

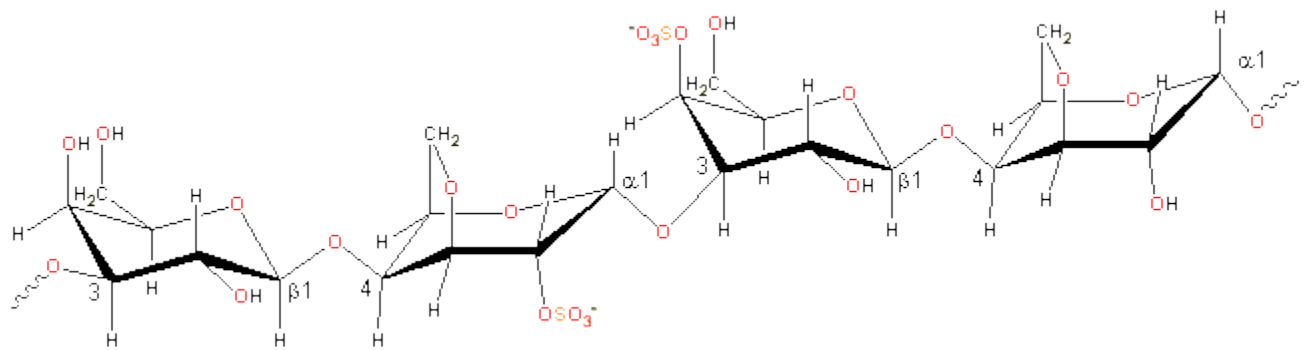
Carrageenan

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Source

Carrageenan (E407) is a collective term for polysaccharides prepared by alkaline extraction (and modification) from red seaweed (*Rhodophyceae*) [1571], mostly of genus *Chondrus*, *Eucheuma*, *Gigartina* and *Iridaea*. Different seaweeds produce different carrageenans.

Structural unit

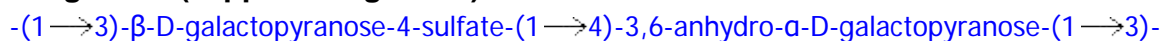


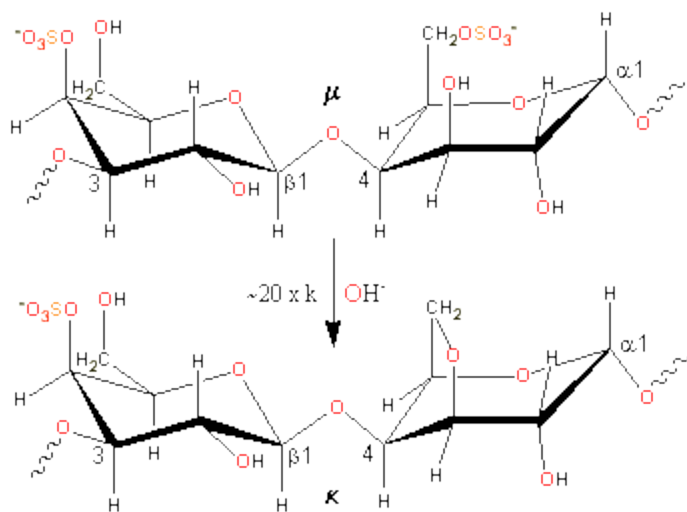
Carrageenan consists of alternating 3-linked- β -D-galactopyranose and 4-linked- α -D-galactopyranose units.

Molecular structure

Carrageenans are linear polymers of about 25,000 galactose derivatives with regular but imprecise structures, dependent on the source and extraction conditions [292]. Idealized structures are given below and κ -carrageenan, for example, has been found to contain a small proportion of the dimer associated with ι -carrageenan.

κ -carrageenan (kappa-carrageenan)

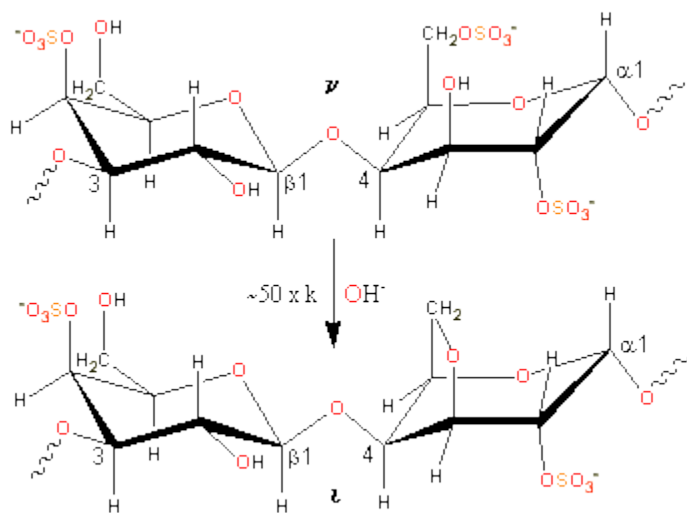




κ -carrageenan is produced by alkaline elimination from μ -carrageenan [1623] isolated mostly from the tropical seaweed *Kappaphycus alvarezii* (also known as *Eucheuma cottonii*). The experimental charge/dimer is 1.03 rather than 1.0 with 0.82 molecules of anhydrogalactose rather than one.

ι -carrageenan (iota-carrageenan)

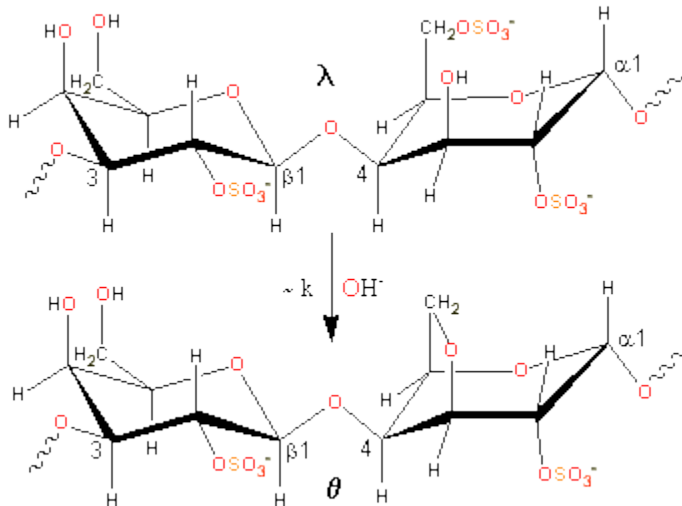
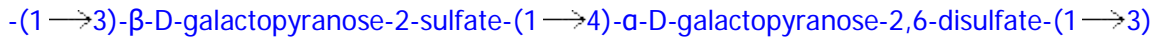
$-(1 \rightarrow 3)\text{-}\beta\text{-D-galactopyranose-4-sulfate-}(1 \rightarrow 4)\text{-}3,6\text{-anhydro-}\alpha\text{-D-galactopyranose-2-sulfate-}(1 \rightarrow 3)\text{-}$



ι -carrageenan is produced by alkaline elimination from ν -carrageenan isolated mostly from the Philippines seaweed *Eucheuma denticulatum* (also called Spinosum). The experimental charge/dimer is 1.49 rather than 2.0 with 0.59 molecules of anhydrogalactose rather than one. The three-dimensional structure of the ι -carrageenan double helix has been determined [247] as forming a half-staggered, parallel, threefold, right-handed double helix, stabilized by interchain O2-H...O-5 and

O6-H...O-2 hydrogen bonds between the β -D-galactopyranose-4-sulfate units (see [structure](#)). The structure of some calcium iota-carrageenans have been determined [1365]

λ -carrageenan (lambda-carrageenan)



λ -carrageenan (isolated mainly from *Gigartina pistillata* or *Chondrus crispus*) is converted into θ -carrageenan (theta-carrageenan) by alkaline elimination, but at a much slower rate than causes the production of ι -carrageenan and κ -carrageenan. The experimental charge/dimer is 2.09 rather than 3.0 with 0.16 molecules of anhydrogalactose rather than zero.

Helices

The [torsion angles](#) phi (ϕ_H , $H_1C_1OC_4$ or $H_1C_1OC_3$), psi (ψ_H , $C_1OC_4H_4$ or $C_1OC_3C_3$) have been determined for λ -, μ - and ν -carrageenans [1095]. All carrageenans are highly flexible molecules which, at higher concentrations, wind around each other to form double-helical zones. Gel formation in κ - and ι -carrageenans involves helix formation on cooling from a hot solution together with gel-inducing and gel-strengthening K^+ or Ca^{2+} cations respectively (not Na^+ , although Na^+ does take part in an aggregation process to form weak gels with κ -carrageenan due to phase separation [723]), which not only aid helix formation but subsequently support aggregating linkages between the helices so forming the junction zones. The strongest gels of κ -carrageenan are formed with K^+ rather than Li^+ , Na^+ , Mg^{2+} , Ca^{2+} , or Sr^{2+} [1077]. Incomplete formation of 1C_4 3,6-anhydro-links will reduce the extent of helix formation as the unbridged α -linked galactose residues may flip to the 4C_1 conformation.

κ -Carrageenan forms stronger gels in D_2O rather than H_2O . This has been attributed to an increase in the number of double-helix aggregates rather than the fraction of helix formed, which differs little between the two solvents [1670]. This is probably due to the increase in the affinity of D_2O molecules for each other relative to polysaccharide water linkages..

Note that the gelling hydrocolloid agar is produced from the same family of seaweeds, the major difference being the presence of L- rather than D-3,6-anhydro- α -galactopyranose units but still forming double helical junction zones. [Back to Top ▲]

Functionality

Carrageenans are used mainly for thickening, suspending and gelling. κ - and ι -carrageenans form thermoreversible gels on cooling in the presence of appropriate counter ions. κ -Carrageenan forms a firm clear, if brittle, gel with poor freeze-thaw stability; the coil-double helix transition being followed by a K^+ -induced aggregation of the helices [516]. κ -Carrageenan gels may be softened (and is generally regarded to be synergistically strengthened^a) with locust bean gum. ι -Carrageenan has less specific ionic binding but increased ionic strength allows helices to form junction zones in soft elastic gels with good freeze-thaw stability. λ -Carrageenan is non gelling as the lack of the 1C_4 3,6-anhydro-link allows the galactose residues to revert to their 4C_1 conformation which does not allow the initial double helix formation required for gelling. Additionally, the high density of charged sulfate groups encourages an extensive conformation. λ -Carrageenan has been found to act as a cryoprotectant and improves the freeze-thaw behavior of locust bean gum.

κ -Carrageenan stabilizes milk κ -casein products due to its charge interaction with the casein micelles (~200 nm diameter); their incorporation into the network preventing whey separation. Such complexes are soluble when both have same charge and are held together by counter ions or oppositely charged patches. Carrageenan is also used as a binder in cooked meats, to firm sausages and as a thickener in toothpaste and puddings.

It may be noted that a cancer health scare concerning degraded carrageenan has recently been examined by the European Commission Scientific Committee on Food which found no evidence in support and states that carrageenan is safe to use in foods. It is believed that carrageenan is safe to use in foods, within current regulations [1684].

Interactive structures are available (Jmol).

Source : <http://www1.lsbu.ac.uk/water/hycar.html>