MICROENCAPSULATION

Microencapsulation began as an "art" that evolved from polymer chemistry research as a result of an identified commercial need for controlled release technology. Microencapsulation encloses a solid, liquid, or gaseous material inside a tiny "bubble" of capsule wall and holds it for a specified time or in a specific environment. Regulation of clinical composition of the capsule wall and processing techniques determines how, when or whether the "payload" inside the capsule is released.

Several different capsule technologies presently are practiced. These are: a) gelatin, starch and similar encapsulation techniques used in pharmaceuticals and foods; urea formaldehyde microencapsulation used in carbonless copy paper; b) sulfur encapsulation used in fertilizers; and c) polymeric microencapsulation.

HOW IS CSI'S TECHNOLOGY SPECIAL?

Polymeric microencapsulation, as practiced at CSI, is a distinctive technology, delivering the most important capsule characteristics:

1) Stability (tendency to retain all the payload if desired);

2) Impermeability (resistance to moisture, air or contaminant penetration);

3) Release Performance (predisposition to release capsule contents in presence of predesignated trigger mechanism (e.g. heat, pressure, chemical reaction, UV radiation enzymatic reaction) or at a specified time);

4) Phase Ratio (the ratio of weight of payload to total weight of capsule);

5) Uniformity (capsule size conformity as required by end-use); and

6) Environmental Safety (lack of toxicity).

CSI's microcapsules have shown excellent results in laboratory tests for stability in extremes of temperature and humidity. The polymeric capsule wall is not susceptible to corrosion or organic breakdown. CSI's capsules can hold materials with water or oil bases, high or low pH factors and any degree of viscosity. They can safely hold toxic or volatile materials. The encapsulated material remains stable because of the innocuous nature of the capsule wall and the protection it provides from exposure to air, water, and other contaminants. A most important characteristic is the isolatable nature of the great majority of CSI's systems.

MICROCAPSULE DESIGN CONSIDERATIONS

INTERNAL PHASE MATERIALS

- Solids
- Liquids
- Gases

WALL VARIABLES

- Size
- Permeability
- Density
- Wettability
- Film Forming Material

RELEASE FACTORS

- Time
- Pressure
- Temperature
- UV Radiation
- Chemical Reaction
- Bacterial Activity
- Enzymatic Reaction
- EB Radiation

Internal Phase(encapsulated material)

Capsule Wall

CAPSULATED SYSTEMS' PROPRIETARY PRODUCTS

AVCAP AND MACAP MACROENCAPSULATION COATINGS

While working on some projects requiring particularly strong, impermeable capsule walls, scientists at CSI theorized that a version of the wall material might be applied as a macroencapsulation conformal coating. This idea has fostered an extraordinarily successful program, a patent and certification of a resultant conformal coating for electronic circuits(AVCAP) for the Department of Defense Qualified Products List for MIL-I-46056C which permits its use for protection of sensitive and valuable defense electronics equipment.

The macroencapsulation conformal coatings systems developed at CSI meet the challenges of moisture and humidity protection of electronic hardware. CSI's macroencapsulation process uses an organic polymer which wraps itself around the surface to be encapsulated to provide uniform protection from contamination. It is easily applied by dip, brush or spray techniques. Some of it's advantages are:

1. Superior Moisture/Oxygen Resistance
2. Pin-Hole Free Coating
3. Flexibility
4. Repairability
5. Excellent Adhesion
6. Protection of Electromigration

7. Excellent Heat Dissipation
8. Thermal Shock Resistance
9. Transparency (UV Tint Available)
10. Thin Film, 1 -2 mils
11. No Shrinkage
12. No Cracking (no plasticizers)
13. Chemical Resistance
14. Easy, Low-Cost Application
15. Compatibility with Other Coatings for Repair/Rework

Purposes(Urethanes and Epoxies)

Additionally, MACAP, a similar product to AVCAP, is being tested as a protective coating for metal structural components (concrete reinforcement bars, bridge and building beams, etc.) Results, thus far, are excellent. MACAP's superior adhesion qualities, pin-hole free coating, moisture/humidity resistance and thermal shock resistance properties exhibit promise that it may be the corrosion inhibition system of the future.

Finally, this polymeric material provides CSI with a unique capability to microencapsulate aqueous based materials heretofore unheard of. Such materials as water/glycerine, sulfuric acid(2% concentration), sodium hydroxide(5% concentration), and pesticides can now be encapsulated and isolated into a free flowing powder using this patented system.

OTHER PRODUCTS

ZNCAP A zinc-rich primer employing microencapsulation technology to produce a superior, corrosion inhibiting coating.

EELS A patented system for encapsulating the phosphors used in electroluminescent lighting to prevent degradation due to humidity. Greatly increases the life of the lamp.

CAPLOK A threaded fastener adhesive coating system.

SILCAP An aqueous-based, dry protective coating.

FY'R'CAP A microencapsulated fire retardant material.

SPOT-A-WAY CSI's only consumer product incorporating microencapsulated 1,1,1 Trichloroethane in a personal cleaning configuration for organic stains.

LUBRICAP A microencapsulated lubrication system for incorporation into thermoplastic and elastomeric compounds to provide lubrication upon exposure to friction.

PHASE-CAP An encapsulated phase change material(usually octadecane or eicosane) used to absorb heat.

AGRICAP A system for encapsulating herbicides and providing nearly zero order (straight line) release over a 60 - 90 day period regardless of the presence of moisture.

STETHEATER A system that heats medical devices to body temperature to provide comfort to patients during medical exams using an exothermic chemical reaction.

KWIK CONNECT A microencapsulated PVC Cement sold by Carlon on precoated PVC couplings. (See Attached)

LEADERSHIP

Roland M. Lynch – President, CEO

Lynch directs Capsulated Systems business operations. He holds a Master of Business Administration Degree from the Darden Graduate School of Business of the University of Virginia, Charlottesville, Virginia, with emphasis in marketing and finance. In addition, he graduated with a Bachelor of Arts Degree in Mathematics from the University of Virginia with emphasis in engineering and computer science. He has held positions as a Corporate Banker at Wachovia Bank in Charlotte, North Carolina, Financial Analyst at Amvest Corporation in Charlottesville, Virginia and as Manager of Financial Planning for The Mead Corporation in Dayton, Ohio. In 1983, he was assigned the position of Manager of Marketing and later Manager of Business Planning of an effort by a group of chemists at Mead who were developing a technology using microencapsulation to develop a color copying system. He lead the effort to create a business unit out of that group which later became Mead Imaging Division now Cycolor Corporation in Dayton, Ohio. In 1985, he was hired by Capsulated Systems as Executive Vice President to lead its strategic planning direction as it prepared to evolve from a technical shop to the world's leader in cutting edge microencapsulation technology. In 1987, Lynch was promoted to the position of president. In 1991, he purchased controlling interest in Capsulated Systems. He is a co-inventor of 4 of Capsulated Systems' patents in microencapsulation.

Technical Leadership

Capsulated Systems' chemists and production personnel have a combined 53 years experience in the macro and microencapsulation field. Their educational backgrounds include Ph.D.s in organic, polymer and physical chemistry. They have scaled up products including epoxy systems and PVC cement to 500 lb. batches that have met the customers specifications.

LABORATORY PRODUCTS LIST AS OF 10/2/2002

The following chemicals have been microencapsulated in CSI's laboratories in research quantities ranging from 100 grams to 5 pounds:

ORGANIC CHEMICALS
Cineole - Citric Acid - Ethylenediaminetetraacetic acid - Disodium Salt - Glycerine/Water - d-Limonenedimercaptan (dLDM) - Menthol - Methyl salicylate - Nicotine citrate - Oleic Acid - Pigments - Sucrose - Tartaric acid - Triethylenetetramine/LiCl - Tetraethylenepentamine/LiCl – Urea

ORGANIC SOLVENTS & OILS
Carbon tetrachloride - Ethyl amyl ketone - Freon MF - Freon TF - Gasoline - Hexane - Isooctane – Methyl hexyl ketone(2-Octanone) - Mineral oil - VM & P Naptha - - Perfluoro-1,3-dimethylcyclohexane, perfluoro(methyldecalin)- Polychlorinated biphenyl(PCB)- Stoddard solvent - Tetrahydrofuran - Toluene - 1,1,1-Trichloroethane - Trichloroethylene

ORGANIC PEROXIDES
Benzoyl peroxide - Lupersol 331-80B - Lupersol PDO - Trigonox 29B-75 - t-Butyl Perbenzoate - Varox DBPH

EPOXY RESINS
Epon 828 - Epon 830

WAXES
Bayberry wax - Eicosane - Hexadecane - Lauric acid - Methyl palmitate - Octadecane – Paraffin wax - Spermaceti wax - Stearic acid

DYES (Neat or in solution)
Color dyes - Fluorescent - Photochromic

INORGANIC SOLIDS
Copper Sulfate -Graphite - Magnetite - Magnesium Hydroxide - Samarium cobalt

INORGANIC PHOSPHORS
Electroluminescent - CRT - Phosphorescent

LOW TEMPERATURE EUTETICS
Cerrobend

PIGMENTED SYSTEMS
Paraffin wax & carbon black
Paraffin wax & magnitite–(Toner)

PIGMENTS
Milori blue - Zinc oxide

ELEMENTAL METALS
Aluminum - Boron - Magnesium – Zinc

ORGANOMETALLICS
Dibutyltin dilaurate