Molecule of the Month - June 1996

Urea

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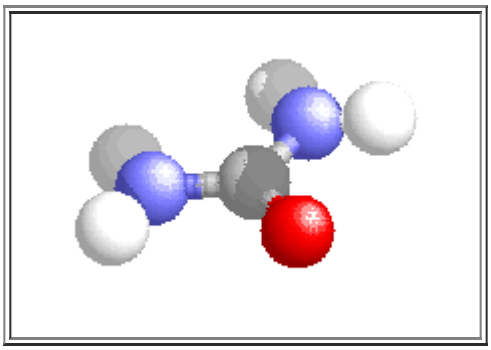


History

Urea was first discovered in human urine by **H.M. Rouelle** in *1773*.

It was synthesised in *1828* by **Friedrich Wohler** and was the first organic compound to be synthesised from inorganic starting materials. It was found when **Wohler** attempted to synthesis ammonium cyanate, to continue a study of cyanates which he had be carrying out for several years. On treating silver cyanate with ammonium chloride solution he obtained a white crystalline material which proved identical to urea obtained from urine.

This discovery prompted **Wohler** to write triumphantly to **Berzelius**:-

"I must tell you that I can make urea without the use of kidneys, either man or dog. Ammonium cyanate is urea."

This organic systhesis dealt a severe blow to a widespread belief called "vitalism" which maintained that organic chemicals could be modified by chemistry but could only be produced through the agency of a vital force present in living plants and animals.

In *1870* urea was produced by heating ammonium carbamate in a sealed vessel. This provided the basis of the current industrial process for its production.

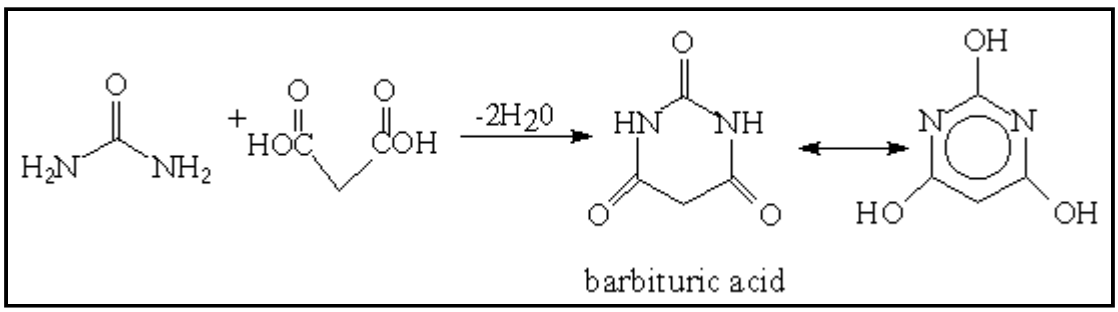
Production

Urea is produced commercially by the dehydration of ammonium carbamate (NH_2COONH_4) at elevated temperature and pressure. Ammonium carbamate is obtained by direct reaction of ammonia with carbon dioxide. These reactions are normally carried out simultaneously in a high pressure reactor.

Uses

Pharmacaeutical

Urea and malonic acid react to form barbituric acid.

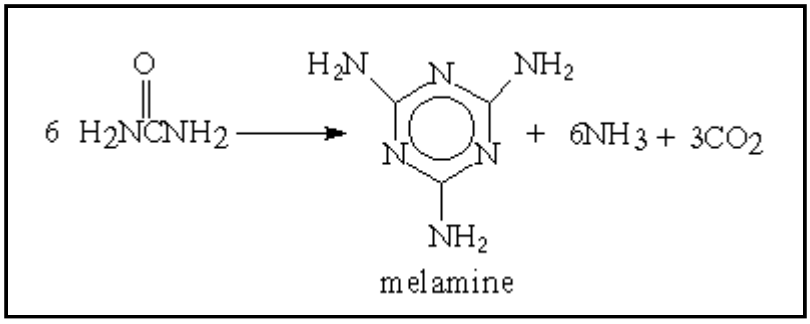


barbituric acid

This was discovered by **Adolf Bayer** in *1864*. But the barbiturates were not exploited as hypnotics until the early 1900's. Urea is also used in the production of various acylureas and urethanes for use as sedatives and hypnotics.

Resins

Melamine is formed by the dehydration of urea.



Almost 100 years elapsed between **Liebig's** discovery in *1834* and a commercial process being developed.

Melamine is primarily used in the production of melamine-formaldehyde resins which have much greater hardness and stain resistance than urea-formaldehyde resins.

Both melamine-formaldehyde and urea-formaldehyde have very varied uses including adhesives, laminates, moulding compounds, coatings and textile finishes.

Agricultural

Urea is used as a nitrogen release fertilizer as it hydrolyses back to $2NH_2$ and CO_2 but its most common impurity (biuret,NH_2-CO-NH-CO-NH_2) must be present at less than 2% as it impairs plant growth. It is also used in many multi-component solid fertilizer formulations.

Its action of nitrogen release is due to the conditions favouring the reagent side of the equilibriums which produce urea.

Industrial Uses

Urea has the ability to form 'loose compounds' with many organic compounds. The organic compounds are held in channels formed by interpenetrating helices comprising of hydrogen bonded urea molecules. This behaviour can be used to separate mixtures and has been used in the production of aviation fuel and lubricating oils.

As the helices are interconnected all helices in a crystal must have the same 'handedness'. This is determined when the crystal is nucleated and can thus be forced by seeding. This property has been used to separate racemic mixtures.

References

For general information:-
Kirk Othmer Encyclopedia of Chemical Technology, 1983, 3rd ed, Wiley Interscience, Vol. 23.

For historical information:-
PARTINGTON J.R., (1962), **A History of Chemistry**, MacMillan, London, Vol. 3.
PARTINGTON J.R., (1964), **A History of Chemistry**, MacMillan, London, Vol. 4.
These are good sources with the information collated via the scientists.

For information on channel compounds of urea (not for the faint hearted):-
PARSONAGE N.G. and STAVELEY L.A.K, (1978), **Disorder in Crystals**, Clarendon Press, Oxford, pp.756-779.

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