Glycol Ethers for Aqueous Cleaners

Cleaning Fundamentals

Cleaning can be defined as the removal of an undesired material from a surface. Adhesion forces act to hold the soils to the surface. These forces can range from very strong covalent bonds to relatively weak van der Waal's interactions. For cleaning to occur, some form of energy must be applied to overcome these adhesion forces. Some mechanisms for cleaning are: dissolution, displacement and dispersion, reaction, and mechanical removal of substances from a surface.

Cleaning can be broken down into removal of liquid and solid soils. The most common liquid soils are hydrocarbon (oily) based. Solid soils larger than 0.5 microns are usually held in place by capillary action with oily soils. By cleaning the oily soil, the solid soil comes off as well. Small solid soils (<0.5 microns) that are held on surfaces by van der Waal's forces are not typically encountered or removed by household cleaning and are not covered here.

Soil roll up occurs only with light soils, and small amphiphilic solvents or surfactants in water (see Figure 1). This cleaning can be accomplished by alcohols. The solvent must have lower surface tension than the soil and must be partially (not fully) soluble in the soil it is displacing.

Figure 1 : Soil roll-up

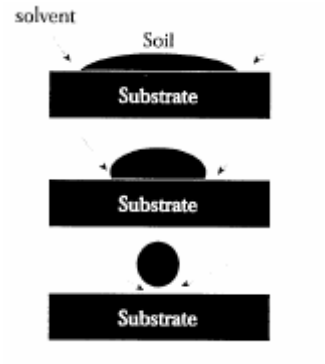
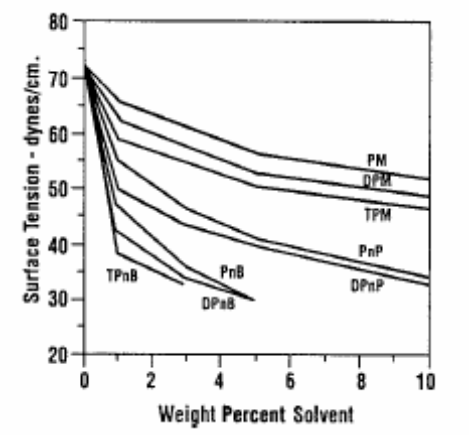


Figure 2: Surface tension-lowering abilities of glycol ethers in aqueous solutions (25°C)



Entropic swelling occurs with medium to heavy soils and moderately sized functional solvents (e.g. DOWANOL* DPnB Glycol Ether). The solvent in the cleaner partitions out of the water and into the soil (see Figure 3). This reduces the soil viscosity and surface tension with water. This softening of the soil allows for surfactant emulsification and mechanical breakup. Without this softening, removal would be impossible or very difficult. This phenomena is typical of glycol ethers in aqueous cleaners.

Figure 3: Entropic Swelling

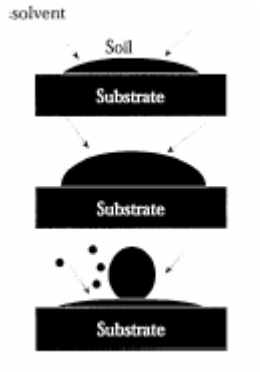
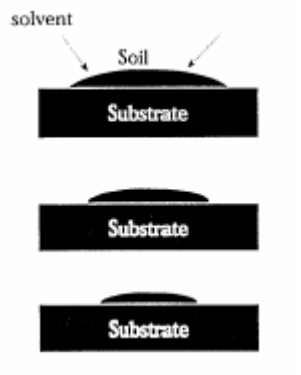


Figure 4: Soil Solubilization



Soil solubilization occurs when the soil is completely soluble in the solvent/cleaner. The soils and solvent must have very closely matched solubility parameters. The soil simply dissolves into the liquid (see Figure 4). Straight hydrocarbons and water-immiscible solvents are typical solubilization cleaners.

Solvent-based cleaners primarily clean by using their solvency power to penetrate and dissolve the soil. Water is not an exceptionally good solvent for most soils; therefore, the formulator of water-based cleaners must add materials that will aid in optimizing all of the potential cleaning mechanisms. Typical components of water-based cleaning formulations are: surfactants, builders, thickeners, chelants, hydrotropes, antimicrobials, and solvents.

Glycol ethers and alcohols are widely used in water-based formulations due to their high degree of water compatibility. Glycol ethers provide efficient, active solvency power for formulations. Our hydrophobic glycol ethers are excellent solvents for most oils, greases, and dirts:

• DOWANOL* PnP, DPnP, PnB, DPnB
• Hexyl CELLOSOLVE™ Solvent, and Hexyl CARBITOL™ Solvent

This solvency aids in the dissolution mechanism of soil removal. Low surface tension is critical for achieving proper wetting and cleaning by the displacement and dispersion mechanism. Due to the low molecular weights of glycol ethers, aqueous formulations containing them exhibit lower dynamic surface tensions than formulations containing just traditional surfactants alone. Dynamic surface tensions dominate the interfacial activities during the initial stage of interface formation between the liquid and the soil.

Glycol ethers also act as coupling agents by compatibilizing the hydrophobic oils and soils with water to hold the soil in suspension and to prevent the “dirt” from re-depositing on the substrate.

Finally, glycol ethers control the evaporation rate for effective removal, and this property should be considered when selecting the appropriate glycol ether for a given cleaning task.

Dissolve Oil-Soluble and Water-Soluble Soils

DOW glycol ethers have an alcohol component to dissolve water-soluble soil and an aliphatic component to dissolve oil-soluble soil. Not only does this dual nature help your formulation effectively clean both kinds of soil, it is also the basis for the surface wetting and coupling action provided by DOW glycol ether products. Furthermore, glycol ethers can help reduce or eliminate the need for other ingredients such as co-solvents, surfactants, or hydrotropes.

Beneficial in a Wide Range of Formulations

With a large family of DOW glycol ethers available, you can select from an extensive combination of basic physical and performance properties. This wide range of properties means DOW glycol ether products are beneficial in household and industrial hard surface cleaners, floor waxes, carpet cleaners, metal cleaners, disinfectants, germicides, and more.

Cleaner Applications of DOW Glycol Ether Products

Most DOW glycol ethers can be used in one or more of the following applications:

Acid cleaners
Alkaline cleaners
All-purpose cleaners
Aluminum cleaners
Automotive cleaners
Bathroom cleaners
Carpet care products
Chrome cleaners
Copper cleaners
Degreasers
Dishwashing detergents
Disinfectants, sanitizers
Engine cleaners
Electronic cleaners
Floor care products,
Wax strippers
General, all-purpose cleaners
Glass cleaners
Graffiti removers
Janitorial cleaners
Kitchen cleaners
Laundry detergents
Laundry prespotters
Leather, vinyl, plastic cleaners
Liquid soaps
Liquid steam cleaning compounds
Oven cleaners
Paint and varnish removers
Rug cleaners
Rust removers
Scouring cleaners
Specialty cleaners
Vehicle washes, waxes
Whitewall tire cleaners

Surface Tension Reduction

DOW glycol ethers and their blends efficiently reduce the surface tension of water, even at low concentrations. They are, therefore, able to act by themselves or in combination with surfactants to lower the surface tension of aqueous cleaning solutions. Glycol ethers improve the wetting of the surface to be cleaned, and penetrate both water-soluble and oil-soluble soils. Once the surface tension of the water is lowered, more thorough contact of the soiled surface by the cleaner is achieved. Thus, they also help to loosen soil and keep it emulsified (suspended) and dispersed in the cleaning solution. This prevents the soil from re-depositing on the cleaned surface before it can be wiped or rinsed away. The result is a more efficient cleaner and more effective cleaning.

Excellent Coupling Ability

Coupling is a method of compatibilizing a multiphase system that results in an increase in the degree of homogeneity of the system.[1]

DOW glycol ethers are strong couplers. With this capability and their inherent cleaning power, they work in combination with surfactants to pull oil- and water-soluble dirt from the soiled material.

Excellent Coupling Ability cont.

The glycol ether also couples oil-soluble dirt with water and, together with the surfactant, keeps the dirt suspended in the cleaning solution to prevent it from being re-deposited on the cleaned surface.

Figures 5 and 6 show how various concentrations and blends of DOW glycol ethers couple corn oil and water and soybean oil and water. In these examples, note the synergistic effect of mixing a hydrophobic glycol ether such as DOWANOL PnB with PM. The resultant mixture performs better than each glycol ether on its own. The two products are essentially coupling each other to their mutual benefit.

Figure 5: Coupling Performance of DOW Glycol Ethers (corn oil and water)

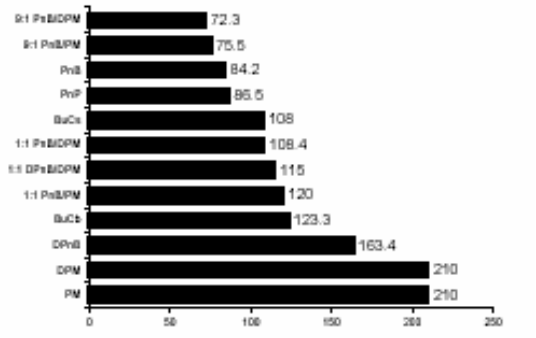
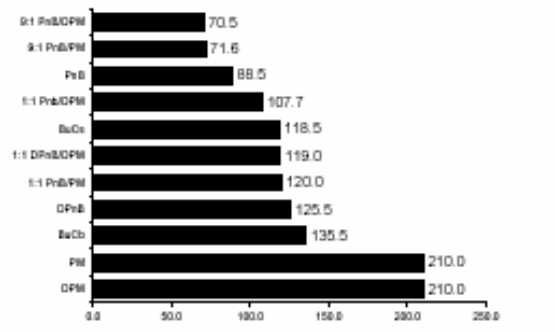


Figure 6: Coupling Performance of DOW Glycol Ethers (soybean oil and water)



The coupling ability of DOW glycol ether products also contributes to the clarity of cleaning solutions. Most cleaners are combinations of surfactants and water, which may produce a cloudy blend. A glycol ether added to the formulation couples the surfactant and water, producing the clear solution preferred by consumers. In this way, glycol ethers can also facilitate the break up of liquid crystal formation due to surfactant alignment. By interfering with the formation of the lattice structure, more fluid, lower viscosity systems can be created.

The Best Evaporation Rate for Your Formulation

Whatever your cleaner's job, there is a DOW glycol ether with an optimum evaporation rate. Within both P-series and Eseries lines, you have a choice of fast, medium, or slow evaporation rates. By blending various DOW glycol ethers, you can achieve the precise evaporation rate best suited for the special requirements of a given cleaning application. The result is greater formulating flexibility and more efficient and effective cleaning formulations.

Evaporation Rate Flexibility

DOW glycol ethers offer a wide range of evaporation rates for formulation requirements. For example, DOWANOL PnB, Butyl CELLOSOLVE™ Solvent and Hexyl CELLOSOLVE solvent are excellent choices for a window cleaner that evaporates fast enough to prevent streaking. On the other hand, slower evaporating products such as DOWANOL PPh, Butyl CARBITOL™ Solvent or Hexyl CARBITOL Solvent do well in formulations such as oven cleaners, where they provide the longer contact time necessary to thoroughly penetrate the grease and baked-on material, even at elevated temperatures.

Kitchen Cleaners

Kitchen cleaners are usually non-dilutable spray cleaners with outstanding grease-cutting properties. They are ideally suited to removing burnt-on grease from tiles and walls in kitchens and from around stoves, although they are not intended as oven cleaners.

Kitchen cleaner formulations normally include hydrophobic solvents at concentrations of 5% to 10%, and anionic/nonionic surfactants. A highly alkaline pH is usually preferred, and this is achieved by adding caustic soda or ethanolamines.

All-purpose, Hard-surface cleaners and Concentrates

All-purpose, hard-surface cleaners and concentrates are normally formulated for dilution. If these formulations are diluted with tap water, they will require builders to soften hard water. Builders such as citrates, phosphates and carbonates are invariably included in products which are diluted by the user. Technically, all-purpose, hard-surface cleaners can be considered the same as kitchen cleaners with the addition of builders. A builder is a substance that increases the effectiveness of a soap or synthetic surfactant by adding to its detergent power. Butyl CARBITOL Solvent, and DOWANOL DPM blended with DPnB are excellent choices for all purpose dilutable cleaners.Concentrated products are usually supplied as refill packs, as they offer savings in the amount of water transported and in the amount of plastic packaging required.

DOWANOL PnP is the solvent of choice for these formulations, based on its low odor and complete water solubility. In addition, its low surface tension provides excellent degreasing properties. Use of DOWANOL PnP may enable a formulation to be concentrated from four up to six times without stability problems.

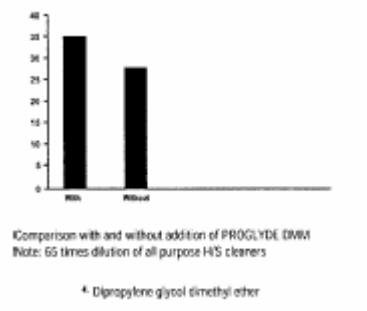
Hard-surface cleaners containing bleach

The ever-increasing need for improved disinfection of surfaces has led to the development of cleaners containing bleach. Originally, aqueous solutions of hypochlorite were used. The development of ingredients such as surfactants which are stable in the presence of bleach has led to improved hypochlorite-based products. These are now available as dilutable, all-purpose, hard-surface cleaners, spray cleaners and squeeze-out gels for bathroom use.

Today, the development of environmentally acceptable and bleach-compatible solvents such as PROGLYDE DMM[4] glycol diether offers new opportunities in this product area. PROGLYDE DMM significantly improves the ability of bleach-containing cleaners to remove grease, even when they are diluted.

PROGLYDE DMM is an aprotic, low-odor solvent with high water solubility. The excellent toxicology, environmental profile, and stability of PROGLYDE DMM make it the recommended choice for hard-surface bleach-containing cleaners where improved degreasing performance is needed.

Figure 7: Performance Effectiveness for All-purpose H/S Cleaners Containing Bleach



Comparison with and without addition of PROGLYDE DMM
Note: 65 times dilution of all purpose H/S cleaners

[4] Dipropylene glycol dimethyl ether

Window Cleaners

Window cleaners consist primarily of water and solvent, the latter at a concentration which is typically in the range of 4% to 12%. Window cleaning products are usually sprays and are designed leave windows free of smears or streaks. Streaks can be caused by traces of dirt or by residues of non-volatile chemicals used in the formulation.

A small quantity of surfactant must be added in order to wet the surface to be cleaned, but because these surfactants are non-volatile, they may cause streaking. The choice of surfactant is therefore important. Anionic surfactants are recommended because they have a high affinity for water. In contrast, cationic surfactants may be strongly absorbed by glass. Nonionic surfactants may absorb on to glass surfaces, especially those with lower hydrophilic/lipophilic balance (HLB) values. A HLB value is a measure of a chemical's tendency to partition between aqueous and organic phases. Another useful attribute of many anionic surfactants is their ability to increase the water solubility of hydrophobic ingredients, such as perfumes and some hydrophobic glycol ethers.

Surfactants tend to be used in an acid form. To achieve the recommended alkaline pH of around 10, it is necessary to add neutralizing or buffering agents, such as caustic soda or ethanolamines. Minor additives used in window cleaner formulations include dyes, chelating agents (when hard water is a concern) and electrolyte salts.

Window and multi-purpose cleaners

Window and multi-purpose cleaners are also formulated as sprays. They are used on glass as well as other surfaces, and so their formulation is a compromise between those of window cleaners and kitchen cleaners. The major differences from window cleaners are a higher solvent content and a slight increase in surfactant concentration. These differences improve the ability to remove grease without causing undue smearing when the products are used on glass