Formulating Liquid Laundry Detergents
Shoaib Arif, Pilot Chemical CO. Cincinnati, OH 513-939-6150 sarif@pilotchemical.com

Major part of liquid laundry detergent formula is based on surfactants which remove soil from the fabric and clean it. A combination of anionic and nonionic surfactants is commonly used for optimum performance. In general, anionics are good for particulate soil removal and nonionics are good for greasy soil removal. Other components of a liquid laundry detergent formula are listed below. Thus a liquid laundry detergent formula can be as simple and economical as say 5% active surfactant solution in water with preservatives. This formula will foam and do some cleaning of the cloths. From here one can improve this basic formula to any desired level in order to enhance the performance and position it for various categories such as economical, mid tier, premium, ultra, and 2 X, 3 X, 4 X etc.

**Builders:** Remove the hardness ions so the surfactant can be fully functional. Sodium Citrate, Tetrasodium EDTA are commonly used in liquid laundry detergents.

**Antiredeposition agent:** Keeps the soil particles suspended in the wash liquor and do not get deposited back on the fabric. Various polymers are used for this purpose.

**Dye transfer inhibitors:** Help prevent the dye coming off from one fabric and getting deposited on other. PVP K-30, Chromabond S-100 (PVP with betaine functionality) Chromabond S-400 (PVP with nitrogen oxide functionality) from ISP

**Soil release polymer:** Soil release polymers provide a barrier to the fabric, which is removed during the wash, together with the soil. Sorez 100 (polyethylene Glycol Polyester Copolymer) from ISP, Repel-O-Tex SRP-6 (polyethylene glycol polyester) from Rhodia and Texcare SRN 170 (Polyester in aqueous solution) from Clariant.

**Optical brighteners:** Improve the apparent “whiteness” of cloths by absorbing invisible UV light and giving off a blue fluorescence. Tinopal CBS-X from BASF

**Enzymes:** Enzymes help remove stains and soils like blood, grass, gravy etc. by breaking them down to smaller, easily removable components. Protease, Lipase, Amylase and Cellulase are commonly used in laundry detergent formulas.
pH control: Bring pH to desired level
Citric Acid, monoethanolamine

Viscosity control: Increase or decrease viscosity to desired level
Propylene glycol, Sodium Xylene Sulfonate, Polymers

Suds control: Control excessive foaming
Soap, silicones

Preservatives: Microbial control

Perfume & Dye: Looks and smell

Miscellaneous: For viscosity, buffering action, alkalinity and enzyme stability
Calcium Chloride
Sodium Tetraborate
Propylene Glycol
Sodium Formate
Sodium Citrate
Monoethanolamine

Enough talk!!! Let us now stop talking and start formulating. Where do we start from? Why not start from an economy, really economy formula. A formula that is less than 10 cents per pound in raw material cost. Such a formula will be a mixture of low cost surfactants, thickeners, builders and preservatives. So if we take 2.5% of DDBSA like Pilot Chemical’s Calsoft® LAS-99 and neutralize it with about 0.65% of 50% caustic soda in water to a pH of 8-10 and then add 1% of Cocamide DEA (Calamide® C) and 1% of Sodium Citrate and add a suitable dye & preservative then this will be our economy or shall we say ultra economy formula. This formula will have a pH of about 9.0 and viscosity of about 100 cp. at 70°F.

I hear you!!!! You said the above formula does not have many of the ingredients we listed on page 1 & 2 above. Well that is what you get for less than 10 cents a pound. This formula will foam and do some cleaning of the fabric but off course will not perform as a premium laundry detergent. Dig a little deeper into your pocket and we can add at least some more ingredients to this basic economic formula. How about we go to an economy formula from the ultra economy we listed above? To be honest, you may have to spend around 12-15 cents per pound in the raw material cost for this upgrade from ultra economy to economy formula. Remember the formulation magic can only go so far after that you get what you pay for. Here is the economy formula. Take 86.7% water add 1.3% of sodium hydroxide 50%. Start mixing. Add 5% of DDBSA (Calsoft® LAS-99 - Pilot). Mix well until complete neutralization. Add 3% of alcohol ethoxylate (Masodol® 25-7 – Pilot) and 1% each of Lauramine oxide (Caloxamine® LO - Pilot),
Cocamide DEA (Calamide® C – Pilot), Tetrasodium EDTA (Versene 220 – Dow) and a hydrophobically modified acrylate polymer (Aculyn 22 – Dow). Mix well and adjust the pH to 9-10 with DDBSA or sodium hydroxide. Add preservative, dye and perfume. Mix well until a smooth, homogenous batch is obtained. This formula is about 9% solids with a pH of 9-10 and a viscosity of 500 – 1000 cp. at 25°C (Brookfield RV, spindle 3 speed 20 RPM). Some companies also offer blends for laundry applications. Blends offer some advantages such as convenience, less storage space, less chances of error and batch to batch variations etc. Pilot offers a blend called Calsuds® CD-6. An economy formula can be made by diluting 10% of this blend with water.

The above listed formulas of ultra economy and economy liquid laundry detergents can be classified as value brand products. Let us continue our journey and climb to medium tier and then finally to premium grade liquid laundry detergents. First let us formulate a medium tier liquid laundry detergent. Needless to say, it will cost more. The raw material cost may go to 20-30 cents per pound (The cost will vary according to the purchase quantity of major ingredients and how well partnered you are with your suppliers?). The solid level will vary from 15 – 25%. The medium grade formulas contain surfactants, builders, antiredeposition agents, optical brighteners and the minors like preservative, perfume, dye. We will use a combination of alkyl benzene sulfonate and lauryl ether sulfate as part of the anionic surfactant portion of the formula. For nonionic portion we will still use an alcohol ethoxylate. In this category we can also choose to stay with the surfactants listed on “Cleangredients” database for DfE approval of the formula. For builders and antiredeposition we will add sodium citrate and a polyacrylate. We will also add an optical brightener. Let us now develop the formula here. Add 72.31% of water in the mixing tank and start mixing. Add 2.5% of sodium hydroxide (50% solution) followed by 9.6% of DDBSA (Calsoft® LAS-99 - Pilot). Mix well until complete neutralization to pH 7-9. Add 5% of SLES (Calfoam® ES-702 - Pilot). Mix well until a clear, homogenous solution. Add 2 % sodium citrate and 1% polyacrylate (Accusol 445 N – Dow) followed by 5% of alcohol ethoxylate (Masodol® 25-7 – Pilot). Continue mixing. Add 0.05% of optical brightener (Tinopal CBS-X – BASF). Mix well and add the minors with constant mixing. And now you have your medium grade laundry detergent ready. This formula can be modified to achieve various product positioning and performance attributes. For example if you like to call this predominantly naturally derived formula then replace LAS by sodium lauryl sulfate. (Calfoam® SLS-30 – Pilot) If you want to upgrade the formula to an upper mid tier formula then add a dye transfer inhibitor and a soil release polymer like for example 0.25 % of PVP K-30 (ISP) and 0.4% of Texcare SRN 240 (Clariant).

Let us see!!! If we can dig a little deeper into our pockets and go all out to develop the ultimate liquid laundry detergent or in other words make a premium formula. Now we are talking about making a formula with 30-40% solids containing all the ingredients listed in the beginning of this article. Here we will use a combination of three anionic surfactants, two nonionics, and an amine oxide. For builder we will stay with Sodium Citrate. We will use PVP NO (Chromabond S-400-ISP) and a modified polyester copolymer (Sorez 100 ISP) for dye transfer inhibition, soil release and antiredeposition effects. Also let us add some oleic acid soap for suds control. For optical brightener let us use Tinopal CBX (BASF) and for pH adjustment we will go with citric acid and monoethanolamine. Try propylene glycol and Sodium diphenyloxide disulfonates (Calfax® DB-45 – Pilot) for viscosity control and coupling. The disulfonates are excellent anionic surfactants as well as hydrotropes and couplers. In premium 2X or 3X laundry detergent formulas they increase the activity of the formula but at the same time lower the viscosity and also perform the coupling action. This is a unique benefit of disulfonates. Most other anionic surfactants used in liquid laundry formulas tend to increase the viscosity and may even cause gelling. Disulfonates are also stable in chlorine bleach, peroxide, alkalis and acids. That is why they can be used in a
wide variety of H I & I cleaners. We will also use enzymes in this formula. Enzymes offer enhanced performance on various kinds of soils like grease, protein and others and also help clothes look whiter and brighter. Enzymes are somewhat delicate materials, however, and must be treated with a little TLC. That includes slow mixing when processing a batch, avoid hot temperatures, make formula with less water and more actives and finally add enzyme stabilizers like Propylene glycol, calcium chloride, borax, sodium citrate, sodium formate etc.

All right, let us get to work now and develop a nice premium 2X liquid laundry detergent formula. For the surfactant part of the formula we need a well rounded and balanced combination that can clean various kinds of soils. I suggest we use a combination of linear alkyl benzene sulfonate (Calsoft® LAS-99 – Pilot- neutralized with potassium hydroxide), diphenyl ether disulfonate (Calfax® DBA-70- Pilot- neutralized with potassium hydroxide), alkyl ether sulfate (Calfoam® ES-603- Pilot), alcohol ethoxylate (Masodol® 1-7- Pilot) and amine oxide (Caloxamine® LO - Pilot). Let us also use some builders like Sodium Citrate. For soil release, antiredeposition and dye transfer inhibition we will use a combination of PVPNO (Chromabond S-400 ISP) and a modified polyester copolymer (Sorez 100 ISP). How about Tinopal CBS-X from BASF as optical brightener? I know you would agree to use some silicone antifoam for suds control something like Dow Corning’s 1520 antifoam. For enzymes we will go with Lipase (Lipolase 100 L – Novozyme), Protease (Savinase 16 L – Novozyme), Amylase (Termamyl 300 L) and Cellulase (Carezyme 4500 L- Novozyme). The rest of the ingredients listed below will act as enzyme stabilizer, viscosity modifier, foam control agents and pH buffers. These include Calcium Chloride, Sodium formate, propylene glycol, borax and monoethanolamine and potassium oleate.

Let us go to the lab and prepare a sample of the premium 2X liquid laundry detergent. First add 41.90 % of D.I water followed by 6.1% of potassium hydroxide 45% solution in an appropriate beaker. Start mixing and slowly add 10.0% Calsoft® LAS-99 and 5% Calfax® DBA-70. Let mix slowly (to avoid excessive foaming) for 10-15 minutes. Add 3.0% Oleic Acid, 1% monoethanolamine and mix well. Check the pH and adjust to 7-8, if necessary, with Calsoft® LAS-99 or Potassium Hydroxide. With continuous mixing add 0.25% Dow Corning 1520 antifoam, 12% Masodol® 1-7 and 5% Propylene Glycol. Then add 7.0% Calfoam® ES-603 and 2.0% of Caloxamine® LO. Mix well at slow speed. Add 1.5% Sodium Citrate, 0.5% Sodium Formate, 0.2% Calcium Chloride, 0.5% Borax, 0.6% Chromabond S-400, 0.6% Sorez 100, 0.05% Tinopal CBS-X. Mix well and cool the batch down to room temp. if necessary before adding the enzymes. Add 0.3% of Carezyme 4500 L, 0.5% Lipolase 100L, 1.0% Savinase 16 L and 1.0% Termamyl 300L. Add preservatives, perfume and dye as required and mix well.

Disclaimer: The information contained herein is provided in good faith as starting guideline to formulators and is based on the study in our laboratories and work of others. Pilot Chemical Company makes no warranties, expressed or implied, as to the accuracy of the information contained herein. Nothing contained herein grants or extends a license or permission in connection with patents of Pilot Chemical Company or others.