Formulating Scrubs

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Abstract

Nonaqueous-based scrubs provide more functions and benefits for complete treatment of the body's skin and are a new category of cleansing tools focusing on cleansing, conditioning and treating. Oils, glycols and silicone oil are three continuous phases in non-aqueous scrubs discussed in this article.

Scrub products have gained popularity in recent years and continue to enjoy an upswing in the growing spa market, which emphasizes the holistic philosophy of de-stressing and relaxation. In addition to traditional aqueous-based scrubs,[1] several new nonaqueous types are flooding into the market. These focus on skin treatment and rejuvenation in addition to the traditional function of cleansing. Scrub products have gradually adapted from prestige origin into mass markets.[2-4]

In general, scrubs function both by removing old cells to produce a smooth and rejuvenated skin surface and by providing physical stimulation to skin through a massaging effect. Scrub performance depends on the water-soluble or water-insoluble abrasives used in a scrub product. Water-soluble abrasives, such as salt and sugar, are used in nonaqueous-based formulas. Water-insoluble abrasives, such as polyethylene beads, natural shells or seeds and pumice, are used in water-based formulas. An additional benefit is the treatment of skin with conditioners such as minerals, natural oils, emollients, vitamins and other nutrients.[1,5]

There are not many references available for describing fundamental formulations and methodologies despite the numerous nonaqueous scrubs appearing in the market. This article is intended to fill the gap and provide some practical information for formulating chemists.

Aqueous Formulary

Aqueous-based scrub products have been in market for years.[6-9] There are three basic types of aqueous formulas: paste-like, gel-like and cream or lotion-like (Table 1). Paste-like formulas are mainly based on sodium stearate/stearic acid mixtures, which are able to suspend the abrasive particles.[6] The gel-like formulas are anionic surfactant systems with additional gelling agents for suspending the abrasives.[7,8] The emulsion type is a thickened cleansing emulsion, which is capable of suspending abrasive particles.[6-8]

Table 1. Aqueous Formulary

	Polyethylene	Natural shells
Gel-like	X	X
Emulsion	X	X
Paste-like	X	X

Abrasives used in aqueous-based scrub formulas include natural shells or seeds, polyethylene beads and pumice. Natural shell or seed scrubs include, for example, apricot seed, almond shell, birch powder, coix seed, grape seed, jojoba beads, peach seed, sunflower seed, walnut shell, watermelon seed and cottonseed shell. Waxes and other items include orange peel and almond meal. Synthetic abrasives include polyethylene powder, nylon powder, polypropylene, cellulose beads and polystyrene.

Pumice is a very light porous volcanic scoria, usually gray in color. It consists of pores the size of capillaries that are organized in parallel configuration, giving it a fibrous structure. It is produced by the escape of water vapor from liquid or plastic lava.

Abrasives are evaluated on the basis of three factors – hardness, particle size and shape – and should be chosen according to desired performance. Nakahira et al. have developed an apparatus and method for evaluating these factors.[1] Scrubs made with large, hard and irregularly shaped abrasives will give a rough feel on skin and may cause irritation and

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Table 2. Non-aqueous Formulary

	Salts		Sugar	
	Separated	Suspended	Separated	Suspended
Oils	X	X	X	X
Glycols	X	X		
Silicones	X	X	X	X

sometimes damage. In contrast, softer or powder-like abrasives do not give enough massaging effect for de-stressing claims. The most appropriate range of hardness is from 0.5 to 7 (hardness scale from 0 to 10, 0 is hardest and 10 is softest).[10] The most appropriate shape is spherical, and the best range of size is from 40-80 Mesh (180 to 420 microns). Special attention should be paid when using natural shells or seed abrasives because they are susceptible to bacterial contamination. The safest way to prevent contamination is to radiate these raw materials before use in manufacture.

Nonaqueous Formulary

Salt and sugar scrubs have recently become very popular for body, hand and foot applications. These products were developed to meet the consumer trend of cleansing, treating and rejuvenating skin all at the same time. Because salt and sugar are water-soluble, their abrasive properties can only be utilized in nonaqueous formulations. Listed in Table 2 are oils (including natural ester oils, mineral oil, and/or synthetic oils), glycols and silicone fluids. These are the most common liquids used in the continuous phase of nonaqueous formulations. The salt or sugar abrasives can either be immersed or suspended in the continuous phase.

Dead Sea salts, sea salts, magnesium sulfate and sodium chloride are salts are commonly used in this type of formula. Sea salts, especially Dead Sea salts, contain a substantial amount of essential minerals. The composition of Dead Sea salts is 31% to 35% magnesium chloride, 24% to 26% potassium chloride, 0.1% to 0.5% calcium chloride, 4.0% to 6.0% sodium chloride and 26% to 30% of crystallizing water.[11] It has been experimentally and clinically confirmed that Dead Sea salts are effective in the treatment of osteoarthritis,[12] rheumatic discomfort[13] and psoriasis.[14]

The size and shape of salts are critical for product performance. The most preferred sizes range from 20-80 Mesh (180-840 microns). Facial scrubs normally employ finer particles, while body scrubs have medium range particles and foot scrubs still larger. Cubic (or more regular) shapes are preferable for less skin irritation and improved feel.

When the abrasive properties of sugar and salt are compared, sugar is found to have certain advantages: sugar is softer and can be made with a variety colors. On the other hand, sugar is slightly more expensive than salt and contains no minerals for treatment functions. Therefore, the sugar scrubs are not as popular as salt scrubs.

Oil-based scrubs: Oils include natural ester oils, mineral oil and synthetic oils. Some of the natural oils included are shown in Table 3. Most of these oils are triglycerides, which deliver good skin feel, moisturization and skin protection.

One problem with natural oils is their tendency to become rancid. Antioxidizing agents such as tocopherol (vitamin E), BHT (butylated hydroxytoluene) or benzotriazolyl dodecyl *p*-cresol[a] are necessary to prevent rancidity. In addition, winterized natural oils are preferred to prevent temperature-related sedimentation.

In oil scrub formulas that carry salt/sugar abrasives, the total amount of oil is 25% to 40%, with corresponding salt/sugar levels of 60% to 75%. The specific gravity of these particles is higher than oil; thus, they will sink to the bottom of the container when immersed in oil. When this occurs, the overall product will present with two distinct phases.

There are some limitations when employing natural oils in salt and sugar scrubs. Changing the color of the oil phase is difficult because most natural oils have a yellow or green-yellow hue. In addition, natural oils do not spread easily across surfaces. Therefore the spreadability of natural oils comes into play and is normally represented in terms of viscosity. Light natural oils (low viscosity) are preferred to heavy natural oils (high viscosity) because they are easier to spread across the skin surface and do not leave a heavy feel. The preferred viscosity range of oil or oil blends is 50-200 cps. It is the unfortunate case, however, that natural oils (except sunflower oil and safflower oil) show moderate comedogenicity.[15]

Mineral oil, isoparaffin or synthetic esters (oils) can also be used in scrub formulations. They are usually colorless and odorless and, as such, are readily colored and fragranced to meet marketing requirements. They are also easy to spread and are perceived to be less "heavy" on skin. Viscosities below 300 cps are preferred in better performing products. Formula ratios of oil phase to salt/sugar phase for this base type are the same as with natural oil formulations.

It is worth mentioning that mineral oils are colorless, clear and odorless liquids. They are excellent cosmetic emollients because they are inert and do not penetrate into the skin.

[a] *Tinogard TL, from Ciba Specialty Chemicals Corp., Basel, Switzerland*

Table 3. Natural oils found in oil-based scrubs

Common	Latin
Almond	*Prunus dulcis*
Aloe vera	*Aloe barbertiniae*
Avocado	*Persea americana*
Borage	*Borago officinalis*
Camellia	*Camellia japonica*
Canola	*Brassica napus*
Castor	*Ricinus communis*
Coconut	*Cocos nucifera*
Cottonseed	*Baccharis halimifolia*
Evening primrose	*Oenothera deltoides*
Hazelnut	*Corylus heterophylla*
Jojoba	*Simmondsia chinensis*
Kukui nut	*Aleurites moluccana*
Lemon	*Citrus limon*
Macadamia nut	*Macadamia integrifolia*
Meadowfoam seed	*Limnanthes douglasii*
Olive	*Olea europea*
Orange	*Citrus sinensis*
Peppermint	*Mentha piperita x*
Palm	*Setaria palmifolia*
Passion fruit	*Passiflora edulis*
Peanut	*Arachis hypogaea*
Pecan	*Carya illinoiensis*
Pistachio	*Pistacia vera*
Rosemary	*Rosmarinus officinalis*
Safflower	*Carthamus tinctorius*
Sesame	*Sesamum indicum*
Spearmint	*Mentha spicata*
Soybean	*Glycine max*
Sunflower	*Helianthus annuus*
Tea tree	*Leptospermum scoparium*
Walnut	*Juglans spp*
Wheat germ	*Triticum aestivum*

Mineral oils have superb skin compatibility and show little or no comedogenic effects.[15]

There are many synthetic esters (oils) that can be used in scrubs. Included are: isopropyl esters, ethylhexyl esters, oleic acid esters, caprylic/capric acid esters, n-butyl stearate, isocetyl stearates, octyldodecanol, diisopropyl adipate and pentaerythritol tetraisostearate. The price of synthetic oils ranges widely, depending on the chemistry involved in making these oils. Generally however, they cost more than natural or mineral oils.

Suspended oil scrubs: It is somewhat inconvenient to use dual-phase salt/sugar and oil mixtures, since salt/sugar particles settle to the bottom of the container. It then takes time and effort to mix two phases into a degree of homogeneity. To simplify the application process, these abrasives are suspended in the mixture permanently. In suspended formulas, salt/sugar is blended in the oil phase and will not sink to the bottom of the container.

Several methods are used to achieve suspension of salt/sugar abrasives in the oil phase. In the following example, oils are gelled with thickening agents that impart yield value to the solution. It is the yield value that allows particles to remain in suspension. Fumed silica[b] is one of the agents for gelling the oil phase.[16] It should be noted that fumed silica is very light and dusty, and special protective measures should be taken by compounders. The use of ethylene copolymers is another method of creating gelled oils.[17] Both methods form gels that break easily under shear stress, yet recover viscosity and yield quickly over time, which is to say they have thixotropic properties. As such they are considered a desirable medium for supporting and suspending particles in scrub formulations. The amount of fumed silica or ethylene copolymers varies according to oil type and the desired consistency of the final product.[16, 17]

Other oil thickening agents are quaternium-18 bentonites[c] or stearalkonium bentonites[c], trihydroxystearin[d],[18, 19] and *Rhus verniciflua* peel wax[e].[20] These gelling agents also impart yield to the continuous phase and thus will suspend salts or sugar.

Certain pre-made gels are also suitable for this application. One company offers several pre-made gels[f] composed of mineral oil, ethylene/propylene/styrene copolymer and butylene/ethylene/styrene copolymer.[21] Another company's line[g] has more than ten different pre-made gels that are oils thickened by bentonite derivatives.[18]

Consistency will vary with the amount of salt or sugar added to the formulation. The consistency can further be modified by incorporating surfactants into the system, which can improve both the viscosity, foaming or nonfoaming, and skin after-feel.

The ratio of oil to salt/sugar is more flexible in suspended oil scrubs than in the previously mentioned nonaqueous systems. The percentage of oil can range

[b] *Cab-O-Sil, Cabot Corporation, Tuscola, Illinois USA*
[c] *From Süd-Chemie Rheologicals, Louisville, Kentucky USA*
[d] *From Süd-Chemie Rheologicals and from Southern Clay Products, Inc., Gonzales, Texas USA*
[e] *From Botanigenics, Inc., Northbridge, California USA*
[f] *Versagel M 200, Versagel M 500 and Versagel 750 from Penreco, Houston, Texas USA*
[g] *Mastergel, from Süd-Chemie Rheologicals*

from 30% to 60% and salts/sugar can range from 40% to 70%. In summary, colorless oils can be easily colored to obtain different appearances, and the performance can be adjusted using surfactants.

Special attention should be paid to the temperature dependency of viscosity and yield. For suspending salts or sugar, the viscosity and yield of oil phases should be stable in the temperature range of –20°C to 50°C. Different oil thickeners have different temperature dependency of viscosity and yield. Carefully evaluation is needed to safeguard the stable products.

Glycol-based scrubs: Glycols and other humectants can be used as carriers in salt scrubs. Included in this category are glycerin, propylene glycol, butylene glycol, pentylene glycol, hexylene glycol and polyethylene glycols of various chain lengths. Sugar is somewhat soluble in glycols and is not appropriate for this type of formula.

Glycol-based scrubs have a self-heating function when they are rinsed with water, which provides an interesting consumer perception for treating and rejuvenating skin as these products are used.

Glycol scrubs have two important benefits: they are colorless and are not susceptible to chemical change. Thus, chemists can easily make a variety of colorful products and need not worry about problems such as rancidity.

Both separated and suspended scrub types are achievable with glycols. The ratio employed in the salt/sugar and oil formulary also holds for glycol formulas: 25% to 35% glycols and 65% to 75% salt phase. The disadvantage for this type of scrub is lack of good skin after-feel. Suspended formulas are more popular in the market. In suspended formulations, a thickened glycol phase is achieved by adding rheology-modifying polymers, emulsifiers with emollients, or a combination of both. The polymers must be glycol-soluble in order to thicken the continuous phase. Examples of applicable polymers include polyquaternium-10 or xanthan gum.

When formulating glycol-based scrubs using emulsifiers and emollients, one could use the same approach used for a normal water-based cream or lotion. In this case however, water is replaced by glycols. Possible emulsifiers are glyceryl stearate, certain polysorbates[h] and other nonionic surfactants. Possible emollients are fatty alcohols, natural and synthetic oils, and plant extracts.

Glycol scrubs impart skin benefits via humectants (as moisturizers), minerals (for treating skin), and emollients (for improved skin feel and protection). The performance is adjustable by changing the ratio of these ingredients. The salt concentration varies from 50% to 70% and the glycol concentration varies from 50% to 30%.

Dramatic temperature dependency of viscosity is the nature of glycol scrubs. The formula should be well balanced with emulsifiers and emollients to ensure the product's integrity in normal temperature variation in different seasons.

Scrubs based on silicone oils: To achieve the best skin after-feel, silicone oils can be used in scrub formulations. Both separated type and suspended type can be formulated with silicone oils.

The consistency of silicone oils is critical in separated formulas. Dimethicone and/or cyclomethicone (pentamer) fluids must have viscosities lower than 300 cps to be useful for this purpose. The performance can be adjusted by adding water-soluble dimethicone copolyols into silicone oils. The amount of salt is about 65% to 75% and the amount of silicone oils is about 35% to 25%.

Suspended formulas are made by using silicone elastomer to thicken low molecular weight silicone oils. The performance also can be adjusted with water-soluble dimethicone copolyols. The ratio of salt/sugar to silicone oils is about the same as the separated type. Another way to thicken silicone oils is by incorporating quaternium-18 bentonites or tridydroxysterin.[18]

Scrubs based on silicone oils give the best skin after-feel, but provide less skin protection and cost more than other types. Still, they are applicable in high-end products.

Future of Scrubs Formulary

Scrub products have only recently gained momentum.[2,4] It seems that this section of the market will continue to increase in popularity with increasing consumer knowledge of skin "de-stress" and "detoxification" within the mass market. From a formulation viewpoint, the nonaqueous-based products will probably show increased preference since they are easy to use and possess more functions and benefits. Thus skin after-feel and skin protection will encourage more consumers to buy these products.

Summary

There are two categories of cleansing scrubs, aqueous and nonaqueous. Water-insoluble abrasives are used in aqueous-based scrubs. Hardness, shape and particle size are three critical factors for evaluation of abrasives. The most appropri-

[b] *Tween-20 (INCI: polysorbate 20) and Tween-80 (INCI: polysorbate 80) are products of ICI Surfactants, Inc., Wilton, Middlesbrough, Cleveland, England.*

ate hardness range is from 0.5 to 7. The most appropriate shape is spherical and the best size ranges from 40-80 Mesh (180 to 420 microns). Gel-like, paste-like and cream (emulsion)-like solutions are three different types of aqueous formulas wherein abrasives are varied from 0.5% to 10%.

In contrast to traditional aqueous scrubs, nonaqueous-based scrubs are focused on cleansing, conditioning and treating skin at the same time. Oils, glycols and silicone oils are three possible continuous phases in nonaqueous scrubs. Lower viscosity liquids are preferred in the continuous phase, giving better performance in application. The abrasives normally used in these scrubs are salt and sugar. They can be suspended or allowed to settle to the bottom of the container depending upon the formulation desired. The hardness, size and shape of abrasives are paramount factors in determining scrub performance. The most preferred sizes range from 20-80 Mesh. The cubic (more regular) shapes are preferred for less abrasive skin-feel. Skin benefits stem from both the continuous phases and abrasives.

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