What is honey made of? The optical rotation of natural sugars

Time

2 h.

Curriculum links

Carbohydrates, chirality, optical rotation.

Group size

2–3.

Materials and equipment

Materials per group

- 30 g honey.

Equipment per group

- polarimeter. A simple polarimeter may be built[1] as part of the activity (see Activity 1)

Safety

There are no significant hazards associated with this experiment.

Risk assessment

It is the responsibility of the teacher to carry out a suitable risk assessment.

This is an open-ended problem solving activity, so the guidance given here is necessarily incomplete. Teachers need to be particularly vigilant, and a higher degree of supervision is needed than in activities which have more closed outcomes. Students must be encouraged to take a responsible attitude towards safety, both their own and that of others. In planning an activity students should always include safety as a factor to be considered. Plans should be checked by the teacher before implementing them.

You must always comply with your employer's procedures and in some cases may decide that a particular activity is inappropriate in your situation. Further information on Health and Safety should be obtained from reputable sources such as CLEAPSS [http://science.cleapss.org.uk/] in England, Wales and Northern Ireland and, in Scotland, SSERC [https://www.sserc.org.uk/].

Commentary

In discussing the chirality of naturally occurring molecules students will learn that living systems are stereospecific.[2] Proteins are built almost exclusively from chiral amino acids (the L isomers) and carbohydrates are based on D sugar molecules.

Honey, a natural substance, contains sugars that are comprised of D molecules. Honeys made from the nectar of flowers are laevorotatory, a finding which should bring home the idea that D molecules are associated with the laevorotatory isomer.

Honey is a very complex substance in terms of the number and complexity of its constituents[3] but the largest proportion of the dry matter present consists of sugars. It is laevorotatory because fructose, which has a negative specific rotation, is present in the greatest quantity. The specific rotations are[4]:

sucrose	$[\alpha]_D^{20}$	+66.5°
glucose	$[\alpha]_D^{20}$	+52.5°
fructose	$[\alpha]_D^{20}$	–92.5°

Glucose and fructose together make up about 70% of the total; disaccharides including sucrose add about 10%. Only 17–20% of honey is water.

If the honey is dextrorotatory it is either honeydew honey or it has been adulterated. This was a useful test in the days when unscrupulous suppliers were likely to add cane sugar or corn syrup to honey. Today the result does not necessarily indicate purity as the honey may have been adulterated with high fructose syrup. Honeydew is produced by plant-sucking insects feeding on natural exudations of plants and it is gathered by bees which convert it into a type of honey that contains less fructose.

Procedure

A concentration of 26 g of honey to 100 cm^3 water is recommended in AOAC Official Methods of Analysis (1990).

Immediately after diluting the honey with water the optical rotation will change by a few degrees over several hours. A change of 3.5° in 20 h has been quoted.[4] This phenomenon is known as mutarotation but for honey the mechanism is not fully understood.

Some types of honey in solution are sufficiently opaque to cause problems because of light scattering and absorption during polarimetry. In such cases the honey solution can be clarified by heating rapidly to boiling, then filtering. The solution must be used immediately.

Extension

It is possible to separate and identify the sugars in honey by paper chromatography.[5]

The plant sources of honey can be identified by pollen analysis; pollen grains from different plants can be distinguished under the microscope.[6]

Other physical properties of honey are of interest. The water content of honey may be estimated from refractive index measurements. A few honeys are known for their non-Newtonian flow properties, for instance ling heather honey is thixotropic; this is due to the relatively high concentrations of certain proteins in this honey.[6]

Information about bees and honey may be obtained from the International Bee Research Association (IBRA), 18 North Road, Cardiff, CF1 3DY. An excellent book on honey, written by Eva Crane[6], is available from IBRA.

References

1. *Revised Nuffield advanced science chemistry teachers guide II.* Harlow: Longmans, 1988.
2. P. W. Atkins, *Molecules*. New York: Scientific American Library, 1987.
3. *Honey: a comprehensive survey*, E. Crane (ed). London: Heineman, 1975.
4. C. A. Browne and F. W. Zerban, *Physical and chemical methods of sugar analysis*. Chichester: J. Wiley, 1941.
5. J. N. Adds, *School Sci. Rev*., 1992, **74**, 94.
6. E. Crane, *A book of honey*. Oxford: OUP, 1980.

Credits

Health & safety checked May 2018

Page last updated October 2018