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Performance Products

HYDRAPOL® RP Series Surfactants

Surfactants for the Future










New products for Household, Industrial and Institutional applications created through new technology specifically to fulfil the demands of tomorrow's markets

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Huntsman Mission

We are dedicated to giving our customers the finest quality and service available. Customers are valued partners who permit us to remain in business; we are privileged to serve their needs.

About Huntsman

Huntsman is a global manufacturer and marketer of differentiated chemicals. Its operating companies manufacture products for a variety of global industries, including plastics, automotive, aviation, textiles, footwear, paints and coatings, construction, technology, agriculture, health care, detergent, personal care, furniture, appliances and packaging. Originally known for pioneering innovations in packaging and, later, for rapid and integrated growth in petrochemicals, Huntsman today has 12,000 employees and over 75 operations in 24 countries.

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About the HYDRAPOL RP® Surfactants

The HYDRAPOL® RP Series of non-ionic surfactants are the result of a focused research and development project specifically directed at finding practical solutions to the current and future challenges facing the specialty chemicals industry.

The HYDRAPOL® RP Series of nonionic surfactants are high performance wetting and dispersing agents intended for general application as a primary wetters, detergents and scouring agents.

The HYDRAPOL® RP Series of nonionic surfactants offer the rapid biodegradability of the linear fatty alcohol ethoxylates without the problematic aquatic toxicity associated with these products.

The HYDRAPOL® RP Series of nonionic surfactants provide the formulation versatility of the nonyl phenol ethoxylates, but have no structural elements which could give rise to incomplete biodegradation or possible endocrine modulation effects. They may be used as functional alternatives to the TERIC® N Series surfactants in most wetting and detergency applications.

The HYDRAPOL® RP Series surfactants are useful in the formulation of domestic and industrial detergents, leather degreasing, scouring detergents, textile and paper processing aids, specialty emulsions, adhesives and agricultural wetting agents.

The HYDRAPOL® RP Series surfactants are very useful as industrial process aids where extremely efficient wetting, penetration and dispersion properties are required in a wide variety of end use conditions.

The HYDRAPOL® RP Series surfactants are versatile surfactants that display robust surface activity across a broad range of operating conditions.

The HYDRAPOL® RP Series surfactants are clear low viscosity liquids at ambient temperature. They are easy to pump, meter and handle in bulk. Because they do not form strong or extensive gel structures they are readily dissolved and dispersed in cold water.

Environmental Impact

Biodegradability

HYDRAPOL® RP Series surfactants biodegrade to greater than 70% in 28 days when evaluated according to the international test protocol ISO 7827, and therefore can be classified as Readily Biodegradable. Further testing, using the ISO 14593 :1999 protocol, confirms that HYDRAPOL® surfactants are indeed readily biodegradable. This latter test determines the ultimate aerobic biodegradability of organic compounds in aqueous medium, by a procedure which addresses issues of possible chemisorption of the candidate and its metabolites during the degradation process.

Aquatic Toxicity

Test	Species	Protocol	Result
Acute toxicity to aquatic organisms	Green algae	OECD 201	72 Hr ErC_{50} 3.8 – 5.5 mg/L 72 Hr NOEC 1 mg/L
Acute toxicity to marine invertebrates	Daphnia Magna	OECD 202	48 Hr EC_{50} 3.2 – 4.0 mg/L
Acute fish toxicity	Rainbow Trout	OECD 203	96 Hr LC_{50} 4.2 – 10 mg/L

The acute aquatic toxicity profile demonstrates that the HYDRAPOL® RP Series surfactants fall into the classification range of 1<LC50/EC50/IC50< 10 mg/L. Because the HYDRAPOL® RP Series surfactants are also readily biodegradable, they do not fulfil the criteria for classification as UN 3082, Class 9 Dangerous Goods, making them convenient to transport and to use in a wide range of applications.

Chemistry of the HYDRAPOL® RP Surfactants

The HYDRAPOL® RP Series surfactants belong to the class of surfactants known as nonionic polyethers. They are alkyl poly (alkylene oxide) derivatives based on a linear synthetic primary alcohol. The predominant alkylene oxide is ethylene oxide, and the products may contain specific amounts of a higher alkylene oxide.

They conform to the following formula: $RO\text{-}(R'\text{-}CH_2O)_x\ H$

Where R = linear synthetic primary alcohol, R′ = $C_1 - C_3$ alkyl group, and x = the average degree of ethoxylation in terms of moles of ethylene oxide per mole of the alcohol.

Nomenclature of HYDRAPOL® RP Surfactants

The numeric suffix in the HYDRAPOL® RP Series surfactants naming code equates to the degree of ethoxylation for the corresponding nonyl phenol ethoxylate with a similar level of water solubility, inverse cloud point or HLB value.

This creative scheme recognises that the most immediate application for these novel surface active agents will be as replacements for the imminently redundant nonyl phenol ethoxylates.

Physical Form of HYDRAPOL® RP Surfactants

At ambient temperatures in the range 20 – 25ºC, HYDRAPOL® RP40, RP50, RP60 and RP80 surfactants are clear to slightly hazy liquids, with a low viscosity and a low pour point. HYDRAPOL® RP90 surfactant is also a clear to slightly hazy, low viscosity liquid under the same conditions and has a pour point of approximately 16ºC, hence it will present as a soft paste in cooler regions.

It is normal for these products to form a slight floc or sediment on standing for extended periods at temperatures less than ambient. This floc will melt and completely disappear with gentle warming to 25-30ºC. In warmer climate regions the products will present as clear homogeneous liquids.

The more highly ethoxylated products, HYDRAPOL® RP100 surfactant and HYDRAPOL® RP120 surfactant, are soft white pastes at 20-25ºC and are clear to slightly hazy, low viscosity liquids at 30ºC. Because these two products gradually melt at ambient temperatures between 25-30ºC, it is normal for them to show variable appearance depending on their thermal history. This may be observed as a partial separation in the form of a white floc. The products become homogeneous on warming to approximately 30ºC – 35ºC.

Application Guidelines for HYDRAPOL® RP Surfactants

HYDRAPOL® RP Series surfactants introduce the formulation chemist to a whole new suite of creative opportunities. These purpose-designed nonionic surfactants offer a simple route to alkylphenol ethoxylate replacement, particularly in general wetting, detergency and industrial process aid applications, with the added benefits of a favorable eco-toxicity profile and rapid biodegradability.

Emulsion Systems

As with most other nonionic surfactants based on relatively short chain linear primary alcohols, the HYDRAPOL® RP Series surfactants are not intended for use as emulsifiers in their own right, but that does not preclude their possible use as co-emulsifiers in applications where it is required that the emulsion also has significant wetting ability. These surfactants are fully compatible with anionic emulsifiers such as NANSA® EVM series surfactants, ALKANATE® P series phosphate ester surfactants and TERIC® nonionic surfactants, any of which could be appropriate co-emulsifiers. For industrial applications where an emulsion with transient stability is beneficial, such as “quick break” solvent emulsion degreasers, the HYDRAPOL® RP surfactants provide a convenient formulation route.

Household Detergents

HYDRAPOL® RP50, RP80, RP90 and RP100 surfactants are recommended for use as primary wetting agents and detergents in hard surface cleaning formulations, detergent sanitizer formulations, isotropic laundry liquid formulations and in prewash products.

HYDRAPOL® RP80 and RP90 surfactants can be used as the nonionic additive to an anionic-based manual dishwashing liquid formulation, to complement the wetting properties and improve the flash foam behaviour of the product.

Adhesives & Resins

HYDRAPOL® RP80, RP90 and RP100 surfactants can be applied as wetting agents in phenol formaldehyde resins and urea formaldehyde resins used in the manufacture of particle board from wood chips. The surfactants act to improve surface coverage and bond strength, and consequently have the potential to reduce resin consumption.

HYDRAPOL® RP80 or RP90 surfactants may also be used in PVA based wood and paper adhesives to increase penetration and spreading with resultant improvement in bond strength. High concentrations of polyether based surfactants in adhesives of this type may tend to act as plasticizers, but because of their exceptional wetting ability, only a small amount of HYDRAPOL® RP surfactants is required in order to achieve the desired effect.

HYDRAPOL® RP surfactants may also be considered as additives to textile bonding adhesives. Due to the wide variety of synthetic fibres used in modern fabrics and the equally broad range of finishes used on those fabrics, some experimentation will be required to identify the optimum wetting agent. HYDRAPOL® RP60 and RP80 surfactants are suggested starting points.

Pulp & Paper

HYDRAPOL® RP50, RP60, RP80 and RP90 surfactants can be used in paper pulp bleaching, de-resinification and pitch removal. Penetration of wood chip by acid sulphite cooking liquor can also be enhanced by the use of a wetting agent. Wetting agents can also enhance the pitch dispersion effect of polymeric dispersants. Drainage of digestion liquor from the pulp can be accelerated by small additions of wetting agent to the pulp during processing.

Paints & Inks

HYDRAPOL® RP50, RP60, RP80 and RP90 surfactants can find application as high efficiency wetting agents in the manufacture of concentrated pigment pastes and inks. They may be used alone, or in combination with a defoaming wetter such as TERIC® 167 if foam is found to be an issue.

HYDRAPOL® RP80 or RP90 surfactants may be used in pigment flushing processes, and for the manufacture of pigment pastes. The unique solubility characteristics of HYDRAPOL® RP surfactants are of particular benefit in the formulation of pigment pastes. For example, HYDRAPOL® RP90 surfactant is readily soluble in water, aromatic solvents and aliphatic solvents, has a relatively low viscosity and a narrow gel region, and its wetting ability is superior to that of the alkylphenol ethoxylates commonly used as a vehicle for pigment pastes.

HYDRAPOL® RP120 surfactant is suggested for use as a wetter / dispersant in formulated pigment systems. It may also have utility as a synergist when used in conjunction with polycarboxylate dispersants, many of which have low inherent wetting ability in their own right.

Leather, Hide and Fur Processing

Significant quantities of surfactants are employed in the processing of raw hides through to finished leather, particularly in the soaking, liming, tanning, crusting and fat-liquoring segments of the process. In the soaking operation the role of the surfactant is to wet the hide so that water can penetrate the hide and soften it. The liming operation removes the epidermis and hair, and again, surfactants are used to aid penetration of the skin. Dimethylamine may be used to accelerate the action of the lime. In the tanning process, the tanning agent must penetrate the hide so that it can complex with the protein in the leather. Furthermore, even distribution of the tanning agents is essential for achieving a uniform finish on the leather. Fat liquoring restores lubricants to the skin, previously removed by the multiple cleaning processes.

HYDRAPOL® RP60, RP80 or RP90 surfactants can be applied to the soaking and washing stages of this process, depending on the temperature used. The excellent electrolyte resistance exhibited by HYDRAPOL® RP80 and RP90 surfactants indicates their use as wetting agents during the liming process. The broad solubility characteristics of HYDRAPOL® RP surfactants, and the fact that they are chemically inert, ensure their compatibility with accelerators such as dimethylamine. The fat-liquoring process combines emulsification and penetrative wetting mechanisms. HYDRAPOL® RP50 and RP60 surfactants are suggested as co-emulsifiers in this process. Rewetting hides after the crusting process requires a highly water soluble surfactant with excellent electrolyte tolerance. HYDRAPOL® RP100 and RP120 surfactants are recommended.

Early Stage Wool Processing

HYDRAPOL® RP80 and RP90 surfactants are readily biodegradable detergents appropriate to the scouring of raw wool and wooly sheepskins. The rapid biodegradability and low aquatic toxicity of these high performance surfactants makes them ideally suited as replacements for the alkylphenol ethoxylates traditionally used for raw wool scouring. HYDRAPOL® RP series surfactants are sufficiently advanced in their design technology to exhibit the complex phase behaviour necessary for the efficient scouring of raw wool, a feature previously almost unique to the nonyl phenol ethoxylates.

The highly efficient wetting kinetics of the HYDRAPOL® RP Series surfactants renders them well suited to the re-wetting of dusted carbonized wool. Their stability in non-oxidising mineral acids and the retention of their excellent wetting characteristics in this environment makes them ideal wetting agents for use during the raw wool carbonizing process for the destruction of desiccated vegetable matter.

These same beneficial properties, coupled with their relatively low foaming propensity, also indicate their application to the Chlorine-Hercosett SUPERWASH process, and to the OPTIM™ wool fibre engineering process. HYDRAPOL® RP50, RP60 and RP80 surfactants are recommended for these applications.

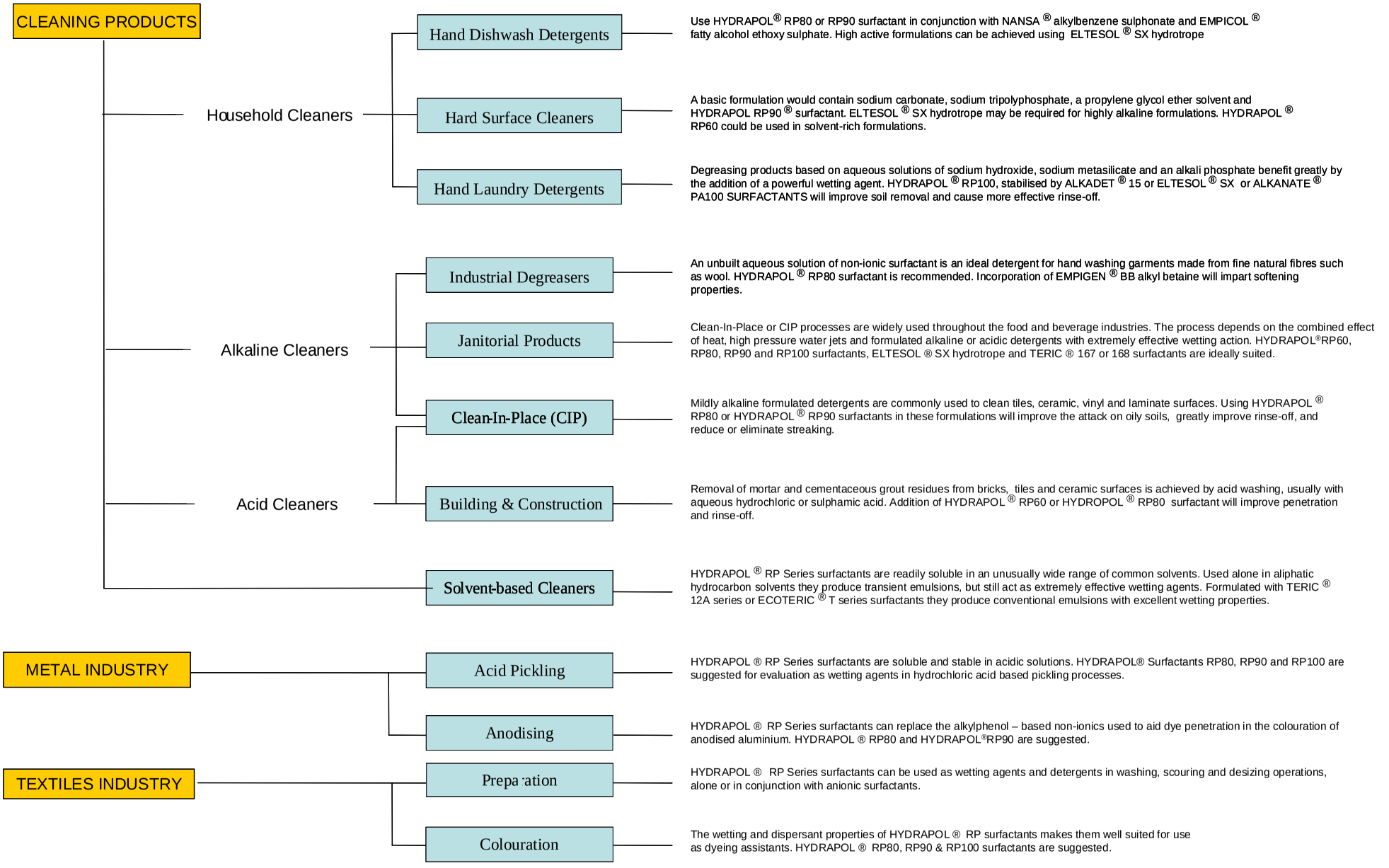
Household Detergents Formulation

Whilst it is theoretically possible to formulate a manual dishwashing liquid detergent using only nonionic surface active agents, such a product usually does not meet the economic and cosmetic requirements of the consumer. However, a high performance manual dishwashing liquid detergent almost invariably contains at least one nonionic surfactant as part of its formulation. The most common formulation style is one based predominantly on anionic surfactants, typically alkyl benzene sulphonates and alkyl ethoxysulphates, with a relatively minor amount of nonionic surfactant used to impart specific properties.

The nonionic component in such formulations can perform several different functions. For example, highly ethoxylated nonionic surfactants are used to increase the solubility of the alkylbenzene sulphonate salts, thereby increasing the physical stability of the formulation without recourse to coupling solvents. HYDRAPOL® RP100 or RP120 surfactants are examples of this function.

The nonionic component can be used to improve oily soil removal at lower wash temperatures, by reinforcing the pre-emulsification state in the detergency process. Such formulations typically show sustained washing ability even with heavy soil loads. HYDRAPOL® RP80 or RP90 surfactants are examples of this effect. In a high active formulation, it is normal to use a mixed salt form of the anionic surfactant, in order to accommodate the less soluble nonionic.

The nonionic component can be used to modify the foam profile of the formulated detergent. The addition of a relatively short chain nonionic surfactant, preferably with low dynamic surface tension characteristics, can result in the rapid development of voluminous foam, called a “flash foam”, very early in the life of the detergent. This has very little practical value, but is a desired cosmetic attribute. HYDRAPOL® RP50 or RP60 surfactant is suggested.


CLEANING PRODUCTS
Household Cleaners
Hand Dishwash Detergents
Use HYDRAPOL® RP80 or RP90 surfactant in conjunction with NANSA ® alkylbenzene sulphonate and EMPICOL ® fatty alcohol ethoxy sulphate. High active formulations can be achieved using ELTESOL ® SX hydrotrope
Hard Surface Cleaners
A basic formulation would contain sodium carbonate, sodium tripolyphosphate, a propylene glycol ether solvent and HYDRAPOL RP90 ® surfactant. ELTESOL ® SX hydrotrope may be required for highly alkaline formulations. HYDRAPOL ® RP60 could be used in solvent-rich formulations.
Hand Laundry Detergents
Degreasing products based on aqueous solutions of sodium hydroxide, sodium metasilicate and an alkali phosphate benefit greatly by the addition of a powerful wetting agent. HYDRAPOL ® RP100, stabilised by ALKADET ® 15 or ELTESOL ® SX or ALKANATE ® PA100 SURFACTANTS will improve soil removal and cause more effective rinse-off.
Alkaline Cleaners
Industrial Degreasers
An unbuilt aqueous solution of non-ionic surfactant is an ideal detergent for hand washing garments made from fine natural fibres such as wool. HYDRAPOL ® RP80 surfactant is recommended. Incorporation of EMPIGEN ® BB alkyl betaine will impart softening properties.
Janitorial Products
Clean-In-Place or CIP processes are widely used throughout the food and beverage industries. The process depends on the combined effect of heat, high pressure water jets and formulated alkaline or acidic detergents with extremely effective wetting action. HYDRAPOL®RP60, RP80, RP90 and RP100 surfactants, ELTESOL ® SX hydrotrope and TERIC ® 167 or 168 surfactants are ideally suited.
Clean-In-Place (CIP)
Mildly alkaline formulated detergents are commonly used to clean tiles, ceramic, vinyl and laminate surfaces. Using HYDRAPOL ® RP80 or HYDRAPOL ® RP90 surfactants in these formulations will improve the attack on oily soils, greatly improve rinse-off, and reduce or eliminate streaking.
Acid Cleaners
Building & Construction
Removal of mortar and cementaceous grout residues from bricks, tiles and ceramic surfaces is achieved by acid washing, usually with aqueous hydrochloric or sulphamic acid. Addition of HYDRAPOL ® RP60 or HYDROPOL ® RP80 surfactant will improve penetration and rinse-off.
Solvent-based Cleaners
HYDRAPOL ® RP Series surfactants are readily soluble in an unusually wide range of common solvents. Used alone in aliphatic hydrocarbon solvents they produce transient emulsions, but still act as extremely effective wetting agents. Formulated with TERIC ® 12A series or ECOTERIC ® T series surfactants they produce conventional emulsions with excellent wetting properties.
METAL INDUSTRY
Acid Pickling
HYDRAPOL ® RP Series surfactants are soluble and stable in acidic solutions. HYDRAPOL® Surfactants RP80, RP90 and RP100 are suggested for evaluation as wetting agents in hydrochloric acid based pickling processes.
Anodising
HYDRAPOL ® RP Series surfactants can replace the alkylphenol – based non-ionics used to aid dye penetration in the colouration of anodised aluminium. HYDRAPOL ® RP80 and HYDRAPOL®RP90 are suggested.
TEXTILES INDUSTRY
Prepa ation
HYDRAPOL ® RP Series surfactants can be used as wetting agents and detergents in washing, scouring and desizing operations, alone or in conjunction with anionic surfactants.
Colouration
The wetting and dispersant properties of HYDRAPOL ® RP surfactants makes them well suited for use as dyeing assistants. HYDRAPOL ® RP80, RP90 & RP100 surfactants are suggested.

Properties of HYDRAPOL® RP Surfactants

The physical and solution properties of HYDRAPOL® RP surfactants are shown in the following series of tables. The chemical, physical and solution property values presented in Tables 1 – 6 are typical properties and do not constitute specifications. Refer to the individual product data sheets for current sales specifications.

Basic Physical Properties

Table 1

HYDRAPOL® Surfactant	Water %	Colour Pt-Co	Cloud Point °C	pH 1% solution	HLB	Pour Point °C	Specific Gravity @20°C
RP40	0.2	50	~45*	5.5-8.0	7.8	-10	0.949
RP50	0.2	50	~57*	5.5-8.0	10.2	0	0.964
RP60	0.2	50	~59*	5.5-8.0	10.8	2	0.967
RP80	0.2	50	~30**	5.5-8.0	12.0	8	0.974
RP90	0.2	50	50-55**	5.5-8.0	13.0	16	0.993
RP100	0.2	50	65-69**	5.5-8.0	13.8	21	0.977
RP120	0.2	50	79-84**	5.5-8.0	14.7	22	0.986

** measured on a 20% solution of the surfactant in 25%w/v aqueous butyl diglycol*
*** measured on a 1% aqueous solution of the surfactant*

Viscosity vs Temperature

Table 2

Surfactant	Brookfield Viscosity (cP) at Temperature T°C					
	0°	10°	20°	30°	40°	50°
HYDRAPOL® RP40	110	55	35	26	20	17
HYDRAPOL® RP50	113	72	39	30	22	18
HYDRAPOL® RP60	1750	165	41	31	24	20
HYDRAPOL® RP80	1800	350	47	35	26	20
HYDRAPOL® RP90	>1 x 10^5	>1 x 10^5	90	42	31	23
HYDRAPOL® RP100	>1 x 10^5	>1 x 10^5	191	56	37	29
HYDRAPOL® RP120	>1 x 10^5	>1 x 10^5	2162	72	43	32
TERIC® N9	>1 x10^5	810	335	177	103	64
TERIC® G12A8	>1 x 10^5	>1 x 10^5	>1 x 10^5	87	38	28

At ambient temperatures, the viscosity of the HYDRAPOL® RP surfactants is similar to that of conventional fatty alcohol and Nonyl phenol ethoxylates.

Viscosity on Dilution

Table 3

% Water	HYDRAPOL® Surfactant						
	RP40	RP50	RP60	RP80	RP90	RP100	RP120
0	29	32	38	50	63	1390	paste
10	51	61	66	80	100	117	135
20	70	81	93	121	148	165	193
30	100	**4650**	**7850**	**9870**	**7970**	**3840**	316
40	**1820**	**7150**	**6750**	**5930**	**3750**	440	**>10^4**
50	**1350**	**1420**	**1330**	**690**	448	**>10^4**	**>10^4**
60	1920	**188**	**113**	**153**	400	**>10^4**	358
70	920	**91**	**81**	120	113	50	43
80	270	**220**	**79**	55	20	9	10
90	120	30	25	13	13	5.5	5.5

Table 3, above, provides information about the viscosity of HYDRAPOL® RP surfactants solutions as a function of their concentration in water, in centipoise, at 20°C.

The **bold**/blue values define a region in which the surfactant solution exists as a clear to slightly turbid viscid but pourable fluid. The **bold**/orange values indicate a region where the solutions are hazy liquids, and the **bold**/green region indicates a non-pourable gel structure. The viscosity, in centipoises, was measured at 20°C using a Brookfield LVT viscometer at 60 rpm.

As is characteristic of virtually all nonionic surfactants, alcohol alkoxylates have the potential to form viscous gels on dilution with water. However, due to the unique and innovative chemistry embodied in the HYDRAPOL® RP Series surfactants, the gel range is much narrower than that of conventional nonionic surfactants. In many instances the surfactant solution stays pourable, albeit with a very high viscosity.

General Surfactant Properties

Table 4, below, summarises the most basic solution properties of the surfactants. This data can be used to compare the functional properties of these surfactants with those of most other conventional surface active agents.

Table 4

HYDRAPOL® Surfactant	Surface Tension (mN/m) 0.1% aqueous @ 20ºC	Tape Wetting (sec) 0.1% aqueous @ 20ºC	Foam Height (cm) 0.1% aqueous @ 20ºC	
			Initial	Final
RP40	27.3	5.0	1.7	0.8
RP50	27.7	3.3	3.1	0.8
RP60	27.2	2.6	6.7	2.3
RP80	27.9	2.2	9.5	2.5
RP90	28.1	2.2	12.0	3.0
RP100	28.4	3.3	12.5	5.5
RP120	29.6	5.6	12.5	3.0
TERIC® N9	30.6	3.8	10.6	9.3
TERIC® G12A8	30.0	8.0	11.1	10.8

This data shows that the HYDROPOL® RP series surfactants are at least as surface active as the nonyl phenol ethoxylate, TERIC® N9 and the linear detergent alcohol ethoxylate, TERIC® G12A8, as indicated by the magnitude of the surface tension values.

Displacement wetting of the HYDRAPOL® RP surfactants is generally superior to that of the nonyl phenol ethoxylate, and significantly better than that of the detergent alcohol ethoxylate.

Initial foam development is generally similar to that of the comparators, but foam stability of the HYDRAPOL® RP surfactants is lower, suggesting that they will offer advantage in situations where excess foam is a potential problem.

Hard Surface Wetting Ability

The contact angle of a surfactant solution on a hard surface is an excellent indicator of the wetting power of that surfactant on that surface, and indirectly provides a guide as to the effectiveness of that surfactant in a detergent formulation intended to clean that surface. A low contact angle indicates good wetting and results in rapid spreading on the surface in question.

In areas other than cleaning, contact angle of a fluid on a substrate can be a guide to adhesion, in the case of adhesives and coatings, and a guide to film integrity in the case of hydrodynamic lubricants.

Table 5

HYDRAPOL® Surfactant	Contact Angle (º)			
	0.2% in water	0.1% in water	0.05% in water	0.1% in 3% NaOH
RP40	38.7	48.8	51.1	48.2
RP50	39.1	46.0	47.4	47.1
RP60	39.8	44.0	44.8	44.0
RP80	38.9	40.5	41.1	41.9
RP90	44.1	39.9	40.3	41.2
RP100	46.5	39.1	40.0	40.3
RP120	51.4	38.6	40.0	41.8
TERIC® N8 (NPE8)	47.1	46.3	46.7	48.1
TERIC® G12A8 (LAE8)	47.2	48.2	51.2	49.0
Water	111.0	111.0	111.0	76.2

Contact angle measured at 20ºC, after 60 seconds, on “Parafilm”. NPE8 is polyoxyethylene (8) nonyl phenol, and LAE8 is polyoxyethylene (8) lauryl alcohol, these conventional nonionic surfactants having been included for the purpose of comparison.

The data shows that HYDRAPOL® RP surfactants are generally superior hard surface wetters, when compared to the conventional benchmark surfactants. Furthermore, the HYDRAPOL® RP surfactants retain their effectiveness in aggressive environments, as exemplified by the performance in 3% sodium hydroxide solution.

From the formulation standpoint, this data clearly shows that HYDRAPOL® RP60, RP80, RP90 and RP100 surfactants are ideally suited to use in domestic and industrial hard surface cleaners.

Dynamic Surface Tension Reduction

Dynamic surface tension (DST) data is less commonly regarded as information of value to the specialty chemicals formulator. However, DST can be an important parameter in the selection of wetting agents for use in systems where a surfactant effect is required to occur in a very short period of time. Typical examples are in the formulation of aerosol sprays, surface coatings intended for spray application, herbicide formulations and pollution control devices such as water curtains in spray booths. DST is a measure of the time taken for a surfactant molecule to become active at an interface. The data in Table 6 clearly shows that HYDRAPOL® RP80 surfactant is a very effective wetting agent under dynamic conditions.

Table 6

Surfactant Trade Name	Dynamic Surface Tension, mN/m Bubble Life, milliseconds, @ 20°C					
	15	25	50	100	500	2500
HYDRAPOL® RP80	45	38	33	30	28	28
TERIC® N8	62	54	43	35	31	30
TERIC® G12A8	61	54	48	42	34	30

Solubility of HYDRAPOL® RP Surfactants

The solubility of HYDRAPOL® RP surfactants in various common solvents is illustrated in Table 4, below.

Conventional nonionic surfactant behaviour is exhibited. For example, low HLB members of the series are only dispersible in water, and the lower alcohols and glycol ethers are universal solvents for the series.

However, these extraordinary new surfactants are also universally soluble in low polarity liquids such as solvent neutral paraffinic oils and kerosene fractions. Such ability suggests a clear potential for application in the formulation of microemulsions, and solvent-free solubilisation of fragrances and essential oils.

Table 7

Solubility, 10% w/w in various solvents									
HYDRAPOL® SURFACTANT	Water	Ethanol	Paraffin 70N oil	Kerosene	Dichloro-methane	Butyl DI-GLYSOLV® Solvent	C_{16-18} Fatty Acid Methyl	Xylene	Acetone
RP40	O	+	+	+	+	+	+	+	+
RP50	O	+	+	+	+	+	+	+	+
RP60	O	+	+	+	+	+	+	+	+
PR80	+	+	+	+	+	+	+	+	+
RP90	+	+	+	+	+	+	+	+	+
RP100	+	+	+	+	+	+	+	+	+
RP120	+	+	+	+	+	+	+	+	+

+ = forms a clear solution in water. O = dispersible -- = insoluble

HYDRAPOL® RP Surfactants in Electrolyte Solutions

Table 8

Solubility, 10% w/w in various electrolyte solutions					
Surfactant	**Water**	**5% Hydrochloric Acid**	**5% Sodium Chloride**	**5% Sodium Tripoly-Phosphate**	**5% Sodium Hydroxide**
HYDRAPOL® RP40	stable dispersion	soluble	phase separation	phase separation	phase separation
HYDRAPOL® RP50	phase separation	soluble	phase separation	stable dispersion	stable dispersion
HYDRAPOL® RP60	phases separation	soluble	phase separation	stable dispersion	stable dispersion
HYDRAPOL® RP80	soluble	soluble	soluble	soluble	stable dispersion
HYDRAPOL® RP90	soluble	soluble	soluble	soluble	soluble
HYDRAPOL® RP100	soluble	soluble	soluble	soluble	soluble
HYDRAPOL® RP120	soluble	soluble	soluble	soluble	soluble

In many practical applications, especially those relating to industrial cleaning, surfactants are required to be soluble and stable in formulations containing a significant concentration of alkali salts, inorganic builders and various electrolytes. In metalworking industries, for example, surfactants are also required to function in strongly acidic environments.

The extent of solubility displayed by a surfactant is a function of the balance between the hydrophobe and the polar hydrophile. Simplistically, the hydrophile participates within the water structure, leading to dissolution of the hydrophobe in micellar form. A surfactant phase will begin to separate from solution if the hydrophilic interactions are destroyed or if hydration structures are dominated by an energetically superior solute. The introduction of an electrolyte to a nonionic surfactant solution can disrupt the surfactant hydration and cause phase separation to occur.

The extent to which a nonionic surfactant solution is destabilized by the presence of electrolyte can be manipulated by attention to structural aspects of the hydrophobe and by the degree of ethoxylation. HYDRAPOL® RP series surfactants are no less tolerant of these hostile environments than any other short chain specialty alkoxylate, as illustrated by the data in Table 8, above.

HYDRAPOL® RP Surfactants in an Acidic Environment

In mildly acidic solutions, HYDRAPOL® RP series surfactants behave in much the same way as they do in essentially neutral formulations. Basic surfactant properties remain unchanged, with the exception that they may exhibit a slight elevation in the aqueous cloud point. In strongly acidic environments these surfactants will be found to be valuable formulation aids.

HYDRAPOL® RP series nonionic surfactants are stable and soluble in most strongly acidic environments. Solubility of nonionic surfactants in an acidic environment is usually higher than in a neutral environment, due primarily to protonation of the ether linkages in the surfactant molecule. For example, a water dispersible nonionic surfactant will form a clear stable solution in phosphoric acid and this solution will retain its greatly enhanced wetting effect on dilution. This phenomenon is the basis for formulation of highly effective cleaning systems used on stainless steel vessels in the food and dairy products industries.

HYDRAPOL® RP series surfactants must not be used in acid cleaning formulations based on oxidizing acids such as nitric acid, chromic acid and hydroiodic acid. Depending on the strength of the acid, a vigorous chemical reaction can take place. This caution also applies to mixtures of nitric and phosphoric acids, used for passivation of stainless steel vessels. In this latter application the purpose designed product, TERIC® 165 surfactant, is more appropriate.

HYDRAPOL® RP Surfactants in an Alkaline Environment

HYDRAPOL® RP90, RP100 AND RP120 surfactants are reasonably soluble in solutions of the commonly used inorganic alkaline cleaning chemicals such as soda ash, caustic soda, alkali phosphates and polyphosphates. However, these products are not sufficiently soluble to permit the formulation of high active concentrates, unless used in conjunction with an additive such as ELTESOL® SX hydrotrope, or other surfactants which exert a strong hydrotropic effect, such as ALKANATE® P series phosphate ester surfactants or ALKADET® 15 alkyl polyglucoside surfactant.

Commodity anionic surfactants such as alkylbenzene sulphonates and alkyl ethoxy-sulphates will exert a mild hydrotropic effect when formulating with HYDRAPOL® RP surfactants in strongly alkaline environments, but they are not nearly as effective as the aromatic sulphonates or the phosphate esters. Furthermore, the commodity anionic surfactants will tend to create too much foam during application in a cleaning process.

The use of HYDRAPOL® RP series surfactants in a fully formulated alkaline cleaner will result in a product with superior performance due to the excellent wetting and detergency provided by the surfactant. If foaming is found to be excessive, the inclusion of TERIC® 167 surfactant or TERIC® 168 surfactant in the formulation will effectively limit foam foam development.

Storage and Handling of HYDRAPOL® RP Surfactants

The HYDRAPOL® RP Series surfactants should be stored indoors in a cool dry place.

The HYDRAPOL® RP Series surfactants are hygroscopic. In opened containers, the surfactants may rapidly absorb moisture, particularly in humid conditions. Therefore drums or containers should be kept tightly sealed and stored under cover. Opened containers may allow the ingress of air which, over time, can lead to oxidation of the product. This is evidenced by the slow deterioration of product colour and or by pH drift.

HYDRAPOL® RP Series surfactants that are pasty or have shown signs of significant zonal freezing and sedimentation due to chilling, should be reconstituted by gently warming to above 30ºC with moderate stirring in order to ensure that the product is homogeneous prior to use.

Materials of Construction

All nonionic surfactants can be handled in vessels, piping and fittings made from 304 or 316 grades of stainless steel. Carbon steel, mild steel and cast iron can be used for undiluted nonionic surfactants, but these materials are not recommended for the handling of nonionic surfactants which have been diluted with water. Rusting will occur quite rapidly, and this will cause severe discolouration of the product. Aluminium is satisfactory for handling undiluted nonionic surfactants, but not for products diluted with water. Nonionic surfactants can form coloured complexes with copper and copper alloys under some conditions.

Surfactants in general can induce environmental stress cracking in some grades of polyethylene and PVC. Oriented polyolefin plastics are quite acceptable for the construction of light duty storage and holding vessels.

Gaskets and seals in contact with water insoluble nonionic surfactants can be made from nitrile, silicone or Viton™ elastomers. For water soluble nonionic surfactants these same elastomers can be used, along with butyl rubber and Neoprene™.

Shelf Life

Provided they are stored properly and the drums or containers are kept tightly sealed, the HYDRAPOL® RP Series surfactants have a minimum shelf life of one year.

Shelf life is influenced by storage and handling conditions. The HYDRAPOL® RP Series surfactants are chemically stable under the recommended conditions of storage, and may be expected to remain so for many years. Accordingly, the HYDRAPOL® RP Series surfactants may remain useable for an extended period of time.

Therefore, it is recommended that product should be retested for conformance against the published specification after a period of 12 months.

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