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HYDROCOLLOIDS

Technical Bulletin

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Hydrocolloids – How to choose?

INTRODUCTION

A colloid is a substance microscopically dispersed evenly throughout another substance. A colloidal system consists of two separate phases: a dispersed phase and a continuous phase. A hydrocolloid is defined as a colloidal system, in which the colloid particles are dispersed in water. A hydrocolloid has colloid particles spread throughout the water and depending on the quantity of water available, that system can be a gel or a sol (liquid). Some hydrocolloids can exist in both a gel and a sol state, and can alternate between the states with the addition or elimination of heat. (source: Wikipedia)

Hydrocolloids used in food are polysaccharides* of high molecular weight, extracted from plants and seaweeds or produced by microbial synthesis. The plant raw materials are then partly processed further, e.g. by the addition of functional side-groups, by hydrolysis, by purification and by standardisation.

* gelatin is disregarded in this document.

Hydrocolloids are used for a wide range of different functions within food: thickening, gelling, generating mouth-feel, film-forming, foaming, improving bake-stability, improving freeze-thaw stability, preventing crystal growth, stabilising suspensions or emulsions, and encapsulation. It can therefore be a challenge to select the right hydrocolloid for a specific food end-product, which is why many users ask whether this choice can be simplified by the creation of practical 'Guidance Notes'.

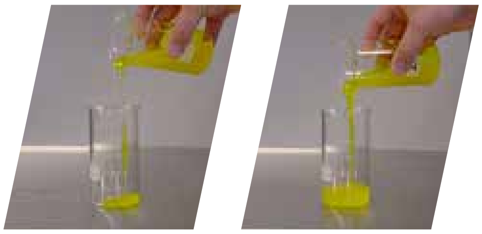
However, since the number of influencing factors which determine the right choice are so numerous, plus these factors can also influence each other, 'simple to use' guidance notes are not easy to create. Therefore, in this application note we have listed several decision criteria, plus the hydrocolloid properties / hydrocolloid performance that are relevant against these criteria. As you will see, for any given food end-product there is normally more than one hydrocolloid that will deliver the required functionality, plus in many cases a combination of hydrocolloids can also be used.

This application note aims to provide practical support which will assist readers to select the right hydrocolloid(s) for testing in product development projects.

Alternating between sol (liquid) and gel state.
Below are some practical examples of the above mentioned phenomena of alternating between sol (liquid) and gel state. Please note that these are model systems, where the hydrocolloid solutions and gels are coloured to make the pictures clearer.

Example 1

A cold viscous solution maintains (partly) viscosity upon heating, e.g. guar gum, xanthan gum and CMC. Compared to the other gums, xanthan gum's viscosity is least effected by temperature increase.



Heating

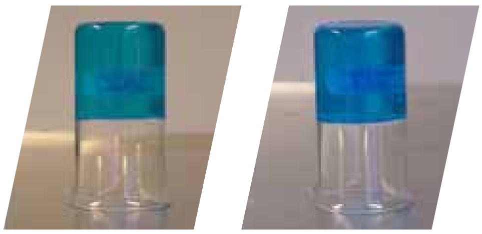
Example 2

A formed gel which melts upon heating, is known as a thermo-reversible gel. Gelatin is the most common example, although pectins and carrageenans can also form thermo-reversible gels.

Heating

Example 3

A formed gel which does not melt upon heating, is known as a thermo-stable or thermo-irreversible gel.
Alginates form thermo-stable gels, plus pectins can be formulated to become thermo-stable.



Heating

Example 4

A cold solution which gels on heating. This property is seen when cooking egg-white. The only hydrocolloids showing this thermo-gelling functionality are the cellulosic products MC and HPMC.

Heating

FUNCTIONALITY OF HYDROCOLLOIDS IN THE FINAL FOOD PRODUCT

The first criteria to consider when selecting the optimum hydrocolloid, is the texture properties you require of the final product and what you would like the hydrocolloid to achieve? Are you looking for sensoric properties as well as texture properties? Do you require a thickened or a more gelled structure? When the final product is a multiphase system (foam, suspensions, emulsion) the hydrocolloid should also deliver some stabilising properties.

HYDROCOLLOID	T = THICKENING G = GELLING S = STABILISATION	DESCRIPTION OF TEXTURE
Alginates	T, G	Alginates or more specifically sodium alginates can be used as a thickening agent (different grades offer a range of viscosities). Alginates can form strong, cohesive, thermo-resistant gels in the presence of calcium ions.
Carrageenan, Iota	T, G	Iota carrageenan forms elastic gels and thixotropic fluids.
Carrageenan, Kappa	G, S	Kappa carrageenan forms firm gels. Very low dosages of kappa carrageenan in milk shows a positive interaction with milk proteins, resulting in suspension of cocoa particles.
Carrageenan, Lambda	T	Lambda carrageenan forms viscous, non-gelling solutions.
Cellulosics, CMC	T, S	CMC forms clear, viscous solutions (a range of viscosities are available). CMC shows protective colloid properties in acidified milk drinks.
Cellulosics, MC and HPMC	T, G	HPMC and MC, which are dissolved in cold water, will gel upon heating (thermo-gelling). Different grades with different viscosities / different gelation temperatures are available. The gel is thermo-reversible, since the system will return to a viscous liquid phase upon cooling.
Gellan gum	G, S	Gellan gum is available in two forms, high and low acyl content. Low acyl gellan gum forms firm, non-elastic, brittle gels. High acyl gellan gum forms soft, very elastic gels. By varying the ratios of the two forms, gellan can produce a wide variety of textures. Gellan gum can be used to stabilise suspensions by forming a solution with a weak gel structure, known as a fluid gel.
Guar gum	T	Guar gum forms viscous solutions with a long texture.
Gum arabic	T, G	Gum arabic is used in confectionary for its gelling properties. Gum arabic is used in flavour and colour emulsions as an emulsifying agent.
Locust Bean Gum (LBG)	T, (G)	LBG forms viscous, shear thinning solutions. LBG can form gels in combination with other hydrocolloids. LBG is excellent in syneresis control.
Pectin, HM	G, S	High methoxyl pectins form gels at low pH and in the presence of sugar. HM pectins are classified as rapid set, medium set or slow set. HM pectins are also used in acidified milk drinks (pH < 4,6) to stabilise the proteins.
Pectin, LM	G	(Amidated) low methoxyl pectins also form gels – partly shear reversible.
Xanthan gum	T, S	Xanthan gum forms pseudo-plastic viscous solutions, which are pH and temperature stable compared to other thickeners. The pseudo-plasticity makes xanthan gum also suitable as a stabiliser of suspensions, emulsions and foams.

FORMULATING WITH HYDROCOLLOIDS; SOLUBILITY, COMPATIBILITY AND THICKENING OR GELLING MECHANISM

Most hydrocolloids are supplied as powders. To become functional (generate viscosity or gel), the hydrocolloid must be in solution. When dissolving a hydrocolloid, the applied temperature as well as the presence of other ingredients will have an effect (potentially both positive and negative).

HYDROCOLLOID	SOLUBILITY	SOLUTION CLARITY	pH RANGE IN APPLICATION	ACID STABILITY
Alginates	Cold or hot soluble in a calcium free medium. In high calcium environment, sequestrants are needed to dissolve the alginate.	Good	4.5 – 7	Fair (will form alginic acid at low pH)
Carrageenans	Iota and Kappa: hot soluble, above 60 °C. Lambda is also cold soluble	Good	4.5 – 7	Poor
Cellulosics, CMC	Cold or hot soluble	Excellent	3.5 – 7	Good
Cellulosics, MC and HPMC	Cold soluble	Excellent	4 – 7	Good
Gellan gum	Hot soluble in an ion free medium. In high ion environment, sequestrants are needed to dissolve gellan.	HA – Good LA – Poor	3 – 7	Good
Guar gum	Cold or hot soluble	Fair	4 – 7	Fair
Gum Arabic	Cold or hot soluble	Excellent	2 – 7	Good
Locust bean gum	Hot soluble, above 80 °C	Fair	4 – 7	Good
Pectin	Hot soluble, above 60 °C	Excellent	2 – 7	Very good
Xanthan gum	Cold or hot soluble	Fair	2 – 7	Very good

When hydrocolloids are solubilised they either work alone, or require other substances, such as ions, to generate viscosity or gel properties.

HYDROCOLLOID	ACT ALONE ACT WITH	DESCRIPTION OF THICKENING OR GELLING MECHANISM
Alginates	With calcium ions	Sodium alginates are composed of two building blocks: mannuronic acid (M) and guluronic acid (G). In the presence of calcium ions, the G-blocks in the alginate chain will join together and form a gel structure. Alginates with a high content of G-blocks, form stronger gels than alginates with high M-blocks content. When there is enough free calcium available, the alginate gel will become thermo-irreversible. Please note: alginate gel forms in cold conditions.
Carrageenan, Iota	With calcium ions	After being heat treated to dissolve the carrageenan, the molecules will join together during cooling, thereby forming a gel structure. The iota carrageenan network forms a transparent, elastic gel. When stirring this network can easily be destroyed, but the gel is rebuilt quickly as soon as the mechanical action stops. The gels of iota carrageenan are thermo-reversible.
Carrageenan, Kappa	With potassium ions	After being heat treated to dissolve the carrageenan, the molecules will join together during cooling, thereby forming a gel structure. Kappa carrageenan needs the presence of potassium ions to form a firm, brittle gel. The gels of kappa carrageenan are thermo-reversible. Kappa-carrageenan shows synergistic gel strength when combined with locust bean gum.
Carrageenan, Lambda	Alone	The molecules of lambda carrageenan do not strongly join together and therefore do not form gels. Lambda carrageenan functions as a thickener.
Cellulosics, CMC	Alone	CMC acts alone to form viscous solutions. The wide variety of viscosity ranges available, make it a versatile hydrocolloid for many applications.
Cellulosics, MC and HPMC	Alone	When the temperature of a MC/HPMC solution is increased, the polymers lose their water of hydration and the viscosity decreases. When the gel point is reached, the dehydration of the polymers cause polymer-to-polymer interaction and the solution begins to gel. Gel strength builds as the temperature is held above the gel point. When the system is cooled, the gel begins to reverse, and the system becomes a liquid viscous system again. Depending on the type of MC or HPMC the gel point can vary from 50 °C to 90 °C.
Gellan gum	With potassium, sodium and calcium ions	Gellan gum forms gels with divalent as well as monovalent ions. Calcium ions are more effective in making gels than sodium and potassium ions. The concentration of ions also influences the gelling and melting temperature of the gel which is formed. Low acyl gellan gum tends to form thermo-stable gels, whereas high acyl gellan gum tends to form thermo-reversible gels.
Guar gum	Alone or with xanthan gum	Guar gum acts alone to form viscous solutions. In combination with xanthan gum a synergistic viscosity development can be noticed.
Gum arabic	Alone	Gum arabic is a unique molecule and contains 2 to 3% peptides as an integral part of the structure. It is believed that these peptide fractions are responsible for the emulsifying capacity. Gum arabic forms very low viscous solutions, concentrations up to 50% can be achieved.
Locust bean gum (LBG)	Alone or with xanthan gum or carrageenan	LBG forms viscous, shear thinning solutions. In combination with xanthan gum and/or kappa carrageenan, LBG forms mixed gels with an elastic texture, which show no syneresis.
Pectin, HM	With sugar and low pH	HM (high methoxy) pectins form thermo- irreversible gels when the pH is low (< pH 3.5) and the sugar concentration is high (dry matter content > 55 %).
Pectin, HM	With protein	HM pectins are excellent stabilisers of acid milk drinks. They act as a protective colloid, preventing the casein particles from coagulating and sedimenting, when added before acidification.
Pectin, LM	With calcium ions	LM (amidated) low methoxy pectins can form thermo-reversible as well as thermo-stable gels. Depending on the calcium concentration and the calcium reactivity of the specific grade, a range of textures can be achieved.
Xanthan gum	Alone or with guar gum	Xanthan gum acts alone to form viscous, pseudo-plastic solutions. In combination with guar gum, a synergistic viscosity development can be noticed.

APPLICATIONS

The application areas for hydrocolloids are numerous, plus hydrocolloids can be used in a variety of combinations. Therefore, the application grid provided below and the other information provided earlier, should be used as a guideline only, to provide a starting point for development work.

	ALGINATES	CARRAGEENAN	CELLULOSICS, CMC	CELLULOSICS, MC + HPMC	GELLAN GUM	GUAR GUM	GUM ARABIC	LOCUST BEAN GUM	PECTIN	XANTHAN GUM
Bakery products (incl. bakery fillings)	■■		■■	■	■	■■		■	■■	■■
Beverages		■	■■		■	■	■		■■	■
Confectionery					■		■■		■■	
Convenience: sauces, dressings, soups, marinades		■	■	■		■■		■		■■
Dairy, acidified / fermented drinks, desserts			■■						■■	
Dairy, sweet drinks, desserts	■	■■	■		■	■		■		
Flavour emulsions			■	■			■■		■	
Fruit preparations, jams, marmalades	■■	■	■	■	■	■		■	■■	■
Ice-cream	■	■	■■			■		■■	■	■
Meat and poultry processing	■■	■■	■	■■		■				■
Vegetable, potato preparations	■		■	■■						■

SOURCE

Please find below information on the source of the different hydrocolloids, plus abbreviations and synonyms which are used in the industry.

HYDROCOLLOID	ABBREVIATIONS SYNONYMS	E NUMBER	RAW MATERIAL
Alginates	Sodium alginates	E 401	Extracted from brown seaweed
Carrageenan	Iota, Kappa, Lambda Carrageenan	E 407	Extracted from red seaweed
Cellulosics, CMC	Carboxymethylcellulose Cellulose gum	E 466	Manufactured using cellulose (from wood pulp or cotton linters) as base material
Cellulosics, MC and HPMC	Methylcellulose Hydroxypropylmethylcellulose	E 461 E 464	Manufactured using cellulose (from wood pulp or cotton linters) as base material
Gellan gum		E 418	Produced by fermentation process
Guar gum *		E 412	Obtained from the endosperm of the guar seed
Gum arabic	Acacia gum	E 414	Exudate from the acacia tree
Locust bean gum (LBG) *	Carob (bean) gum	E 410	Obtained from the endosperm of the seeds of the carob tree.
Pectin		E 440	Extracted from apple pomace and / or citrus peel
Xanthan gum		E 415	Produced by fermentation process

* Galactomannans is a group name, locust bean gum and guar gum are both galactomannans.

REGULATORY

Thickening and gelling agents are food additives and their use is subject to several laws and regulations. For the member states of the European Union, their use is inter alia subject to Regulation (EC) No 1333/2008 on food additives published in December 2008.

Annex I of this Regulation describes the functional classes of food additives:
'gelling agents' are substances which give a foodstuff texture through formation of a gel.

'stabilisers' are substances which make it possible to maintain the physico-chemical state of a foodstuff; stabilisers include substances which enable the maintenance of a homogenous dispersion of two or more immiscible substances in a foodstuff, substances which stabilise, retain or intensify an existing colour of a foodstuff and substances which increase the binding capacity of the food, including the formation of cross-links between proteins enabling the binding of food pieces into re-constituted food;

'thickeners' are substances which increase the viscosity of a foodstuff;

Annex II provides the community list of food additives approved for use in foods
The list is published in November 2011, in Commission Regulation (EU) No 1129/2011 amending Annex II to Regulation (EC) No 1333/2008.

The list includes:
- The name of the food additives and the E numbers (part B)
- Definitions of groups of additives (part C)
- The foods to which the food additives may be added, food categories (part D)
- The conditions under which the food additives may be used (part E)

Specifications of food additives
Commission Regulation (EU) No 231/2012 published in March 2012, provides the specifications, such as purity criteria, origin and other necessary information, for food additives.

For a complete overview of approved hydrocolloids and the exact approved applications, dosage and conditions of use in the European Union, the most current Regulations and directives as well as any other applicable national laws and regulations must be checked. The complete texts as well as consolidated versions of the European Regulations and directives with last updates can be viewed and downloaded from the following website: http://eur-lex.europa.eu/en/index.htm

For any use outside the European Union, please check carefully the laws and regulations applicable for you. Please keep in mind that you are responsible for compliance with any applicable legal and regulatory requirements.

CONTACT US

Brenntag Europe is delighted to offer its customers a wide portfolio of Hydrocolloids. If you would like to discuss with one of our food dedicated specialists, which particular products would best meet your requirements, then please write a short email to food-emea@brenntag.de and your local Brenntag office will provide you with the requested information and samples.

Please visit **www.brenntag-food.eu**

Information Sources:
Technical bulletins of our hydrocolloid suppliers.

The data contained within this publication is intended for information purposes only and is correct to the best of our knowledge. Any recommendations or suggestions are made without any warranty or guarantee. It is the sole responsibility of the user of the products to evaluate for each individual product its suitability for a particular purpose and the compliance with legal and regulatory requirements. In addition, nothing contained within this publication should be construed as a recommendation to use any product in conflict with existing intellectual property rights.

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