Editor's note: *The following information was originally part of an article, "Multi-Sensory Technologies for Today's Effervescent Bath and Shower Products," by Allen Rau, that appears in the October issue of Cosmetics & Toiletries magazine. It presents the basic technology and ingredients used in the creation of effervescent bath and shower products.*

Effervescent Technology Primer

The chemical reaction that creates the fizz in effervescent bath and shower products is quite simple. An acid is used to neutralize a carbonate salt. This releases carbon dioxide gas, the salt of the acid, and water. Obviously, the carbon dioxide gas is the fizzing that characterizes effervescent products.

FIGURE 1:

The Effervescent Reaction

Acid + Carbonate Salt _ CO_2_ + Acid Salt + $H_2$0

Ex: Citric Acid + 3NaHCO3 _ $3CO_2$_ + Na_3Citrate + $3H_2$0

There are a few points here that are not so obvious, but are very important. First, water is needed to start the reaction. Without water, neither the acid nor the carbonate can dissociate. If there is no dissociation, the effervescent reaction cannot start. Once the reaction starts, however, it generates more water. This means that effervescent products must be carefully formulated, produced in appropriate environments and packed properly. Otherwise their inherent instability can ruin them.

Specifically, all raw materials used in an effervescent product must be anhydrous and must be stored so that they remain dry. The manufacturing environments where these products are made must also be designed to maintain dryness. Typically these facilities are dehumidified to less than 10%RH. To protect them from ambient humidity, effervescent products are usually packaged in high barrier foil and/or polymer films or in heavy-wall jars that contain desiccant packs.

Raw Materials for Effervescent Products

Since it is the source of the carbon dioxide, the carbonate salt is a key material in an effervescent formula. The most commonly used carbonate salts are sodium carbonate (soda ash) and sodium bicarbonate (baking soda).

FIGURE 2:

Commonly Used Carbonte Salts

	Na_2CO_3	$NaHCO_3$
Molecular Weight	106	84
Eq. Of Acid to Neutralize	2	1
% CO_2	41.5	52.4

Sodium carbonate has a lower percentage of CO_2 than bicarbonate and since it requires 2 moles of acid per mole of the salt, it is slightly more difficult to neutralize than baking soda. However, these attributes cause products that are formulated with carbonate to be a bit more stable than those that contain only bicarbonate.

Bicarbonate has a higher proportion of CO_2 than soda ash and, due to its ability to easily break down, releasing water, products formulated with it tend to react more quickly and be less stable than carbonate-based products.

Both carbonate and bicarbonate have advantages and disadvantages. Therefore, most formulations use a blend of the two. 50/50 is a typical ratio that generally achieves good reaction time and acceptable stability.

Although the sodium salts are the most commonly used carbonates, potassium and magnesium carbonate can be used successfully in effervescent products.

The other key component in an effervescent composition is the acid. It reacts with the carbonate salt, releasing the CO_2 gas.

FIGURE 3:

Commonly Used Acids

	Citric	Fumaric	Adipic	Malic
Molecular Weight	192.1	116.1	146.1	134.1
Moles of Acidity	3	2	2	2
Eq. Weight	64.05	58.05	73.05	67.05
Solubility (%)	68.6	1.1	1.4	55.8

The most commonly used acid is citric acid. It is low cost, easily available, very soluble and since it is trivalent, has good neutralizing power.

Fumaric acid is also frequently used. Even though it is only divalent, fumaric acid is actually a more efficient neutralizer than citric acid on a weight basis. This can be seen by comparing the equivalent weights of these materials. However, fumaric acid is much less soluble than citric acid and thus gives a slower reaction than citric. Probably because of this difference in solubility, fumaric acid products tend to be a bit more stable than citric acid products. Adipic and malic acids are also commonly used in effervescent bath products. As with the choice of carbonate salt, the desired product performance and manufacturing method will guide the choice of acid.

Not only will the choice of acid affect performance, but the ratio of acid to carbonate will also affect the product. In general, higher ratios of acid to carbonate will yield faster reactions. Also, higher ratios of acid will assure that the carbonate is completely reacted. If the acid does not at least stoichiometrically balance the carbonate, some carbonate will be left unreacted and it will settle to the bottom of the bathtub. In general, 1:1 weight ratios of acid to total carbonate are common. However, highly reactive, highly soluble systems can use acid to carbonate ratios as low as 1:10.

Beyond the reactive ingredients, aesthetic and functional materials are usually incorporated in effervescent products.

Fragrances and essential oils are virtually always included in these products. Typical levels are 0.5% to 3%. Product design and intended consumer use will guide perfume selection and level. Most fragrance houses can provide technical assistance in designing perfumes for use in effervescent products. They can formulate the oil to be compatible with effervescent bases by avoiding materials such as glycol solvents that may cause instability to occur by allowing partial dissociation of the acid or carbonate.

Color selection will depend upon the desired product performance and aesthetics. Most cosmetic colors work well in effervescent bases. If the product needs to color the bath water, use dyes. If coloring only the product itself is important, use lakes and/or pigments. Color stability, particularly in light, must be checked carefully.

Functional materials are included in virtually every effervescent product. The key is to choose materials that are anhydrous, otherwise stability problems will occur. Botanical materials such as freeze-dried aloe, chamomile extract in oil, and even dried flower buds and bulk herbs have been used in effervescent products. Levels used are generally less than 1 or 2%.

Emollient materials such as squalane, vitamin E, almond oil and many cosmetic esters are frequently incorporated, again, generally at 0.1% to 2%. Surfactants are used both as fragrance emulsifiers and as foamers. When used as emulsifiers, surfactants prevent the perfume oil from floating on the water's surface. Many consumers prefer this since floating oil systems tend to be messy and hard to clean up. Typical emulsifiers are PEG-30 castor oil, Polysorbate 80 or 85 and Laureth 4. The precise choice will depend on the HLB of the perfume oil.

If surfactants are going to be used to create foam, special formulations are required to achieve consumer acceptable performance. Polymers can also be added to help modify skin feel and the feel of the bath water. Commonly used materials include Polyquaternium 10 and PEG. Levels are typically 0.2% to 3 or 4%.

Binders are almost always needed to make good, solid effervescent tablets. Sorbitol, lactose and maltodextrin are usually used at levels ranging from 10-20%.

Process aides are materials that are added to help the powders flow more efficiently and to prevent sticking on the production equipment. The most frequently used of these materials are fumed silica, calcium silicate, cornstarch, and sometimes talc. In general, these materials work well when incorporated at only a few tenths of a percent.