

Colors and Chemical Names (1)

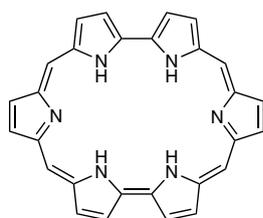
Kentaro Sato

Vivid, diverse, and changeable colors of chemicals lured many of us stepping into the field of chemistry as young students. There are indeed a number of elements and compounds that display beautiful colors. Some of them are used as synthetic dyes and were a major part of the early development of chemical industry. From litmus paper to state-of-the-art bioimaging technologies, color and chemical research always go hand in hand.

So not surprisingly, there are quite a few chemicals with names derived from their colorful appearances. In this article, let us look at some of the interesting examples.

Red

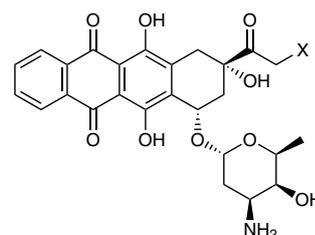
In the periodic table, the element whose name is derived from red is the thirty seventh rubidium. This name was coined because the color of rubidium's emission spectrum was rubidus, meaning red in Latin. The ruby gemstone has the same name origin. As for organic compounds, there is a compound called rubyrin. A relative of porphyrin, rubyrin is composed of six pyrrole rings and shows beautiful red color.



Rubyrin

Some members of anthracycline antibiotics family show red colors such as auronubicin and doxorubicin, where the

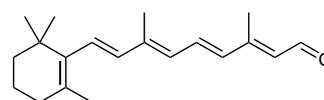
rubi in their names is derived from the color.



X=H: Daunorubicin, X=OH: Doxorubicin

There are several types of redness. For example, rosy color is rhodon in Latin and rhodeos in Greek. These words became the origin of the name of the forty fifth element rhodium since solutions containing rhodium metal appeared rosy red.

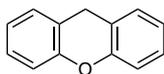
Around 1876, it was discovered that the animal photoreceptor cells contain a reddish substance that are responsible for sensing of light. The substance was named rhodopsin by combining rhodo and opsis (which means vision). The redness is actually a result of the chemically bonded compound called retinal, which produces visual signals in the form of double bond isomerization upon photo irradiation.



Retinal

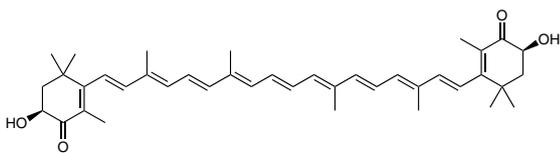
Yellow

Yellow in Greek is xanthon and there are lots of compounds named after it. Xanthene has a structure composed of two benzene rings fused with a pyran and is literally a yellow solid.



Xanthene

Xanthophyll compounds are yellow pigments containing a long chain of conjugated double bonds and are involved in photosynthesis. This group includes compounds such as lutein, zeaxanthin, neoxanthin, violaxanthin, and cryptoxanthin. Some compounds that appear more red than yellow like astaxanthin are also found in the group.

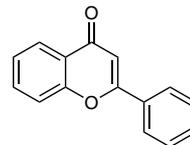
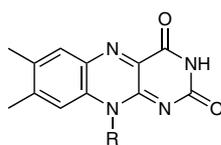


Astaxanthin

Xanthic acids have a formula of $RO-C(=S)SH$ and xanthate salts indeed show yellowish colors. In organic synthesis, xanthate esters are used in the Chugaev elimination reaction (a type of dehydrative olefination) and the Barton-McCombie radical deoxygenation reaction mediated by stannanes.

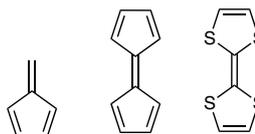
It is probably a common experience for many of us that accidentally touching nitric acid during an experiment turns the affected part of the skin yellow. The reaction is known as the xanthoproteic reaction and is used as a test to determine the amount of protein in the sample. The term *xantho* in this case is also derived from the same origin. The color change is due to the nitration of aromatic rings such as the one contained in tyrosine residues.

On the other hand, the Latin translation of yellow is *flavum* and there are compounds known that are named based on it. One of them is flavines, whose derivatives act as coenzymes, the shortage of which causes various disorders such as inflammation. Flavones sound very similar and are derived from the Latin *flavus* but are unrelated to flavines structurally.



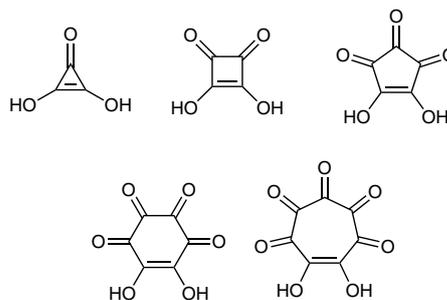
Flavines and flavones

In a similar context, the word fulvous (dull brownish yellow) can be found as part of the names of some compounds. For instance, the hydrocarbon compound shown on the left in the figure below is fulvene, which is an isomer of benzene. The compound in the middle composed of two cyclopentadienes is called fulvalene, but the one on the right, tetrathiafulvalene (TTF) with four sulfur atoms replacing the methine hydrogens, is far more well-known. TTF works as the electron donor of a charge transfer complex and is an iconic compound in the field of organic electronics materials.



Fulven, fulvalene, and tetrathiafulvalene

There is a group of cyclic compounds called oxocarboxylic acids. Three- to seven-membered ring compounds are known and all of them show strong acidity. Among these, the five-membered ring compound is yellow and called croconic acid after the Greek *krokos*, which means saffron or egg yolk. The six-membered ring compound appears rosy red so it is called rhodizonic acid. However, the three, four, and seven-membered ring members are called deltic, squaric, and haptagonic acids, respectively, after their shapes rather than colors. Scientific nomenclature usually stresses consistency, but this is a rather unusual exception.

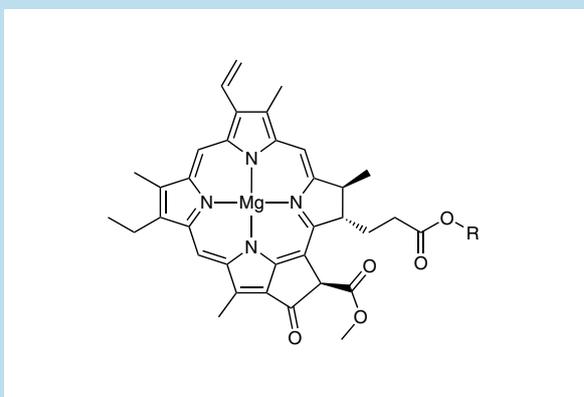


From the upper left, deltic acid, squaric acid, croconic acid, rhodizonic acid, and haptagonic acid

Green

As for elements named after the color of green, there is praseodymium with the atomic number 59 whose name origin is the Greek *prasios*, meaning bluish green. Pr(III) ions indeed appear green. Similarly, the eighty first element thallium was named after the Greek *thallos*, which means green twig, since the spectroscopic spectrum of the element was green.

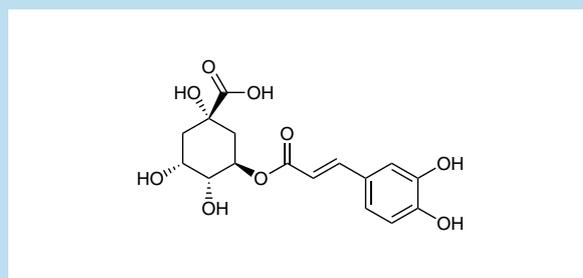
I once thought that chlorophyll contained chlorine atoms because of how the name sounded. But needless to say, the molecule of chlorophyll is made up of C, H, O, N, and Mg, having nothing to do with Cl.



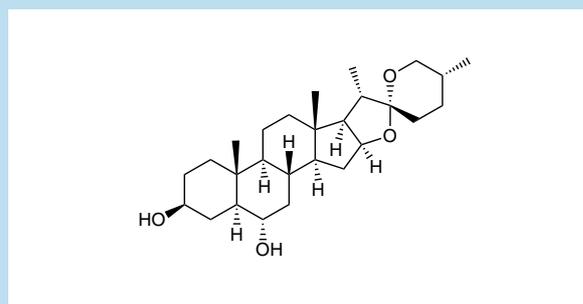
Chlorophyll a

In fact, the name chlorophyll is a portmanteau based on the Greek *chloros* (green) and *phyllon* (leaf). Chlorine has the same name origin as it is a yellowish green gas in an elemental form, but is not directly related.

Chlorogenic acid, a type of polyphenol found in coffee, doesn't contain any chlorine atoms either. The acid was given the name meaning "green generating" because it turns green when it is oxidized. In addition, the steroid compound found in a species of lily *Chlorogalum pomeridianum* is called chlorogenin even though it neither has any chlorines nor structural similarities to chlorogenic acid. This is such a confusing case.



Chlorogenic acid



Chlorogenin

There are more than a few cases where structurally unrelated compounds share the same central component in their names. They are a cause of confusions but it is nonetheless interesting to learn where the names originated. Let us go over more examples for other colors next time.

Introduction of the author :

Kentaro Sato

[Brief career history] He was born in Ibaraki, Japan, in 1970. 1995 M. Sc. Graduate School of Science and Engineering, Tokyo Institute of Technology. 1995-2007 Researcher in a pharmaceutical company. 2007-Present Freelance science writer. 2009-2012 Project assistant professor of the graduate school of Science, the University of Tokyo.

[Specialty] Organic chemistry

[Website] The Museum of Organic Chemistry <<http://www.org-chem.org/yuuki/MOC.html>>