The Specialty Chemicals Innovator™

**TDS-237**
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# Neutralizing Carbopol® and Pemulen® Polymers in Aqueous and Hydroalcoholic Systems

## Effect of pH on Viscosity

Carbopol polymers must be neutralized in order to achieve maximum viscosity. Unneutralized dispersions have an approximate pH range of 2.5-3.5 depending on the polymer concentration. The unneutralized dispersions have very low viscosities, especially Carbopol® ETD and Ultrez polymers. Once a neutralizer is added to the dispersion, thickening gradually occurs as is demonstrated by Figure 1. Optimum neutralization is achieved at a pH of 6.5-7.0, but is not necessary. As demonstrated by the graph, high viscosities can be achieved in a range of 5.0-9.0.

A common question is "what pH is correct for my finished product?" The answer is that there is no correct or incorrect pH. pH should be determined by the desired attributes for a given application.

Viscosity begins to decrease after a pH of 9.0, and will continue to decrease if the pH is increased. This is due to the dampening of the electrostatic repulsion caused by the presence of excess electrolytes. It is possible to achieve high viscosity systems at pH values below 5 and above 9, but the use level of the Carbopol polymer must be increased.

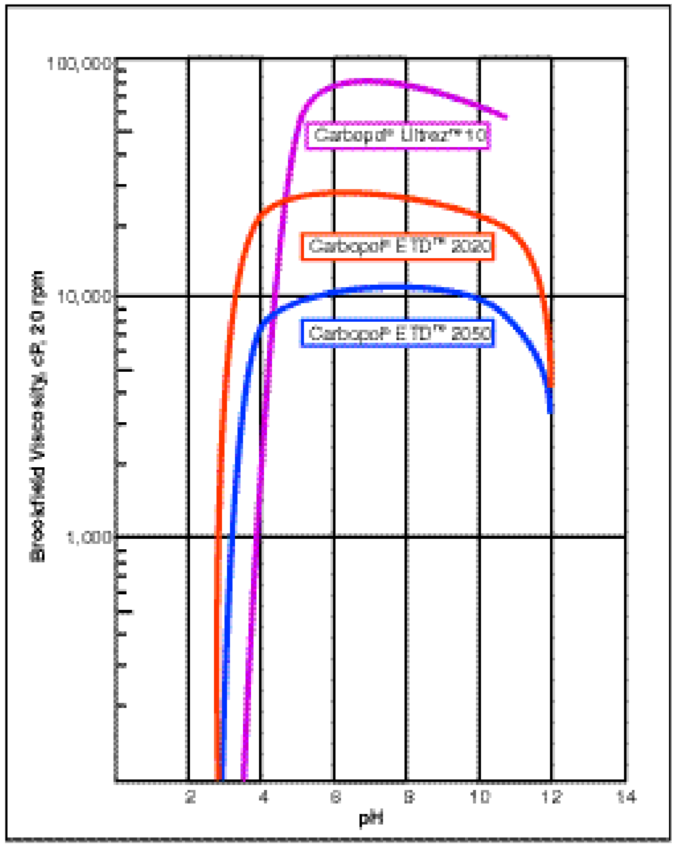


**Figure 1**
**Carbopol Polymers Viscosity vs. pH (0.5% Concentration)**



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**Figure 2**
**Schematic Depicting Molecule of Carbopol Polymer in Coiled State**

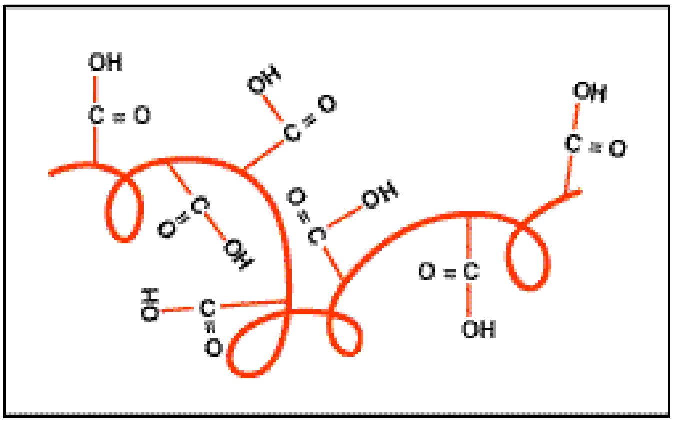
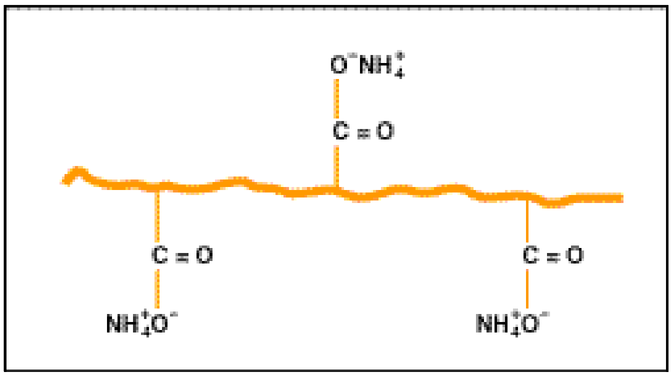



**Figure 3**
**Diagram Depicting Molecule of Carbopol Polymer in Uncoiled State**




## Thickening Mechanism

Carbopol polymers as supplied are dry, tightly coiled acidic molecules. Once dispersed in water, the molecules begin to hydrate and partially uncoil. The most common way to achieve maximum thickening from Carbopol polymers is by converting the acidic Carbopol polymer to a salt. This is easily achieved by neutralizing the Carbopol polymer with a common base such as sodium hydroxide (NaOH) or triethanolamine (TEA).

**Figure 4**
**Neutralization Ratio Chart**

| Trade Name | CTFA Name | Manufacturer | Neutralization Ratio Base/ Carbopol® Polymer |
|---|---|---|---|
| NaOH (18%) | Sodium Hydroxide | | 2.3/1.0 |
| Ammonia (28%) | Ammonium Hydroxide | | 0.7/1.0 |
| KOH (18%) | Potassium Hydroxide | | 2.7/1.0 |
| L-Arginine | Arginine | Ajinomoto | 4.5/1.0 |
| AMP-95® | Aminomethyl Propanol | Angus | 0.9/1.0 |
| Neutrol® TE | Tetrahydro-xypropyl Ethylenediamine | BASF | 2.3/1.0 |
| TEA (99%) | Triethanolamine | | 1.5/1.0 |
| Tris Amino® (40%)* | Tromethamine | Angus | 3.3/1.0 |
| Ethomeen® C-25 | PEG-15 Cocamine | Akzo | 6.2/1.0 |
| Diisopropanol-amine | Diisopropanol-amine | Dow | 1.2/1.0 |
| Triisopropanol-amine | Triisopropanol-amine | Dow | 1.5/1.0 |

* **NOTE**: The 40% solution should be made from Tris Amino crystals from the manufacturer. Do not use the pre-dispersed solution from the manufacturer as it contains many impurities.

## Common Neutralizers

Figure 4 lists ten of the most common neutralizers used, the manufacturers of these neutralizers, and the appropriate ratio (as compared to one part of Carbopol polymers) to use to achieve exact neutralization at a pH of 7.0. The chart is based on Carbopol® Ultrez ™ 10, Noveon, Inc.'s newest addition to the Carbopol polymer family, but is applicable to all Carbopol polymers because they all have the same equivalent weight of 76 ± 4.

**Figure 5**
**Recommended Neutralizers for Hydroalcoholic Systems**

| Up to % Alcohol | Neutralizer |
|---|---|
| 20% | Sodium Hydroxide |
| 30% | Potassium Hydroxide |
| 60% | Triethanolamine |
| 60% | Tris Amino |
| 80% | AMP-95® |
| 90% | Neutrol TE |
| 90% | Diisopropanolamine |
| 90% | Triisopropanolamine |
| >90% | Ethomeen C-25 |

## Hydroalcoholic Thickening

Ethanol and isopropanol can be thickened with Carbopol® polymers. The critical factor is choosing the correct neutralizer based on the amount of alcohol that is to be gelled. If the wrong neutralizer is used, the salt of the Carbopol polymer will precipitate out because it is no longer soluble in the hydroalcoholic blend. Figure 5 gives recommended neutralizers for various alcohol levels.