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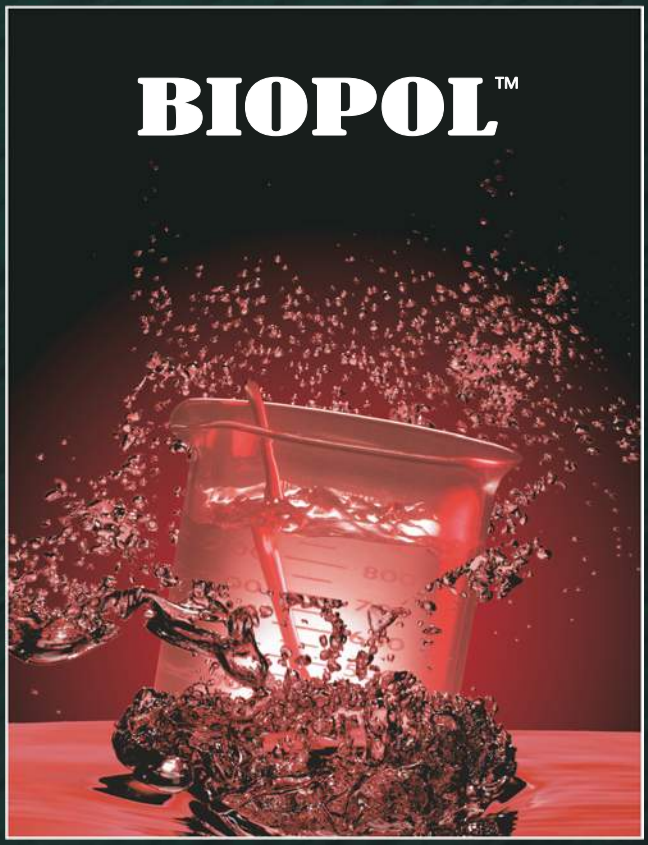
Partnering Through Innovation

BIOPOL™



real **carbomer**

INTRODUCTION

BIOPOL Polymers is water soluble crosslinked Polyacrylic Acid. It is offered as fluffy dry white powder. BIOPOL is used to :

- Thicken - producing a wide range of viscosities and flow properties.
- Suspend insoluble ingredients
- Stabilize emulsions

BIOPOL resin offer these benefits :

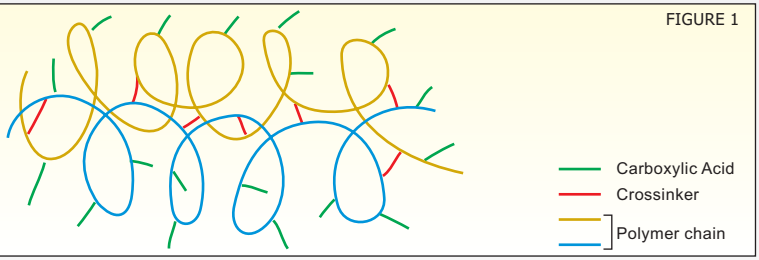
- Thickening efficiency - high viscosities at low concentrations.
- Uniform performance - reproducibility unattainable with natural gums.
- History - over 50 years of successful use.
- Temperature stability – only slight effect on mucilage properties after extended heating/cooling
- Unaffected by aging - excellent shelf life.
- Microbial resistance - resists bacterial attack and does not support mold growth.
- Versatility - although primarily used in aqueous systems with neutralization, it can also be used in solvent systems, with or without neutralization.

Coiled Structure of BIOPOL

BIOPOL is manufactured via suspension polymerization. The polymeric powder is separated from the polymerization medium, purified and dried to the required specifications.

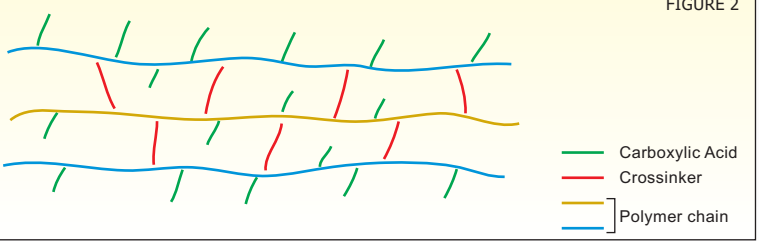
Each particle (about 0.2 micron in diameter with an average agglomerate size of 2-7 microns) is a network structure of polymer chains chemically connected by crosslinks (shown in figure 1).

FIGURE 1



When in contact with water, hydration starts to uncoil the polymer network of BIOPOL. This results in an increase in viscosity of the aqueous dispersion (BIOPOL polymer is not soluble in water but becomes swollen in water). To achieve full viscosity, it is necessary to complete the uncoiling of the polymer chain network. Complete uncoiling is achieved by neutralizing the carboxylic acid groups with a base (an alkali or amine); the resulting anionic charge on the polymer chain creates repulsive forces that rapidly uncoil the network to an extended structure, therefore attaining maximum thickening efficiency (Figure 2).

FIGURE 2



As described above, the viscosity of BIOPOL in water (for example) will increase upon neutralization with a base (such as sodium hydroxide). The relationship of viscosity of an 0.5% aqueous dispersion and pH is depicted in Figure 3. The viscosity of the aqueous dispersion increases as BIOPOL is neutralized, then dispersion viscosity is constant over a range of pH, normally 6.5 - 7 (i.e. a flat plateau as shown in Figure 3). With variation in pH, the viscosity of the aqueous dispersion decreases drastically. This effect is due to the presence of excessive ions. Therefore, care must be taken to avoid overshooting the pH in order to maintain the maximum thickening efficiency.

Effect of pH on viscosity of 0.5% aqueous dispersion

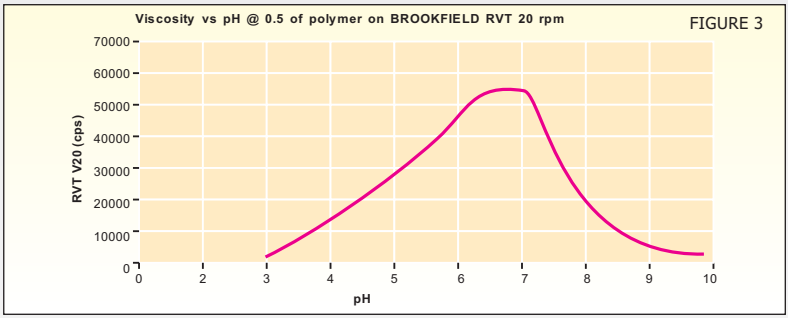


FIGURE 3

The neutralized version of BIOPOL (in form of a salt) is in fact a polyelectrolyte. Therefore, the viscosity of its aqueous dispersion will be susceptible to the presence of electrolytes (e.g. an inorganic salt). The effect of mono-and di-valent salts are depicted in Figure 4. The viscosity drops more dramatically for di-valent ions. (e.g. calcium chloride) than mono-valent ions (e.g. sodium chloride). Solid precipitation can also occur with of di-valent ions. In Industrial practice, the use of a slight excess of BIOPOL or a chelating agent such as EDTA, or both can overcome the presence of inorganic salts to maintain the rheology & thickening efficiency.

Effect of a salt on the viscosity of the 0.5% aqueous Dispersion of BIOPOL 980 at pH 7

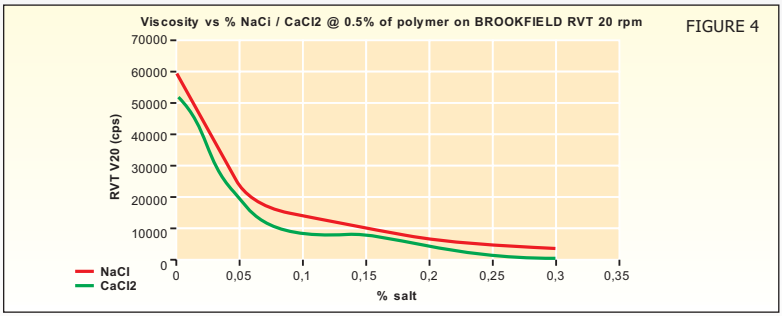
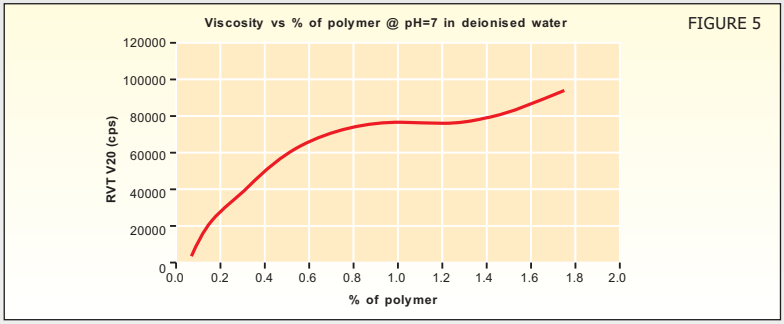


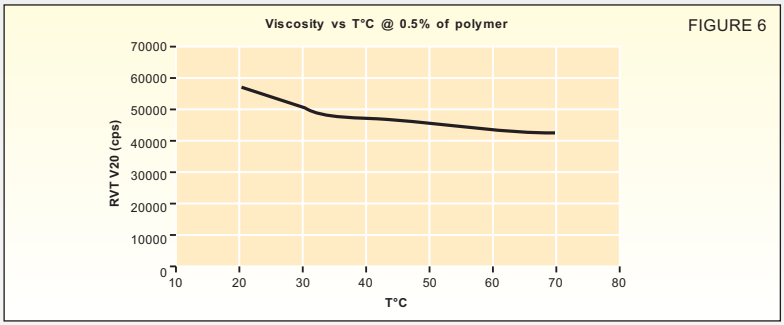
FIGURE 4

Thickening efficiency increases with increasing concentrations of BIOPOL 980 at specific pH (e.g. 7), as depicted in Figure 5. Generally, the viscosity of aqueous dispersions will experience a slight reduction at high temperatures (e.g. 60-70°C), as shown in Figure 6.

Effect of BIOPOL concentration on viscosity at pH 7



Effect of temperature on viscosity of the 0.5% aqueous dispersion of BIOPOL at pH 7



Aqueous dispersion of BIOPOL exhibit pseudoplastic behaviour (i.e. the dispersion has a high apparent viscosity at rest but low viscosity under shear stress). Under normal conditions, the dispersion reverts back to its apparent high viscosity when the shear force is removed. This unique rheological property of BIOPOL provides many benefits for various applications such as cling when applied to a vertical surface and non-splashing when poured out from a container.

Yield value is the minimum amount of shear force required to cause a material to flow. Neutralized aqueous dispersion of BIOPOL exhibit a high yield value that is significant for many applications such as imparting stability to suspensions, emulsions, and vertical cling (as mentioned above). The yield value can be approximated with the Brookfield RVT Viscometer by the following equation :

Brookfield yield Value = (Apparent viscosity at 0.5 rpm - Apparent viscosity at 1 rpm)/100

The yield value and the viscosity of aqueous dispersions are the two important factors for providing stability for an emulsion and stability of suspending solid insoluble particles in a medium.

TYPES OF GRADES

There are two grades of BIOPOL. The pharmaceutical grades of 'BIOPOL NF/USP' are used in oral pharmaceutical formulations. However BIOPOL normal grades are being used in topical personal care formulations.

TYPE	SUGGESTED USES
BIOPOL™ 974P NF/USP BIOPOL™ 934P NF/USP BIOPOL™ 971P NF/USP	Oral Suspensions, Tablet Binder, Controlled Release Formulations, Taste Masking, Toothpaste and Oral Care, Ophthalmic, Intestinal, Nasal, Vaginal & Rectal applications
BIOPOL™ 934 NF	Gels, Ointments, Creams& Lotions
BIOPOL™ 940 NF	Styling Gels, Mousse & Ultra Sounds Gels, Hand Sanitizer, Used with GHTC as a Rheology Modifier in Shampoos.
BIOPOL™ 941 NF	Creams, Lotions & Emulsions
BIOPOL™ 980 NF BIOPOL™ 980 *Crystal*	Styling Gels, Toothpaste & Oral Care, used with GHTC as a Rheology Modifier in Shampoos
BIOPOL™ 981 NF	Silicone Emulsions, Topical Suspensions
BIOPOL™ U10 NF	Creams, Lotions & Emulsions, Hand Sanitizer, Ultrasound Gel
BIOPOL™ U20 BIOPOL™ ETD 2020	Herbal Shampoos, Body Washes, Face Washes for Thickening & Suspending Particles
BIOPOL™ U21	Styling Gels, Shampoos, Mousse, Hand Sanitizer & Ultrasound Gels

PHYSICAL & CHEMICAL PROPERTIES OF BIOPOL

Appearance	fine white powder
Odor	mildly acetic
Particle size	5 microns
Bulk density	0.25 g/cc
Active content	>97%
Viscosity of	Viscosity of
0.5% aqueous dispersion	4,000-120,000 cps
	RV, #6, 20 rpm, 25°C)
pH of 0.5% aqueous dispersion	2.0 - 4.0
Shelf-Life stability	24 months

HOW TO PREPARE AN AQUEOUS DISPERSION OF BIOPOL

BIOPOL has a high affinity for water and powder particles hydrate very quickly. A device to disperse the BIOPOL powder into water slowly and evenly is required to achieve homogeneous dispersions. Care must be taken to avoid clumps of partially hydrated particles and larger surface-wetted agglomerated particles, which require a long time to disperse (swollen fish-eye particles will be present with insufficient agitation time). Constant agitation is required (a speed of 800-1200 rpm is recommended) while the polymer powder is dispersed. Under proper addition conditions, a homogeneous dispersion (lump free) of BIOPOL can be achieved within two hours. The aqueous dispersion is then ready for subsequent neutralization with a base according to the standard procedure.

Foaming can occur in the preparation of aqueous dispersions of BIOPOL. The foam can be eliminated in many cases by the addition of a small amount of a strong mineral acid (e.g. hydrochloric or phosphoric acid).

The above procedure may also be applied to the preparation of dispersions of BIOPOL in solvents. However, BIOPOL will generally disperse very well in solvents.

For aqueous-solvent systems, it is recommended to disperse BIOPOL in the solvent phase prior to the addition of water (and a base for neutralization) to the medium.

SELECTION OF A NEUTRALIZING AGENT

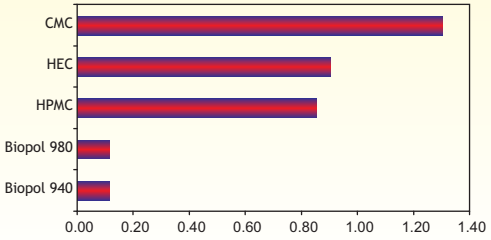
There are many types of bases (i.e. neutralizing agents) available commercially. Hydroxides of sodium, potassium and ammonium are the most common inorganic bases for use in an aqueous system. For hydroalcoholic systems, the choice of a neutralizing agent depends on the hydrophilicity of the medium to be thickened (i.e. hydrophilicity decreases with increasing the amount of alcohol in the medium). The hydrophilicity of the neutralizing agent chosen will decrease with increasing amount of alcohol in the medium (examples shown in below Table).

Examples of NEUTRALIZING AGENT with the amount of an alcohol in a medium

ALCOHOL LEVEL	SUGGESTED NEUTRALIZING AGENT
0-10%	Hydroxides of sodium, potassium and ammonium
30%	Monoethanolamine
	Triethanolamine
60-80%	Aminomethylpropanol (AMP)
	Triisopropanolamine
	Diisopropanolamine
	Triethylamine
	Triamylamine
90-100%	Fatty amine (e.g. Ethomeen C-25)

The same principle holds for thickening organic solvents; an organic amine is recommended. BIOPOL can be used to thicken a variety of polyhydroxy solvents (such as diols, triols and polyols) without a neutralizing agent since the thickening mechanism is hydrogen bonding. In many cases, the use of dual neutralizing agents (inorganic and organic) can be useful for an emulsion system.

Thickening Efficiency (in water) % Thickener Needed for 1,500 cP



Viscosity vs. Yield Value

Material	Brookfield Viscosity	Brookfield Yield Value	Sand Suspension
0.10% Biopol 980	2,175	136	Permanent
2.5% Locust Bean Gum	22,800	80	8 hours
1.5% Sodium CMC	5,900	36	3 hours
1.5% Guar Gum	8,040	32	4 hours
1.5% Sodium Alginate	8,360	16	2 hours

APPLICATIONS OF BIOPOL

BIOPOL is an effective rheology modifier for many applications in personal care, pharmaceutical, home care, industrial and institutional (HI&I) cleaning industries, and others (e.g. solid fuel gels and alkaline batteries).

a) Personal-care cosmetic applications

The hair care applications include :

- Shampoo
- Hair dye and colors
- Styling products

The skin care applications include :

- Creams and lotions
- Sunscreens
- Body washes

b) Pharmaceutical

- Controlled release Tablets
- Liquid Orals
- Tablet Binding
- Taste masking
- Ointments
- Gels

c) Home, Industrial and Institutional (HI&I)

- Hard surface cleaners
- Dish washing (e.g. automatic dish washing liquid gels.)
- Hand cleaners (e.g. heavy duty hand cleaners and hydroalcoholic hand sanitizing gels)
- Fabric Care
- Auto Care
- Deicing fluids

d) Miscellaneous

- Solid fuel gels (e.g. gelled ethanol / methanol for cooking and as a fire starter)
- Alkaline batteries

HANDLING, REGULATORY AND SAFETY OF BIOPOL

BIOPOL is supplied in 20 kg cardboard boxes. The polymer is a hygroscopic, fine powder. The containers should be kept tightly sealed to avoid absorption of moisture during storage. Proper industrial precautions must be taken to control dust when handling a chemical in powder form. Further information is provided on the material safety data sheet. (MSDS).

BIOPOL is a high molecular weight crosslinked poly(acrylic acid). As with other high molecular weight crosslinked polymers, BIOPOL demonstrates low toxicity and low irritation (skin and eye) potentials based on their chemical and physical properties. It also exhibits a low degree of aquatic toxicity.

BIOPOL polymer is not biodegradable and does not support the growth of molds. BIOPOL polymer (mainly in neutralized salt form) will be removed with the biomass during a normal wastewater treatment. Therefore, BIOPOL is not expected to pass through a typical wastewater treatment to the environment.

CARBOMER polymer is listed in the chemical inventories of the following countries :

- USA TSCA
- European Economic Community EINECS
- Canada DSL
- Japan MITI
- Australia AICS
- Korea KICS

The CTFA/INCI name of BIOPOL polymer is Carbomer.

For more information, additional literature & product samples please contact us

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