When dealing with many of today’s foods and pharmaceutical ingredients, we often have an active, which has certain desirable properties we want, but has an undesirable taste. It is possible, or even likely, that coating (also known as encapsulating) the active with a properly
selected film can negate this undesirable property. So, what are some of these possible coatings? Natural polymers and their derivatives, such as cellulose and its derivatives, cover a tremendous range of properties. The list continues with starches, vegetable gums, proteins, and other animal derivatives. Waxes, both natural and synthetic, cover more materials than I could possibly list during this presentation. In addition, there are many plastics, organic coating not listed already, and inorganic coating (see table 1).

Choosing one of these coatings is not a simple selection. Let us look at the factors, which we must consider before making a decision on coating materials. First, we need to look at the active ingredient, which we need to taste mask. Is it a liquid or solid? If it is a liquid, is it volatile? If you want a dry product, can it be absorbed on a carrier? Is it compatible with liquid encapsulation techniques? If it is a powder, what is its particle size, flow characteristics, moisture sensitivity, long term stability, and method of delivery?

Let us look at some of these concerns that relate to coating. One of the most visible characteristics is particle size. If we are dealing with a large particle size, such as larger than 60 mesh (250 mm), we may be able to size our raw material to a very narrow particle range. This is important since we are coating the surface area of a particle. Taste masking involves covering the total surface of the particle with enough coating so that the taste is not apparent to the consumer, whether it be a person or an animal. However, if it is a suspendable product, mixed with other ingredients, or placed in a product that may be chewed, it may need to be a finer particle size. In many of these cases, it may not be possible to screen the raw material due to mechanical characteristics of the particles. Or, we may prescreen a material only to have it show an increase in particle size that is undesirable in the product, or show particle size increasing too fast at optimum processing conditions, which would make the product more economical. In these cases, it may be necessary to coat the product to a minimal level to increase its flowability. We can now screen the material and complete the processing and have a more acceptable final particle size (see table 2).

As the particle size gets smaller, the surface area to be coated grows exponentially, making it even more difficult to coat. On a larger particle, it might be cost effective to apply a heavier coating to achieve the taste masking desired, but on a smaller particle, this may be impossible. This coating will take more time and increase the weight and particle size significantly, causing the selection of a coating material to be more critical so that the desired protection and release profile are obtained with less coating. So, even though there are many coatings available, only a few may meet your immediate needs.

Let us look closer at some of these particle size issues. If a particle is to be suspended in a solution, whether it be a beverage, in food preparation, or a dry suspension, the particle size has to be appropriate to stay suspended. Some formulations may allow for a thicker solution, while others may have little to no viscosity to suspend the coated particles. If you can’t use viscosity, then you need to suspend the particles based on density. This is another factor affecting the coating.

Many taste-masked products are dispensed in a chewable tablet, biscuit, or other manufactured food item. Now, in addition to all the taste concerns, we now need to survive high temperatures, high moisture, and/or high pressure treatment of processing. And, once made, what are the storage conditions that this product will see?
Density and particle size are also critical in dry formulations to keep products from segregating. If a drug, mineral, or vitamin is being dispensed in larger mix, it is critical that the particle distribution stay uniform. And, if the particle will be in a product that is chewed or drunk, what is the maximum particle size that can be used without causing bad mouth feel or premature failure due to rupturing?

We have spent time looking at particle size as it relates to taste in delivery systems. But what about delivery of the active once it has survived the taste test? What factors allow a particle to withstand the hostile environment of preparation, storage, handling, and finally consumption, but then releases within the time window most desirable for maximum bio-availability?

Sometimes our final particle size is decided by the type of release we wish to obtain. A large particle will sometimes not release fast enough with the desired coating where a smaller particle may give us the desired release curve while maintaining the taste acceptance desired (see figure 1). Even the particle size of that small particle will affect the release curve, maintaining the thickness of the coating as a constant (see figure 2).

Now that we have reviewed the particle size, let us look at coating composition. One of the best factors for controlling taste masking and release of active is the substitution of the coating material. Using ethyl cellulose as an example, by using varying amounts of methyl cellulose in the film, we can alter the solubility of a material with an identical % total coating and particle size (see figure 3). In addition to substituting one coating material for another, you can use plasticizers to accomplish the same type of profile (see figure 4). Both by the type of plasticizer (see figure 5), and by the amount of plasticizer (see figure 6), we can customize the release curve of a given active. Once we have established the type of coating, the plasticizer (if any) to use, and the percent of that plasticizer to use, we can play with the level of coating. If all we are trying to accomplish is taste masking, it may be simple taste panel to determine the proper coating level. However, if we are adding stability or time release to the taste mask properties, we may need to look at many different coating levels to get the percent release desired (see figure 7).

What other factors affect the taste of a product? Any time you process material; you risk changing the taste by the temperature at which you process the material. In developing a taste masked product for animal consumption, we modified the coating formulation by substituting one ingredient for another. This change allowed us to process the material much quicker. However, the new encapsulated product had poor acceptability. In re-evaluating the coating process, it was noted that the temperature was different with the new coating, and by changing the temperature, we were again able to make the product with the same acceptance level, without giving up the rate increase we had obtained by the material change.

Other areas that created problems were the use of various solvents. We have had great success in creating taste masked products using hot melt systems. This is the most economical way to apply a film to any product if you can find a coating material to give you the performance desired. Not only is there no solvent expense or residual solvent in the product, there is no storage expense for non-product materials. Your yield can be 100% of all the ingredients used. The application rate is quick since the coating is being applied at 100% solids. But again you have to find a material to give you the desired performance and the material must be able to be melted without degrading under normal handling conditions. Also, if the melting temperature is too low, the film will not be hard enough to keep the particles separate in storage. And if the
melting temperature is too high, it will be difficult to melt the material, spray it in a molten form unto the particles, and keep the material molten long enough to have it flow into a film once deposited.

If hot melts won’t do the job, what is the next most economical? Aqueous based coatings have been used for many years, but most of the traditional aqueous based coatings do not make a good taste barrier. Some work ahs been done on aqueous-solvent based coating solutions, but recently, a number of products have been made available in suspensions, dispersions, latex or pseudo-latex form (such as Aquacoat®, Coateric®, and Eudragit®). These solutions offer a wider variety of films for coating, many which can be used to taste mask products. Again, you have plasticizers to consider when working with suspensions, latexes and dispersions. Water soluble and many water insoluble plasticizers can be used because of the emulsifiers used to create the suspension, latexes and dispersions (see table 3). With the use of water, there are other cost and disadvantages involved. Water is less volatile than commonly used organic solvents, and may result in a higher energy cost to dry the coating. Exceptions do exist such as latexes, which have a very low affinity for water, and therefore can be run at lower temperatures and higher rates. While organic solvents have the possibility of residual solvents in the finished product, aqueous based coatings have the risk of residual water and moisture pickup in processing and storage. This can be eliminated by using the proper drying conditions and proper equipment (see table 4). However, this doesn’t tell us the whole story about the damage to the core material during processing, and during storage (see table 5). And as you see in table 5, sample A due to too much heat, and sample C due to inadequate drying, both had undesirable results creating an unstable product. In addition to the temperature, there is the possibility of microbial proliferation, which could be a problem in solution preparation and storage (see table 6).

Once the proper conditions are worked out, what are the economics of solvent versus aqueous coatings. Table 7 does not use the cost of any materials other than the solvent. There is such a variety of coating materials and plasticizers, that we used a resin soluble both in an organic and aqueous solution. Therefore, the costs are to compare the solvent costs against the added energy costs. You can also include you process time costs by using the coating time comparisons provided in the table.

There are many technologies that can be used to encapsulate your product. Once you have selected a coating material, plasticizer, and have worked out the process conditions, you will have scale up problems. These problems may be any one or all of the following:

- Variability of the core and/or coating as you require larger quantities to be produced. In house manufactured products may be made in a quantity sufficient only for the development stage. We may find that a project developed using a very small number of different samples, may have difficulty being scaled up to larger production equipment. Or, there may be particle changes or structural changes to the particles we have just developed our coating around.

- The coating may have been the best sample ever produced by that supplier. We will need to test the characteristics of a material with the components we will be using, not the test solvent they use. Viscosity, solubility, permeability, and age stability may change with your chosen solvent. Will all the material be the same as that first sample?
I’m sure everyone knows a story or two about scaling up equipment. I am most familiar with fluid bed coating and pan-modified pan coating. In all systems, the density of particles must be considered along with the bed depth and force that can be exerted on the lower particles. These increase forces cannot be duplicated in a small research unit. Equipment components may cause limitations as we start to exceed the physical capacity of some of the components. The spray nozzle may not be able to atomize the solution properly at the faster application rates. The distance the nozzle is away from the core material may cause the film to form differently on the core material, causing spray drying, agglomeration, or rough coatings, which are not effective. When we get to even larger pieces of equipment, we may find that we have multiple nozzles and have overlap problems.

What about product reproducibility from batch to batch, from particle to particle? Data produced using fluid be coating equipment shows the following data: standard deviation from tablet to tablet was found to be 7.2% in the 18” (25 to 90 Liter capacity) fluid bed coater. It was 7.6% in the 46” (180 to 600 Liter capacity) fluid bed coater which is a 7 nozzle unit. When work was performed using 18/20 mesh non-pariels, standard deviations on a single bead was 19.6% at 70 minutes, 17.8% at 120 minutes, and 12.1% at 180 minutes. When we increased the sample size to 100 mg, the variability dropped to less than 3% at 70 minutes, less than 2 % at 120 minutes, and approximately 1 % at 180 minutes. However, in scale up, you may be going from a one nozzle system to a multi-nozzle system. Earlier I discussed the performance of a 7 nozzle system when all the nozzles were working correctly. What happens as we start to have nozzle problems and need to pull the nozzle during a run for cleaning? With a single nozzle out of service for a complete run, the standard deviation was 9.4%.

So, if we can make the product meet the specifications and can always get materials to match the specification established on the original material, we will have a successful product that we can reproduce every time we need to. Remember, in taste masking, it only takes a few bad particles to create a bad taste for all.

**TABLE 1**

| Coating (Encapsulating) Materials | Applied by Coating Place, Inc. |
Including...Aqueous Solutions
           Solvent Solutions
           Latices
           Hot Melts
           Emulsions

Acrylics          Molasses
Aquacoat®         Nylon
Aquatic®          Opadry®
Caseinates        Paraffin Wax
Cellulosics
   EC          Polyamino Acids
   CA          Polyethylene
   CAB         Polyethylene Glycol
   CAP         Polylactides
Chlorinated Rubber Polyvinyl Acetate
Cateric®          Polyvinylacetate Phthalate
Coating Butters   Polyvinyl Alcohol
Daran® Latex      Polyvinyl Chloride
Dextrins          Polyvinylidene Chloride
Enterics          Polyvinyl Pyrrolidone
Eudragits®        Proteins
Eva               Rubber, Synthetic
Fats              Shellac
Fatty Acids       Silicone
Gelatin           Surfactants
Glycerides        Starches
Gums, Vegetables  Stearines
Halocarbon        Sucrose
Hydrocarbon Resins Surelease®
Kynar®            Teflon®
Maltrodextrins    Waxes
Microcrystalline Wax Zein
Milk Solids