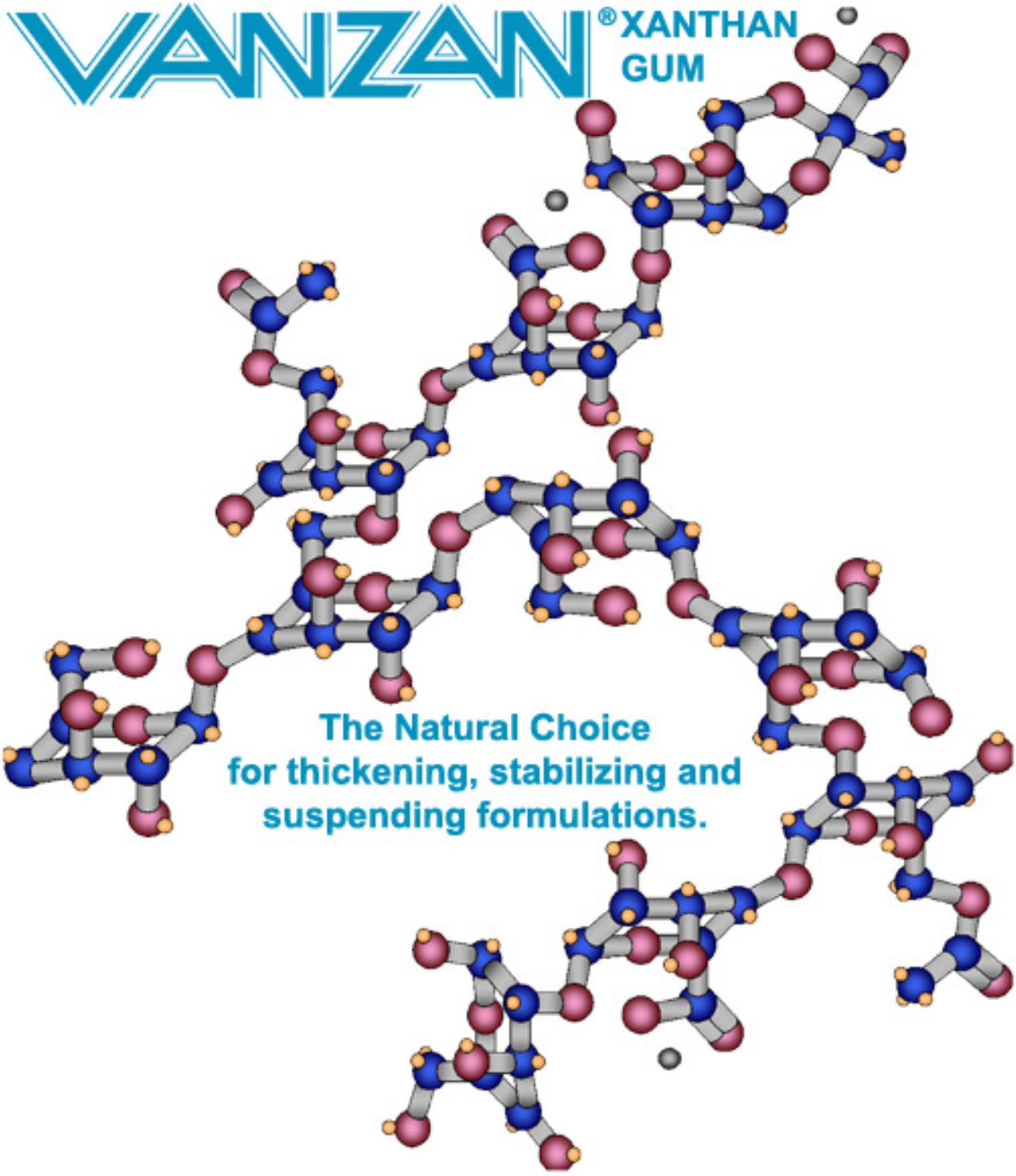
VANZAN® XANTHAN GUM



The Natural Choice for thickening, stabilizing and suspending formulations.

Features

Derived from a Natural Resource
High Efficiency Thickener and Suspending Agent
Enhances Emulsion Stability
Stable Rheology over a Broad Temperature Range
Effective in Strong Acid and Strong Alkali Systems
Resistant to Enzymatic Attack
Soluble in Cold or Warm Water

Before using one of these products, read, understand and comply with the information and precautions and other product safety literature provided. Make sure your employees and other users comply with this requirement to better insure a safe and healthful workplace.

Introduction

Xanthan gum is a high molecular weight exocellular polysaccharide derived from the bacterium *Xanthomonas campestris* using a natural, aerobic fermentation process. The process is conducted in a sterile environment where the pH, oxygen content and temperature are rigorously controlled. After fermentation is complete, the broth is sterilized and the gum is recovered by precipitation with isopropyl alcohol, then dried, milled and packaged under sterile conditions.

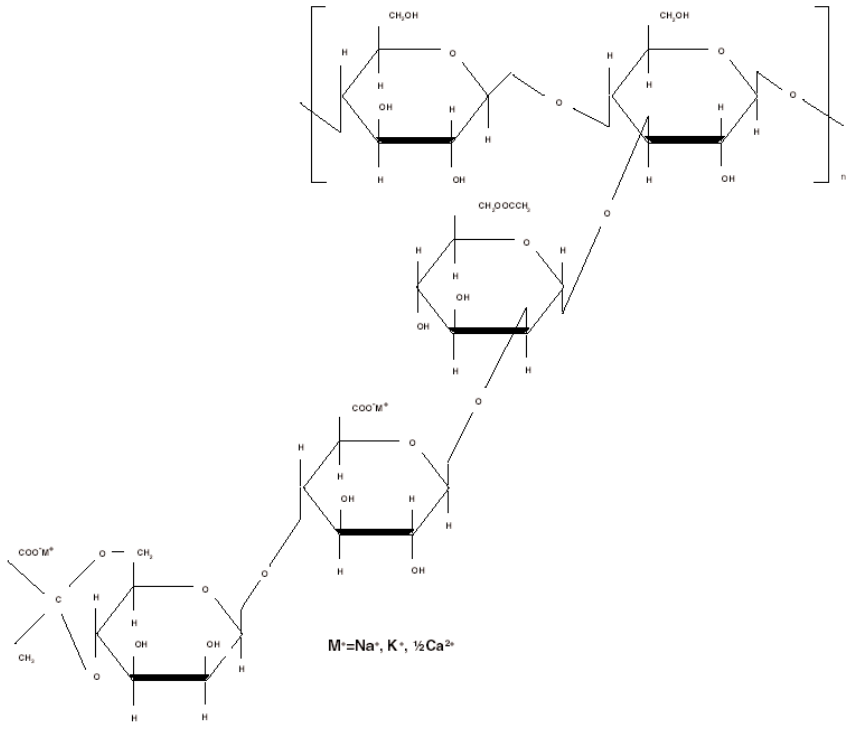
R.T. Vanderbilt Company's xanthan gum bears the trade name VANZAN. It is widely used as a rheology control agent for aqueous systems. It increases viscosity, helps to stabilize emulsions, and prevents the settling of solids in a wide variety of consumer and industrial applications.

VANZAN grades are available for both pharmaceutical and technical applications. Pharmaceutical grades are recommended for personal care applications. Technical grades are recommended for household/institutional products and industrial applications.

Structure

The molecular structure of VANZAN Xanthan Gum is illustrated in Figure 1. The xanthan polymer backbone is identical to that of cellulose, but the unique character of xanthan gum is derived from the trisaccharide side chain on alternate sugar units. This chain is composed of a glucuronic acid salt between a mannose acetate and a terminal mannose unit. A pyruvate is attached to about 60% of these terminal units. The glucuronic acid and pyruvic acid groups on the side chains give xanthan gum its anionic charge. The interaction of these anionic side chains with the polymer backbone and with each other determines the beneficial properties of xanthan gum solutions.

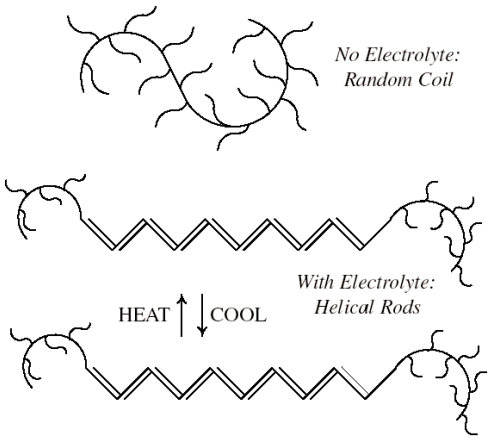
Figure 1: Structure of VANZAN Xanthan Gum



In solutions of low ionic strength or at high temperature, the xanthan gum chains adopt a random coil configuration, since the anionic side chains repel each other. The addition of even small amounts of electrolyte, however,

reduces the electrostatic repulsion among the side chains, allowing them to wrap around and hydrogen bond to the backbone. The polymer chain straightens into a relatively rigid helical rod. This shape tends to revert to the random coil if the gum solution is highly diluted or heated. With increasing electrolyte concentration, however, the rod shape is maintained at higher temperatures and greater dilutions. At ionic strengths above approximately 0.15M, it is retained up to 100°C. Figure 2 shows the effect of electrolyte on xanthan gum molecular configuration.

Figure 2:
Effect of Electrolyte on Xanthan Molecular Configuration

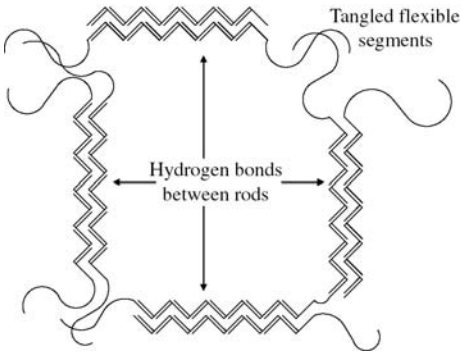


Water-soluble polymers can lose thickening efficiency if the polymer backbone is severed by chemical or enzyme attack. In xanthan gum solutions, the side chains wrapped around the polymer backbone protect it from attack, which explains this gum's unusual resistance to chemical and enzymatic degradation.

RHEOLOGICAL PROPERTIES

The nature of the interaction among xanthan gum molecules in aqueous solution is not certain, although both hydrogen bonding and ionic interactions are believed to be involved. In salt-free solutions, viscosity is built through the entanglement of the random polymer coils, to the extent allowed by the mutual repulsion of the negatively charged side chains. When electrolyte is present, a colloidal network forms, based on intermolecular hydrogen bonding among the helical rod segments, in addition to limited polymer entanglement, as illustrated in Figure 3.

Figure 3: Xanthan Gum Polymer Network

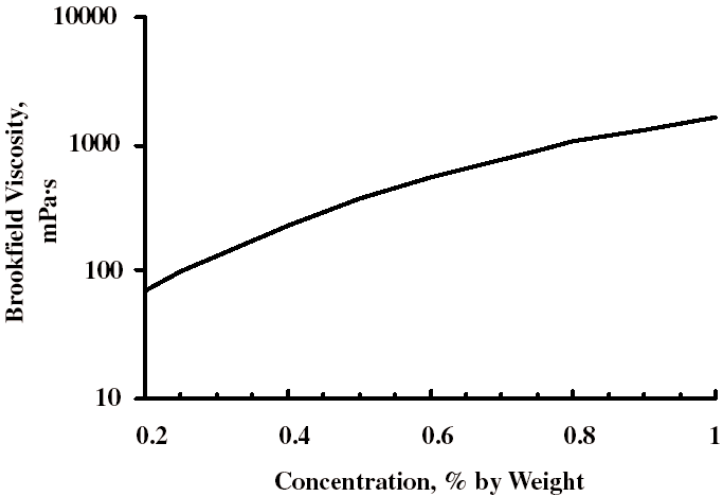


This network of entangled stiff molecules accounts for the characteristic rheological properties of xanthan gum solutions.

Thickening Efficiency

The xanthan polymer network makes VANZAN a highly efficient thickener for aqueous-based systems. Concentrations as low as 0.1% by weight will cause significant increases in viscosity. Concentrations greater than 1.0% by weight will produce very high viscosity systems with gel-like consistency. The relationship between the concentration of VANZAN NF and the viscosity of the aqueous solution is shown in Figure 4.

Figure 4: Viscosity vs. Concentration of VANZAN NF



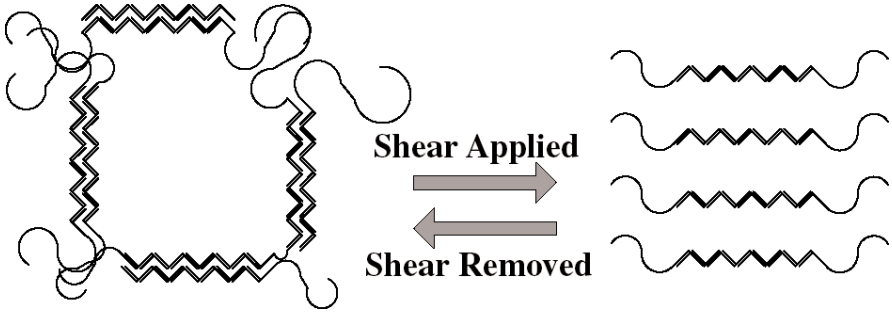
Yield Value

VANZAN imparts yield value in aqueous compositions. Yield value reflects the minimum force (the yield stress) that must be applied to start disrupting the cohesive polymer network. In practical terms, solids, oils and gases are trapped and segregated by the polymer network unless the force of gravity or buoyancy can exert a force greater than the yield stress. The greater the yield value, the more stable the suspension, emulsion or foam. Other polymeric hydrocolloids can provide thickening efficiency, but few provide the yield value obtained from xanthan gum.

Pseudoplasticity

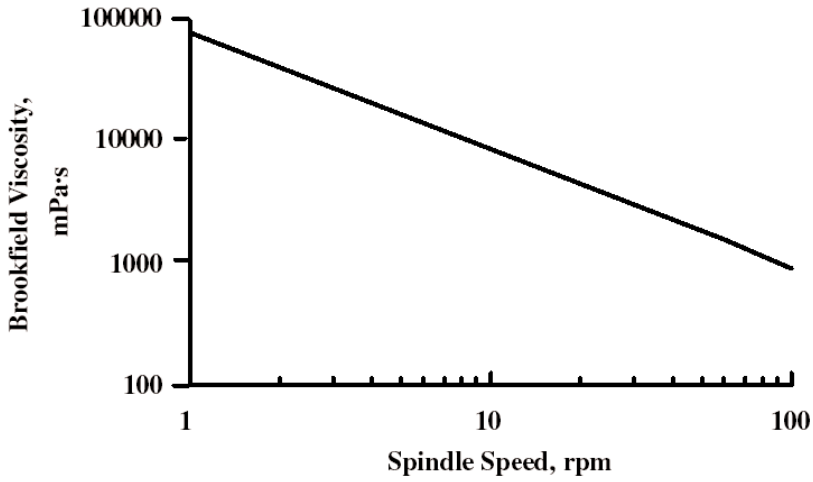
Once the yield stress is exceeded, xanthan gum solutions are pseudoplastic. The network disaggregates as individual polymer molecules align in the direction of the shear force. The extent of this disaggregation is proportional to the shear rate. The network reforms rapidly when shear is removed. The effect of mechanical shear on the xanthan polymer network is depicted in Figure 5.

Figure 5: Effect of Shear on the Xanthan Polymer Network



Aqueous solutions and formulated products containing VANZAN exhibit a high degree of pseudoplasticity. The viscosity of the solution decreases significantly as the rate of shear increases, as shown in Figure 6. The viscosity is very high when the composition is at rest or subjected to low levels of shear. At high shear, which is frequently encountered when the formulated product is used, the viscosity is significantly lower.

Figure 6: Pseudoplasticity of a 1% VANZAN Solution



Effect of Temperature

The rheology of aqueous VANZAN solutions is remarkably stable over a broad temperature range, as shown in Table I. The viscosity and yield value of compositions containing the gum will not change significantly between ambient temperature and 60°C. VANZAN provides the same thickening, stabilizing and suspending properties during long-term storage at elevated temperature as it does at ambient conditions. In addition, it imparts excellent freeze/thaw stability to most compositions.

Table I: Effect of Temperature on Solution Viscosity

VANZAN, wt.%	Measurement Temperature, °C	Viscosity, mPa•s
1.0	20	1550
1.0	40	1550
1.0	60	1500
0.5	20	550
0.5	40	500
0.5	60	450

Effect of pH

VANZAN is recommended for use in both acidic and alkaline systems. As shown in Table II, the viscosity remains nearly constant between pH 2 and pH 12. Below pH 2 and above pH 12, the viscosity tends to decrease slightly. This makes VANZAN an excellent choice for compositions containing relatively high concentrations of acids or bases.

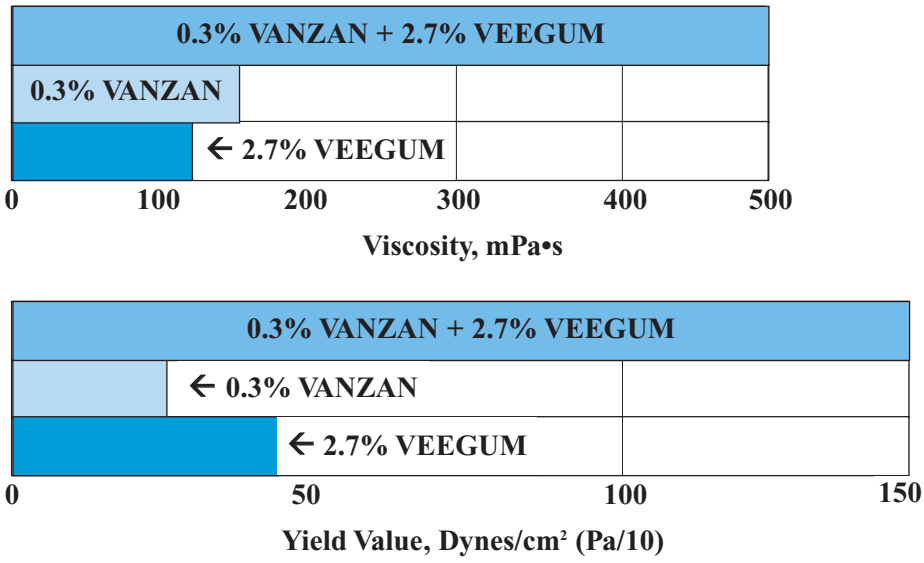
Table II: Viscosity vs. pH in VANZAN Solutions

pH	2	4	6	8	10	12
Viscosity @ 1.0%, mPa•s	1550	1550	1550	1550	1550	1550
Viscosity @ 0.5%, mPa•s	500	550	550	550	550	500

Rheology Synergism

Mixtures of xanthan gum with water-swellable clays or certain galactomannans produce synergistic rheological effects. The mixtures produce greater viscosity and yield value (and therefore greater thickening, stabilizing and suspending properties) than those developed by the individual components of the mixture. A water-swellable clay that is particularly effective in combination with VANZAN is VEEGUM® Magnesium Aluminum Silicate, which is also available from R.T. Vanderbilt Company, Inc. A weight-to-weight ratio of VANZAN to VEEGUM between 1:9 and 1:2 generally produces the most desirable results. Figure 7 demonstrates the synergism between

Figure 7: VANZAN - VEEGUM Synergism



Mixtures of VANZAN Xanthan Gum and VEEGUM Magnesium Aluminum Silicate produce 1.4 to 1.8 times the viscosity as compared to the sum of the viscosity developed by individual components of the mixture. The combination also produces 1.7 to 2.1 times the yield value as compared to that expected from the sum of the individual components.

Strong synergistic effects are exhibited by mixtures of xanthan gum with galactomannans like guar gum and locust bean gum. Weight-to-weight ratios of VANZAN to guar gum between 1:1 and 1:9 are recommended. The synergism with locust bean gum is even stronger than that with guar gum. A weight-to-weight ratio of 1:1 is recommended for most applications. At concentrations greater than 0.2%, mixtures of xanthan gum and locust bean gum will form thermally reversible gels when heated above 55°C and subsequently cooled.

COMPATIBILITY GUIDELINES

Solvents

Because VANZAN is an anionic polysaccharide, it is compatible with other anionic and nonionic ingredients. However, VANZAN is not generally compatible with cationic species, which can cause interactions that lead to the precipitation of both components. It is also incompatible with strong oxidizing agents such as NaOCl and H_2O_2, which can cause rapid and severe degradation of the polymer.

Xanthan gum is compatible with aqueous solutions of common water-miscible solvents. 1% VANZAN solutions, for example, can contain up to 40% to 50% glycerol, glycols, glycol ethers, and alcohols without precipitation of the gum. VANZAN is also broadly compatible with acids, bases and salts.

Acids and Bases

VANZAN exhibits good compatibility in many strong mineral acid solutions, as shown in Table III. VANZAN also provides long-term viscosity stability in alkaline systems, including those containing sodium carbonate, sodium hydroxide, sodium metasilicate or sodium phosphate.

Table III: Compatibility of 1% VANZAN with Acids

Acid	Acid Concentration	Viscosity Retained after 3 Months[1]
Citric Acid	10%	80%
Citric Acid	20%	80%
Acetic Acid	10%	75%
Acetic Acid	20%	75%
Sulfuric Acid	5%	85%
Sulfuric Acid	10%	85%

[1]Viscosity measured with Brookfield LVTD, Spindle 3, 60 rpm

Salts

VANZAN is stable in the presence of high concentrations of many inorganic salts. Table IV lists a number of salt solutions containing 0.5% xanthan gum that exhibit stable viscosity with extended storage.

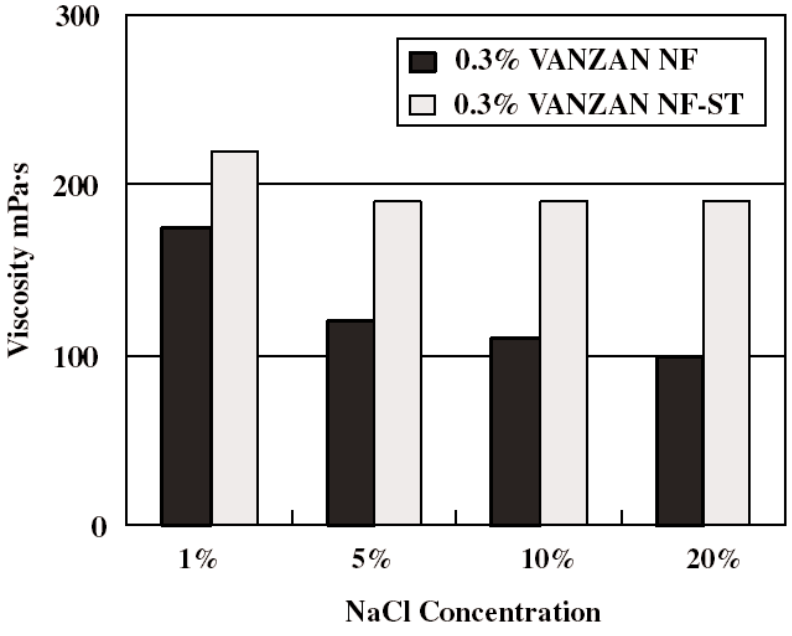
Table IV: Compatibility of 0.5% VANZAN with Salts

Salts	Salt Concentration	Viscosity Retained After 3 months[1]
NaCl	5%	105%
NaCl	10%	110%
NaCl	20%	105%
KCl	5%	110%
KCl	10%	105%
KCl	20%	105%
$MgSO_4$	5%	105%
$MgSO_4$	10%	110%
$MgSO_4$	20%	105%
$CaCl_2$	5%	115%
$CaCl_2$	10%	105%
$CaCl_2$	20%	110%

[1]Viscosity measured with Brookfield LVTD, Spindle 3, 60 rpm

Divalent salts, such as those of calcium, magnesium, and barium can cause the gelation and/or precipitation of xanthan gum at alkaline pH (pH>10). Trivalent salts, such as those of aluminum, iron and chromium can cause gelation at acid and neutral pH levels as well. One grade of VANZAN is specially designed for use in systems containing high salt concentrations: VANZAN NF-ST. It hydrates and dissolves more rapidly when added to salt solutions, and its viscosity is relatively unaffected by high salt levels as compared to the general purpose grade, VANZAN NF, as shown in Figure 8.

Figure 8: Superior Salt Tolerance of VANZAN NF-ST



Pharmaceutical and Personal Care

Five grades of VANZAN Xanthan Gum are available to the pharmaceutical and personal products industries. Key physical properties and features of these grades are summarized in Table V.

All pharmaceutical grades of VANZAN (those designated with the suffix "NF") conform to the requirements of the Xanthan Gum monograph in USP 24/NF 19.

Table V: VANZAN Pharmaceutical/Personal Care Grades

Trade Name	Viscosity, mPa•s[1]	pH[2]	Moisture, %	Particle Size
VANZAN NF	1400 - 1600	6.0 - 8.0	15 max.	95% min. −80 mesh (180 µm)
VANZAN NF-F	1400 - 1600	6.0 - 8.0	15 max.	92% min. −200 mesh (75 µm)
VANZAN NF-C	1300 - 1700	6.0 - 8.0	12 max.	95% min. −80 mesh (180 µm)
VANZAN NF-ED	1300 - 1700	6.0 - 8.0	15 max.	100% −16 mesh (1.18mm)
VANZAN NF-ST	1300 - 1700	6.0 - 7.0	12 max.	92% min. −200 mesh (75 µm)

[1] 1% xanthan gum in 1% KCl solution, measured at 25°C using Brookfield Model LV viscometer at 60 rpm with Spindle #3.
[2] 1% xanthan gum in deionized water at 25°C.

VANZAN NF is the **general purpose** grade suitable for most pharmaceutical and personal care applications.

VANZAN NF-F is a **finely ground powder** designed for applications such as tablets and dry mix powder formulas.

VANZAN NF-C produces **clear** xanthan gum solutions for applications where product clarity is essential, such as syrups and gels.

VANZAN NF-ED provides **easier dispersion** with rapid viscosity development, without the formation of lumps or "fish eyes".

VANZAN NF-ST is a fine powder which tolerates a significantly greater amount of **dissolved salts** in the formulation.

Technical

These grades are recommended for household/institutional products, as well as for a variety of industrial applications. Key properties of these technical grades are summarized in Table VI.

Table VI: VANZAN Technical Grades

Trade Name	Viscosity, mPa•s	pH	Moisture, %	Particle Size
VANZAN	1400 - 1600[1]	5.5 - 8.5[3]	15 max.	95% min. −80 mesh (180 µm)
VANZAN D	800 - 1400[2]	4.5 - 7.0[3]	15 max.	95% min. −45 mesh (355 µm)

[1] 1% xanthan gum in 1% KCl solution, measured at 25°C using Brookfield Model LV viscometer at 60 rpm with Spindle #3.
[2] 1% xanthan gum in deionized water, measured at 25°C using Brookfield Model LV viscometer at 60 rpm with Spindle #3.
[3] 1% xanthan gum in deionized water at 25°C.

VANZAN is the **general purpose** grade suitable for most household, institutional and industrial applications.

VANZAN D is a surface-treated grade which provides **easier dispersion** with rapid viscosity development, without the formation of lumps or "fish eyes".

APPLICATIONS

Grades of VANZAN Xanthan Gum that include the suffix "NF" meet the requirements of the National Formulary's monograph on Xanthan Gum, and are therefore acceptable for use in pharmaceutical products. They are also recommended for personal care applications. Grades of VANZAN without the "NF" designation are technical grades recommended for household, institutional and other industrial applications.

Tables VII - IX summarize the recommended applications for VANZAN, the functions performed in the application, and the grade(s) recommended for the specific application.

Table VII: Pharmaceutical Applications

Application	Thickener	Suspending Agent	Emulsion Stabilizer	Gelling Agent	Foam Stabilizer	Stabilizer	Recommended Grade(s)
Dental Care							
Dental Impression Materials				✓		✓	VANZAN NF-F
Dental Treatment Gels	✓			✓			VANZAN NF & NF-C
Dentifrice Pastes, Gels	✓			✓		✓	VANZAN NF, NF-F & NF-C
Therapeutic Products							
Acne Treatment Lotions	✓	✓	✓				VANZAN NF & NF-ED
Antacid Suspensions		✓					VANZAN NF & NF-ED
Antidiarrheal Suspensions		✓					VANZAN NF & NF-ED
External Analgesics	✓		✓				VANZAN NF & NF-ED
Oral Syrups & Elixirs	✓						VANZAN NF-C
Other Pharmaceuticals							
Anti-Dandruff Shampoos	✓	✓			✓		VANZAN NF & NF-ED
Ophthalmic Liquids	✓						VANZAN NF-C
Tablet Coatings	✓	✓				✓	VANZAN NF-F

Table VIII: Personal Care Applications

Dental Care							
Dentifrice Pastes, Gels	✓			✓		✓	VANZAN NF, NF-F & NF-C
Hair Care							
Shampoos	✓				✓		VANZAN NF & NF-C
Styling Creams & Gels	✓		✓	✓			VANZAN NF & NF-C
Perms & Hair Straighteners	✓			✓			VANZAN NF
Liquid Soaps & Bath Gels	✓		✓	✓	✓		VANZAN NF & NF-C
Skin Care							
Liquid Makeup, Mascara & Eye Shadow	✓	✓	✓				VANZAN NF
Depilatories	✓		✓				VANZAN NF-ST
Roll-on Deodorants & Antiperspirants	✓	✓					VANZAN NF
Skin Creams & Lotions	✓		✓				VANZAN NF
Sunscreens	✓	✓	✓				VANZAN NF

Table IX: Household, Institutional & Industrial Applications

Application	Thickener	Suspending Agent	Emulsion Stabilizer	Gelling Agent	Foam Stabilizer	Stabilizer	Recommended Grade(s)
Household/Institutional Products							
Acid Toilet Bowl Cleaners	✓			✓	✓		VANZAN
Auto Cleaner & Polish	✓	✓	✓				VANZAN
Automatic Dishwasher Detergents(w/o Bleach)	✓				✓		VANZAN & VANZAN D
Basin, Tub and Tile Cleaners	✓	✓			✓	✓	VANZAN
Metal Cleaners & Polish	✓	✓			✓		VANZAN
Oven & Grill Cleaners	✓				✓		VANZAN & VANZAN D
Waterless Hand Cleaners	✓	✓	✓			✓	VANZAN
Industrial Products							
Agricultural Flowables	✓	✓	✓				VANZAN
Adhesives	✓						VANZAN
Carpet Printing Pastes	✓	✓					VANZAN
Ceramic Glazes	✓	✓					VANZAN
Printing Inks	✓	✓					VANZAN
Water-Based Paints & Coatings	✓	✓	✓				VANZAN

REGULATORY STATUS

Grades of VANZAN including the suffix "NF" are pharmaceutical grades and, as such, conform to the requirements of the following regulatory standards:

United States Pharmacopoeia/National Formulary,
USP 24/NF 19, (2000), p2537

British Pharmacopoeia, (1998), p1373

European Pharmacopoeia, 3rd Edition, 2nd Supplement (1998), p1277

Japanese Pharmaceutical Excipients (JPE), 1993

PREPARATION OF SOLUTIONS

VANZAN products are soluble in both cold and warm water. Water temperature has little effect on the dissolution rate of VANZAN.

Differences in dissolution characteristics between different grades exist primarily because of differences in particle size. Specifically, VANZAN NF-F and VANZAN NF-ST are very fine powders; VANZAN, VANZAN NF and VANZAN NF-C are granular; and VANZAN NF-ED and VANZAN D are coarse granules. Each of these three categories exhibits slightly different dissolution characteristics and, consequently, the recommended method to prepare the solution also differs.

VANZAN, VANZAN NF & VANZAN NF-C

When dissolving VANZAN, VANZAN NF or VANZAN NF-C, the mixer should develop a deep vortex in the water in the mix tank. The gum should be slowly sifted into the upper wall of the vortex.

The gum should never be dumped into the water, and large amounts of VANZAN should not be allowed to float on the surface of the water during mixing. This can cause the formation of lumps or "fish eyes" that take much longer to dissolve. Although xanthan gum is not prone to shear degradation, propeller mixers are preferred for the preparation of solutions. Mixing should continue until the solution is smooth and uniform, which usually takes about 30 minutes, or longer for larger batches.

VANZAN NF-F & VANZAN NF-ST

The fine powder grades, VANZAN NF-F and VANZAN NF-ST, require immediate and thorough dispersion of the gum particles as soon as they contact water; otherwise lumps will form that are difficult to dissolve. High efficiency mixers that keep the gum particles well dispersed until they dissolve are essential. Pre-dispersion of the gum in a water-miscible liquid such as an alcohol or glycol helps to prevent the formation of lumps. A ratio of gum to water-miscible liquid between 1:2 and 1:10 is recommended. Dry-blending the gum with another ingredient of similar particle size can also be helpful in avoiding the formation of lumps.

VANZAN NF-ED & VANZAN D

VANZAN NF-ED and VANZAN D are specially designed, easy-to-disperse, coarse granular grades. In the case of VANZAN NF-ED, the larger particle size and smaller effective surface area enables the gum to disperse well and hydrate more slowly in a well-mixed system. As a result there will be less of a tendency to form lumps or “fish eyes”. The development of viscosity will be slower with VANZAN NF-ED, but the overall mixing time required should only be slightly longer than that of other grades.

VANZAN D is a surface-treated grade. The surface treatment allows good dispersion of the particles, even with relatively slow mixing. It also prevents the hydration and dissolution of the gum until the surface treatment is removed by raising the pH of the system to 9 or greater, following which rapid viscosity development will occur. This has the advantage of allowing the formulator to decide when to thicken the composition. It is particularly useful for systems where the final pH is to be alkaline.

Storage and stability

In its dry form, VANZAN is resistant to degradation by bacteria, and a shelf life of 5 years from the date of production is guaranteed if the product is stored in a cool and dry place. The use of a preservative is, however, recommended if solutions of VANZAN are stored longer than 24 hours. VANZAN is compatible with most commonly used preservatives.

Technical Service

For further information or technical service, please contact R.T. Vanderbilt Company or your local technical sales representative. Samples and additional technical literature, as well as detailed specifications of VANZAN products, are available on request.

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R.T. Vanderbilt Company, Inc.

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P.O. Box 5150, Norwalk, CT, U.S.A. 06856-5150
Tel. (203) 853-1400 • Fax (203) 853-1452
E-mail: specialt@rtvanderbilt.com • Web Site: www.rtvanderbilt.com.