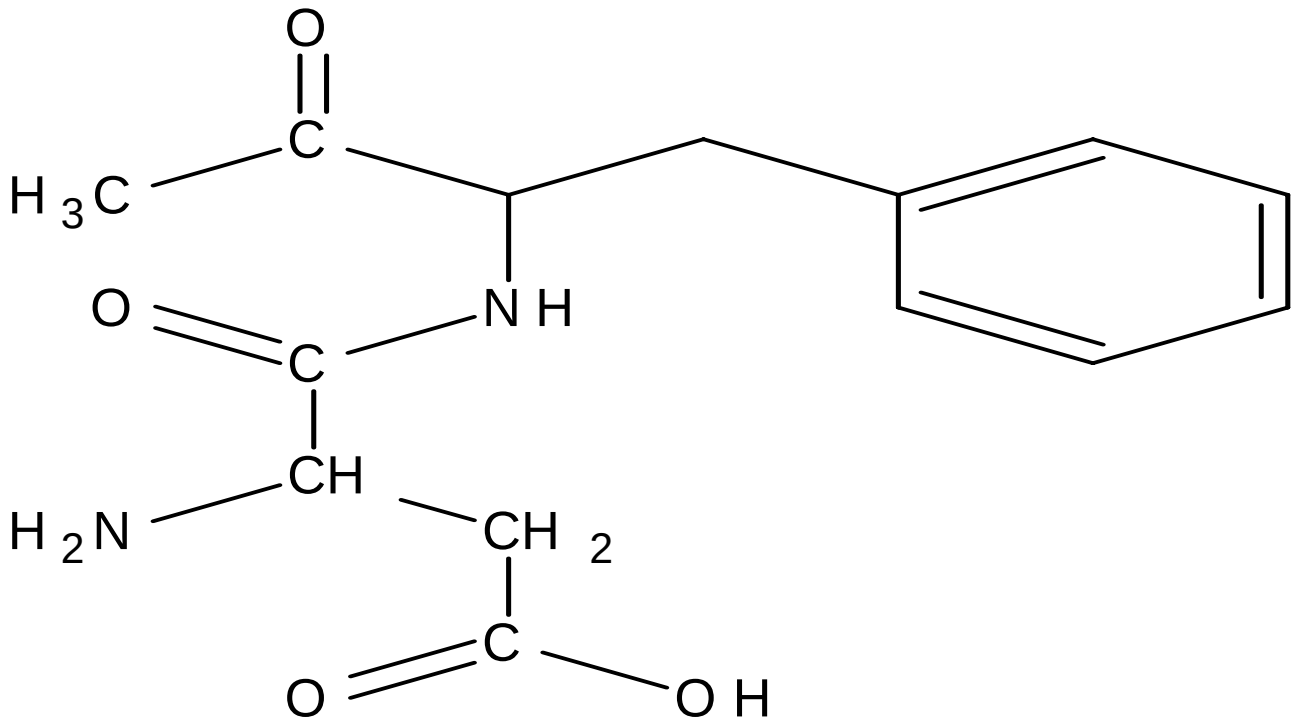
Sweeteners

- Saccharine
  - Na & Ca salts
  - 300 x sweet for conc up to 10% sucrose solution equivalent
  - Readily absorbed and excreted in urine
  - High conc produces bitterness

Sweeteners

- Aspartame
  - L-aspartyl-L-phenylalanine methyl ester
  - Dipeptide & provides calories
  - 200x sweet at 4% sucrose conc
  - Limited shelf life due to hydrolysis by enzymes, mo
  - Used in soft drinks

Aspartame

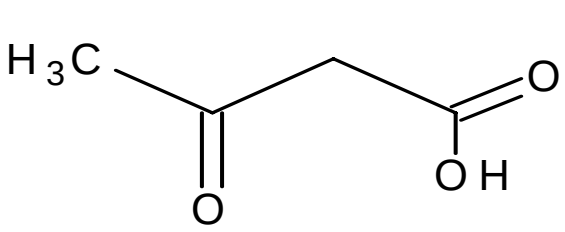


L-aspartyl-l-phenylalanine methyl ester (Aspartame)

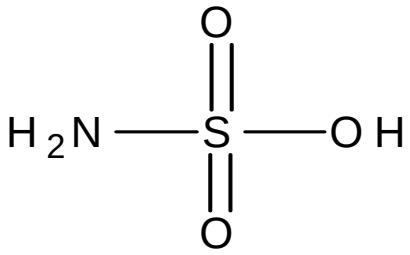
Acesulfame K

- 200X as sweet as sucrose at 3% solution
- Intermediate sweetness between cyclamate and saccharine

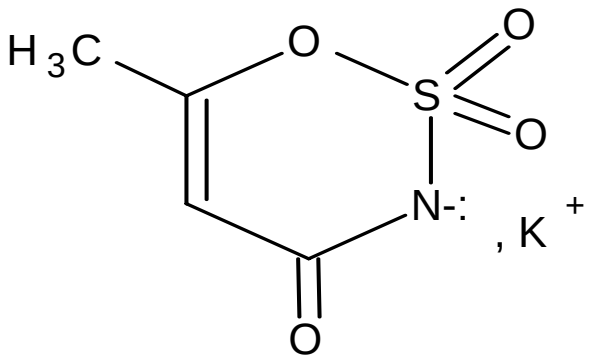
Acesulfame K



Aceto-acetic acid



Sulfamic acid



Acesulfame K

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