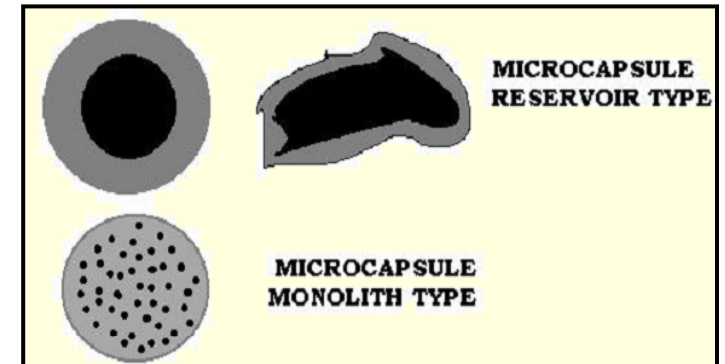


# Microcapsules and Microspheres

# Background for Microcapsules & Microspheres

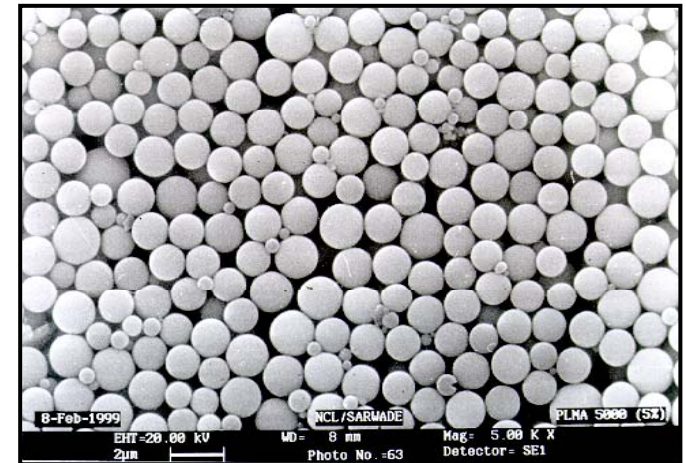
## ▶ Microcapsules

- ▶ Microcapsules contain an active agent and surrounded polymeric shell or dispersed in polymeric matrix.
- ▶ Microcapsule size : 1 to 1000 micron
- ▶ Microcapsules can be of different structures



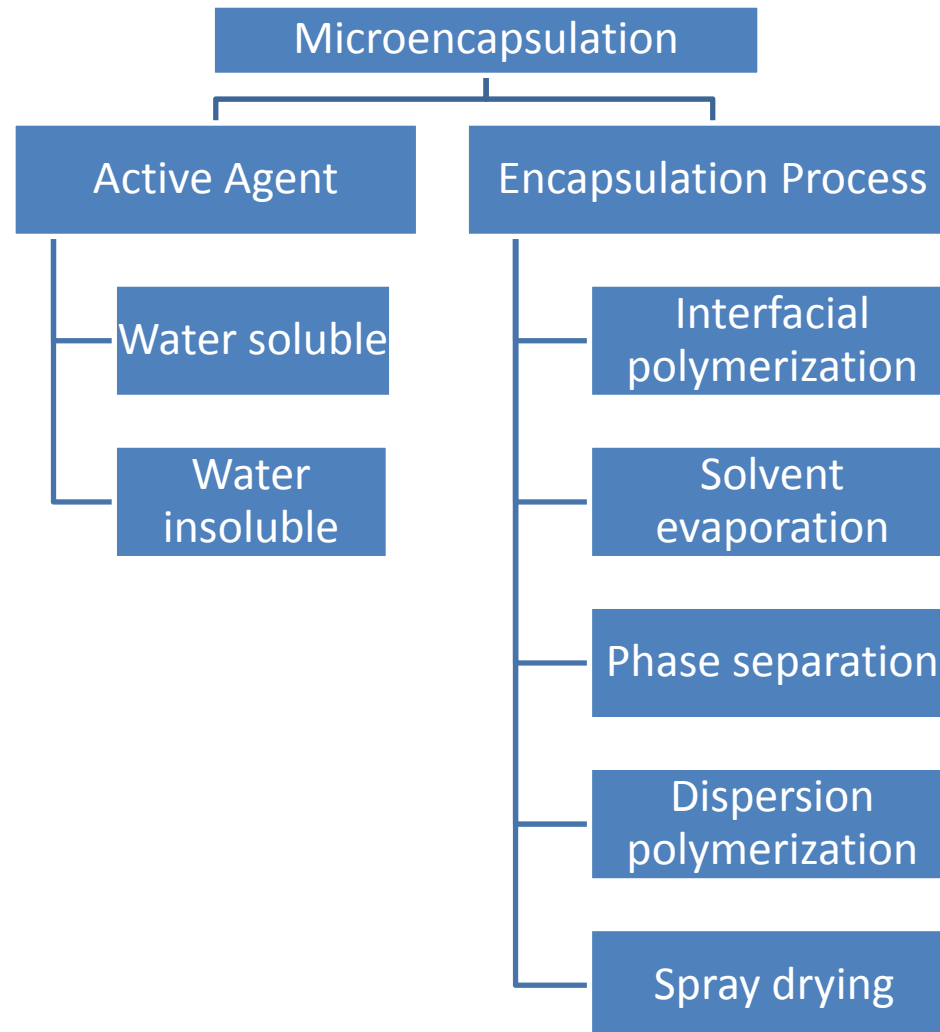
## ▶ Microspheres

- ▶ Small spherical particles (also known as micro particles)
- ▶ Diameter ranges from 1 micron to 1000 micron (1 micron =  $10^{-6}$  meters)
- ▶ Can be made using various materials.  
eg. Polymer, glass, ceramic



# Classification of Microencapsulation methods

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# Scientist

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## **Dr. P. G. Shukla**

Scientist, Polymer Science & Engineering Division

### **Areas of interest :**

- ▶ Synthesis of polymers in particulate (nano and micro) form
- ▶ Controlled release technology especially microencapsulation
- ▶ Controlled release chemical and bio pesticides
- ▶ Controlled release formulations of active agents used in wide range of consumer products

**Web:** <http://www.ncl-india.org/people/showframe.jsp?personid=6>

# NCL Competencies

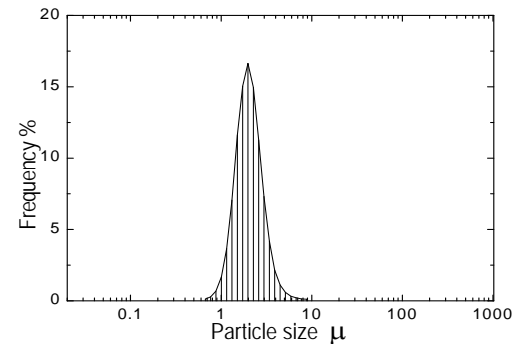
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## Microcapsules

- ▶ Microcapsules of active agents for controlled release applications  
eg. active agents – biocides, pesticides, flavors, fragrances.
- ▶ Can be designed for desired release time span.

## Microspheres

- ▶ Free flowing microspheres with near uniform particle size, in the range of 0.1 to 10 microns.
- ▶ Materials used: Polyurethane, Urea-Formaldehyde, PMMA, Polystyrene



## Know How:

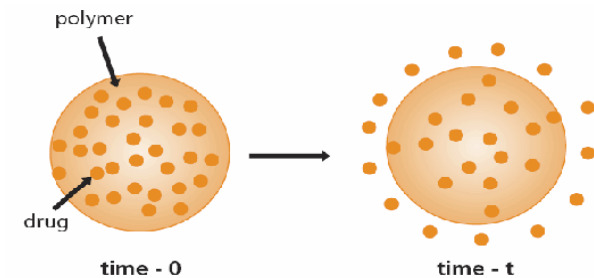
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Process for preparation of microcapsules and microspheres

# NCL Competencies

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## Microencapsulation of chemical and bio-pesticides

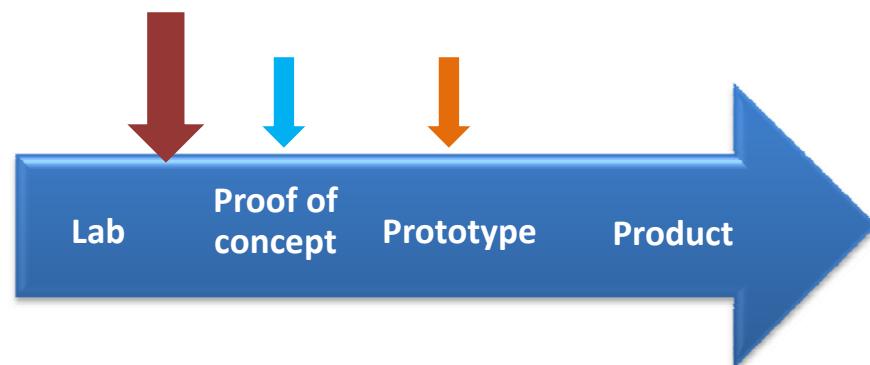


- ▶ Microcapsules encapsulating biocides for controlled release applications were developed
- ▶ Active agents such as carbofuran, chlorpyrifos, monocrotophos, fungi and nematodes etc, were successfully encapsulated
- ▶ Materials used: starch, amino resin, polyamide, polyurethane, gelatin
- ▶ Rate of release is controlled by monomer selection and crosslinker.
- ▶ Achievable encapsulation percentage of active agents - 75 to 80%
- ▶ Bioefficacy trials of controlled release agrochemical formulations showed extended duration of activity and increase in benefit /cost ratio
- ▶ Available microcapsular powder and microcapsular dispersion form

## Representative Markets

Healthcare	
Automotive	
Construction	
Agriculture	
Entertainment	
Infrastructure	
Personal care	
Industrial	
Water	

## Technology Status



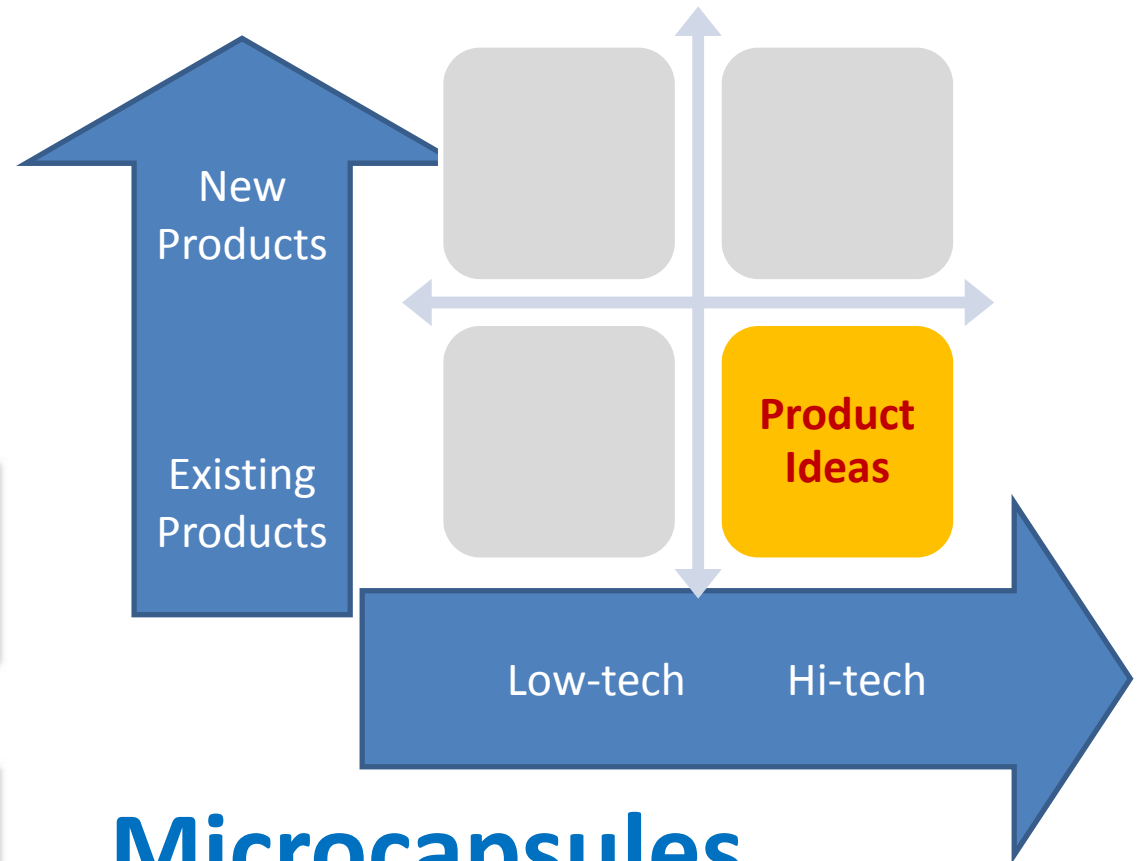
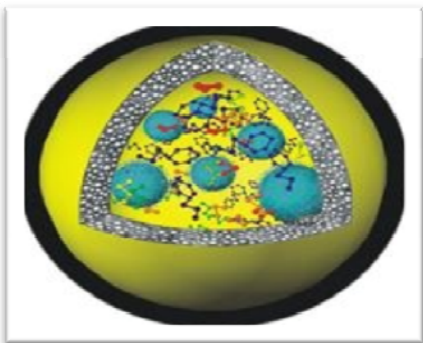
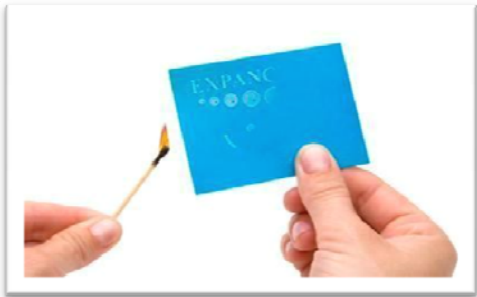
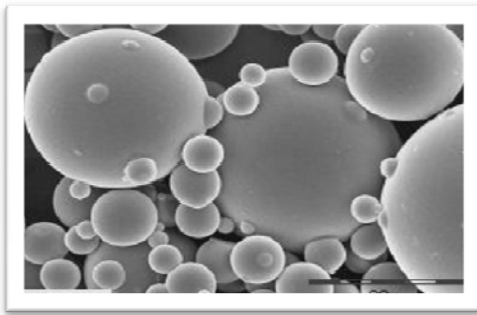
## Costs Associated with Technology

Major costs/risks

- **Key raw materials**
- Additional materials
- Cost of manufacturing
- **Regulatory cost**
- Certification cost & quality control
- Scale of production
- IP costs
- Human resources cost
- Capital expenditure

## IP Status

- ▶ IN 190819
- ▶ IN 167769
- ▶ IN 184975
- ▶ IN 185387
- ▶ US 5814675
- ▶ US 5859075
- ▶ US 5962003
- ▶ US 2006/02546144 A1
- ▶ US 2006/0251688 A1
- ▶ US 2007/0053950 A1



# Microcapsules and Microspheres



# ARESTIN

Microcapsules



## Use

- ▶ Administered antibiotic used for the treatment of chronic periodontitis

## Mechanism

- ▶ Through polymer hydrolysis, the microspheres release the encapsulated antibiotic over a time span

## Key Engineering Parameters

- ▶ Encapsulated in a bioresorbable polymer
  - Poly (glycolide-co-dl-lactide)
- ▶ Rate of drug release 21 days

## Price

- ▶ Arestin- Rs 1455/mg

## Market Segments

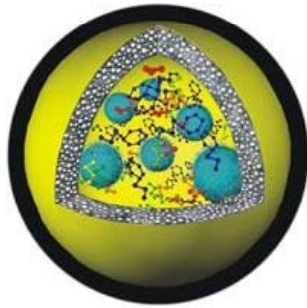
- ▶ Healthcare

## Repr. Manufacturers

- ▶ Foreign
  - ▶ OraPharma, Inc

Source: <http://www.arestin.com/>  
[http://www.arestin.com/docs/R6\\_promo\\_PI\\_03-27-08.pdf](http://www.arestin.com/docs/R6_promo_PI_03-27-08.pdf)  
<http://www.dentalcompare.com/details/6335/ARESTIN.html>

# Flavor Changing Additives



## Use

- ▶ Encapsulate multiple ingredients in the same carrier system & release them, one after the other

## Mechanism

- ▶ Microspheres with nanospheres encapsulated in water/pH-sensitive coating release the active agent in a consecutive manner under desired circumstances

## Key Engineering Parameters

- ▶ Size of microspheres: 10 - 300 microns

## Price

## Market Segments

- ▶ Diagnostics- delivery of antibodies to target sites
- ▶ Personal care- creams, lip balms, shampoo, spray
- ▶ Food – soups, confectionary items, processed meats, dessert mixes

## Repr. Manufacturers

- ▶ Foreign
  - ▶ Salvona Technologies

**Source:** <https://www.inventables.com/technologies/flavor-changing-additives>

Patent- [7,067,152](#) Multi component moisture triggered controlled release system that imparts long lasting cooling sensation on the target site and/or provides high impact fragrance or flavor burst

<http://salvona.com/MultiSal>

# Microencapsulated Ibuprofen



## Use

- ▶ Up to 12 hr sustained release of Ibuprofen

## Mechanism

- ▶ Immediate burst of Ibuprofen, thereafter sustained release of drug up to 12 hrs.

## Key Engineering Parameters

- ▶ Ibuprofen range 300-800 mg/tablet
- ▶ Materials used-Polyethylene oxide, hydroxypropyl methylcellulose (HPMC)
- ▶ HPMC viscosity- 100cps

## Price

## Market Segments

- ▶ Analgesic- estimated market sales \$8b
- ▶ Anti-inflammatory
- ▶ Anti-pyretic

## Repr. Manufacturers

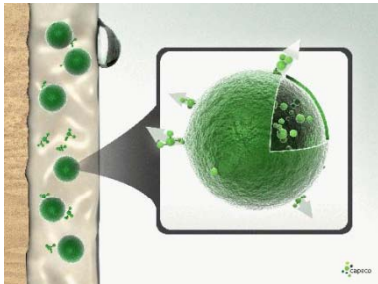
- ▶ Foreign
  - ▶ SCOLR Pharma Inc

Source: <http://www.scolr.com/pharmaceuticals.php>

Modified release ibuprofen dosage form - US 20070077297

<http://www.scolr.com/documents/CRS2005Ibuprofen-final.pdf>

# Paints



## Use

- ▶ Marine antifouling coatings and paints

## Mechanism

- ▶ Biocide is released to the surface of marine coating in presence of water especially salt water.

## Key Engineering Parameters

- ▶ Active agent-Isothiazolone concentration- 0.25mg/100 mg
- ▶ Materials used for encapsulation- Polyvinyl acetate, Urea-resourcinol formaldehyde

## Price

## Market Segments

- ▶ Ships

## Repr. Manufacturers

- ▶ Foreign
  - ▶ **Rohm and Haas Company**
  - ▶ Microtek Laboratories Inc

**Source:** Blends of encapsulated biocides US 7377968

[http://www.rohmdhaas.com/wcm/products/product\\_detail.page?product=1010157](http://www.rohmdhaas.com/wcm/products/product_detail.page?product=1010157)

<http://www.microteklabs.com/paintcoat.html>

# Rub-n-Sniff

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## Use

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- ▶ Fragrance sampling devices

## Mechanism

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- ▶ Gentle rubbing on the skin ruptures microcapsules and releases an effective amount of fragrance

## Key Engineering Parameters

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- ▶ Size of microspheres: 5 - 100 microns
- ▶ Materials used: Gelatin, Cellulose

## Price

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## Market Segments

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- ▶ Perfume samplers
- ▶ Samplers in newspapers, advertising

## Repr. Manufacturers

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- ▶ Foreign
  - ▶ Arcade, Inc.
  - ▶ **Ronald T. Dodge Company**
  - ▶ Sentisphere

# Washing Agents



## Use

- ▶ Detergents, dishwash powders & bars

## Mechanism

- ▶ Microcapsules dissolve upon contact with water and release the microparticles at the site of use.

## Key Engineering Parameters

- ▶ Size of microspheres: 200 micron

## Price

- ▶ Ariel: Rs 99/Kg

## Market Segments

- ▶ Fabric care
- ▶ Utensil cleaning

## Repr. Manufacturers

- ▶ Foreign
  - ▶ **Henkel India**
  - ▶ Procter & Gamble

**Source:** Washing and cleaning agents comprising fine microparticles with cleaning agent components **US 7,601,678**

[http://www.henkelindia.com/cps/rde/xchg/henkel\\_inh/hs.xsl/laundry844.htm?iname=Henko&countryCode=in&BU=detergents&parentredDotUID=000000QTQF&redDotUID=000000QTQF&brand=000000QTQG&param1=history](http://www.henkelindia.com/cps/rde/xchg/henkel_inh/hs.xsl/laundry844.htm?iname=Henko&countryCode=in&BU=detergents&parentredDotUID=000000QTQF&redDotUID=000000QTQF&brand=000000QTQG&param1=history)  
<http://www.pg-india.com/hp/ariel2.htm>

# Moisture Activated Micro-Capsules

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## Use

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- ▶ Aromatherapy products, soaps, deodorizers, anti fungal & anti-bacterial agents, flavour additives

## Mechanism

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- ▶ Microspheres will dissolve and release the active agent upon contact with moisture

## Key Engineering Parameters

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- ▶ Thermal stability up to 140°C at a low pH

## Price

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- ▶ Clinique soap bar- Rs 42/gm

## Market Segments

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- ▶ Food additives industry
- ▶ Cosmetics
- ▶ Consumer goods
- ▶ Confectionary items

## Repr. Manufacturers

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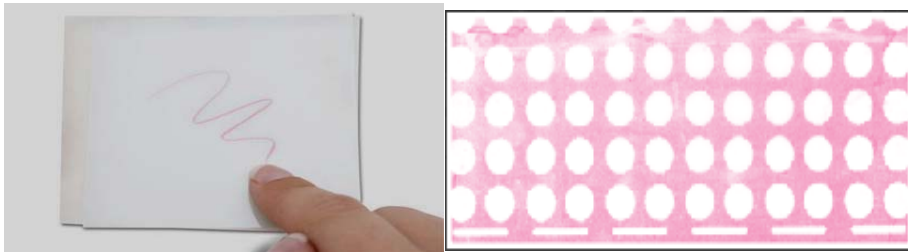
- ▶ Foreign
  - ▶ Salvona Technologies

**Source:** <https://www.inventables.com/technologies/moisture-activated-micro-capsules>

Patent no 20040175404 10/122,549

<http://www.salvona.com/SalSeal>

# Pressure Sensor Film



## Use

- ▶ To look for gaps and leaks, seals and joints

## Mechanism

- ▶ Embedded microcapsules filled with ink will burst under pressure when inserted between two mating parts pinpointing the pressure applied

## Key Engineering Parameters

- ▶ Pressure ranges from 2-43,200 PSI
- ▶ Load bearing ranges from 0.14-3000kg/cm<sup>2</sup>

## Price

- ▶ Pressurex Micro Zero- Rs 716/pc (17"\*11.25")

## Market Segments

- ▶ Sensors
- ▶ Printing industry
- ▶ Packaging industry
- ▶ Automotive industry

## Repr. Manufacturers

- ▶ Foreign
  - ▶ Sensor Products Inc

Source: <https://www.inventables.com/technologies/pressure-sensor-film>  
<http://www.sensorprod.com/pressurex.php>



# Penncap-M<sup>®</sup> (Methyl parathion)

Microcapsules

## Use

- ▶ Preventing, destroying, repelling or mitigating insects

## Mechanism

- ▶ Water suspension of polymeric microencapsules containing methyl parathion is spread by air-blast or boom spraying method.

## Key Engineering Parameters

- ▶ Use rates: 1 - 8 pints/ acre
  - ▶ 24 pints/ year

## Price

- ▶ Penncap-M: ~Rs. 340/liter

## Markets Segment

- ▶ Controlled release insecticide

## Repr. Manufacturers

- ▶ Foreign
  - ▶ United phosphorus, inc

Source: <http://www.upi-usa.com/>  
<http://www.campbellchemicals.com.au/label/PenncapM-PM.pdf>

# KNOX-OUT 2FM (diazinon)

Microcapsules

## Use

- ▶ House hold pest control

## Mechanism

- ▶ A water suspension of microcapsules containing diazinon is formed
- ▶ Microcapsules adhere to the body of insect and release insecticide creating a microenvironment of insecticide around the insect

## Key Engineering Parameters

- ▶ 100 ml for 5 liter/ 100 m<sup>2</sup> area



## Price

## Markets Segment

- ▶ Insecticides for cockroaches, ants, fleas

## Repr. Manufacturers

- ▶ Foreign
  - ▶ Pennwalt Corporation
  - ▶ Astra Industrial Complex co. Ltd.

Source: <http://www.astra-agri.com.sa/products.htm>



## Use

- ▶ To control cane grubs

## Mechanism

- ▶ Broadcast at the depth of 5-10 cm below ground level.
- ▶ Sustained release of pesticide from the granules

## Key Engineering Parameters

- ▶ Pesticide release time: 3 years

## Price

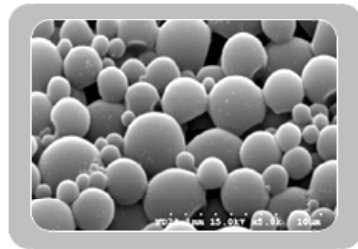
- ▶ Suscon blue: ~Rs 620 / kg

## Markets Segment

- ▶ Pests control for sugarcane

## Repr. Manufacturers

- ▶ Foreign
  - ▶ Crop Care Australia



[ MICROCAPSULE ]

### Use

- ▶ Controlled release of aroma

### Mechanism

- ▶ Microcapsules contain aroma
- ▶ Microcapsules in the form of slurry or powder is mixed in the final form of product during processing.

### Key Engineering Parameters

- ▶ Diameter: 2 – 3 microns
- ▶ pH:  $8 \pm 1$  (adjustable)
- ▶ Aroma retention period: 2-3 years

### Price

### Markets Segment

- ▶ Fabrics
- ▶ Papers
- ▶ Plastics
- ▶ Paints

### Repr. Manufacturers

- ▶ Foreign
  - ▶ J&C Microchem Korea

Source: <http://www.tradekorea.com/product-detail/P00105159/Aromacap.html>



### Use

- ▶ Protection against mosquitoes, ticks, biting flies, chiggers, gnats, fleas and deer flies

### Mechanism

- ▶ DEET in the product blinds the insects senses for biting.
- ▶ Controlled release of DEET over long time span gives protection against mosquitoes, ticks

### Key Engineering Parameters

- ▶ Duration of release: 12 hrs

### Price

- ▶ Rs 343 /100 grams

### Markets Segment

- ▶ Military purposes
- ▶ Outdoor applications

### Repr. Manufacturers

- ▶ Foreign
  - ▶ 3M



### Use

- ▶ Carry hydrophilic fragrances

### Mechanism

- ▶ The beads form a dry free-flowing powder that liquefies upon gentle rubbing

### Key Engineering Parameters

- ▶ Diameter: 20-200 microns

### Price

### Markets Segment

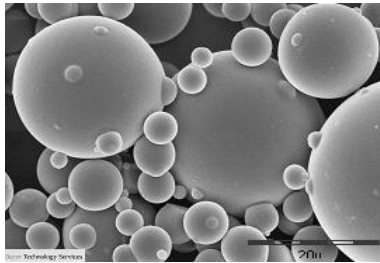
- ▶ Personal care products

### Repr. Manufacturers

- ▶ Foreign
  - ▶ Aveka group

# PU Microspheres for Cosmetic Formulations

Microspheres



## Use

- ▶ Filler for leave-on and rinse-off products
- ▶ Powdery, velvety finish on skin
- ▶ High oil absorption capacity.

## Mechanism

- ▶ Gives dry and non-tacky tactile effect
- ▶ Helps to improve even color distribution on skin

## Key Engineering Parameters

- ▶ Refractive index: 1.52
- ▶ Density: 0.36 g/cubic cm
- ▶ Oil absorption: 100 gm oil/ 100 gm of powder

## Price

## Market Segment

- ▶ Cosmetic formulation

## Repr. Manufacturers

- ▶ Foreign
  - ▶ Bayer materials science AG

# Microspheres for embolization of blood vessel

## Microspheres



**Embolization:** The process of blocking blood vessel by purposely incorporating external object

## Use

- ▶ To reduce or block the blood supply to a tumor

## Key Engineering Parameters

- ▶ Particle size
- ▶ Microspheres should not form agglomeration

## Price

## Mechanism

- ▶ Microspheres are delivered at site using microcatheters
- ▶ Microspheres can be tracked by fluoroscopy, NMR, computerized tomography and ultrasound.

## Markets Segment

- ▶ Healthcare

## Repr. Manufacturers

- ▶ Foreign
  - ▶ CelNova Biosciences
  - ▶ Boston scientific
  - ▶ Cook medical



# Expanding Ink

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## Use

---

- ▶ Wall papers, textiles, papers, boards

## Mechanism

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- ▶ Microspheres encapsulate liquid hydrocarbon. Upon heating the shell expands and the liquid turns into a gas revealing the message

## Key Engineering Parameters

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- ▶ Blend ratio: 0.5% - 10% by weight

## Price

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- ▶ Dry unexpanded spheres ~ Rs 798/kilo
- ▶ Expanded spheres ~Rs1361/kilo.

## Market Segments

---

- ▶ Printing industry

## Repr. Manufacturers

---

- ▶ Foreign
  - ▶ Hughes Processing, INC (Costa Mesa, CA)
  - ▶ Jet Plastics, Inc. (Los Angeles, CA)

# Paper Cup

---



## Use

---

- ▶ Improves the heat insulation of the cup

## Mechanism

---

- ▶ Adding unexpanded microspheres to paper and board increases the bulk and gives a dramatic increase in bending stiffness of the board.

## Key Engineering Parameters

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- ▶ Microsphere content: 40–44%
- ▶ Density: 1000–1100 kg/m<sup>3</sup>

## Price

---

## Market Segments

---

- ▶ Paper Industry
- ▶ Consumer goods

## Repr. Manufacturers

---

- ▶ Foreign
  - ▶ Akzo Nobel

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Source: [http://www.expancel.com/All\\_languages/about/files/EXPGEN002EN\\_Expancel%C2%AEMagic.pdf](http://www.expancel.com/All_languages/about/files/EXPGEN002EN_Expancel%C2%AEMagic.pdf)

# Soft Touch Paper

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## Use

---

- ▶ Apply on file folders, pizza boxes
- ▶ Used on - Perfume bottle box – JLo & Wilson's Leather brochure

## Mechanism

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- ▶ Air filled microspheres applied on top of the paper give a soft touch and a non-slip action.

## Key Engineering Parameters

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## Price

---

## Market Segments

---

- ▶ Printing industry
- ▶ Stationary items

## Repr. Manufacturers

---

# Cultured Marble

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## Use

---

- ▶ Counter tops, wash basins and bath tubs

## Mechanism

---

- ▶ Microspheres lower the weight, improve thermal shock resistance and make after treatment drilling easier

## Key Engineering Parameters

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- ▶ Density: 25–70 kg/m<sup>3</sup>

## Price

---

## Market Segments

---

- ▶ Construction industry

## Repr. Manufacturers

---

- ▶ Foreign
  - ▶ The Onyx collection, USA
  - ▶ Sunrise International Company, US
  - ▶ **Akzo Nobel**
- ▶ Indian
  - ▶ Mahesh India, Mumbai

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**Source:** [http://www.potterseurope.org/documents/Q-Cel\\_Hollow\\_Microspheres\\_in\\_Cultured\\_Marble\\_Applications.pdf](http://www.potterseurope.org/documents/Q-Cel_Hollow_Microspheres_in_Cultured_Marble_Applications.pdf)  
<http://www.onyxcollection.com/>  
<http://www.culturedmarblemolds.com/>  
[http://culturedmarbleusa.com/index.php?option=com\\_frontpage&Itemid=1](http://culturedmarbleusa.com/index.php?option=com_frontpage&Itemid=1)

# Injection Moulded Products

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## Use

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- ▶ Injection moulding products like wine stoppers, shoulder pads.

## Mechanism

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- ▶ Microspheres create double foam with microcellular polyurethanes, resulting in products with low weight and high elasticity

## Key Engineering Parameters

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- ▶ Bulk Density: 400–480 kg/m<sup>3</sup>

## Price

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## Market Segments

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- ▶ Footwear industry
- ▶ Kitchenware
- ▶ Bottling industry

## Repr. Manufacturers

---

- ▶ Foreign
  - ▶ Akzo Nobel
- ▶ Indian
  - ▶ Mahesh India

# Cable Filling Compound

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## Use

---

- ▶ Fills the voids between the conductors of a cable

## Mechanism

---

- ▶ Microspheres lower the volume contraction at cooling and eliminate water penetration

## Key Engineering Parameters

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- ▶ Density: 25–70 kg/m<sup>3</sup>

## Price

---

## Market Segments

---

- ▶ Communication cables

## Repr. Manufacturers

---

- ▶ Foreign
  - ▶ Akzo Nobel

# Polyester Putties



## Use

- ▶ Fills pinholes, sand scratches

## Mechanism

- ▶ Improves the sandability of the putty that gives it a creamy consistency that makes it easier to apply.

## Key Engineering Parameters

- ▶ Density reduction:  $1800 \text{ kg/m}^3$  to  $1100 \text{ kg/m}^3$

## Price

## Market Segments

- ▶ Automotive industry

## Repr. Manufacturers

- ▶ Foreign
  - ▶ **Akzo Nobel**
  - ▶ 3M Premium Polyester Finishing Putty
- ▶ Indian
  - ▶ Hero paints private limited
  - ▶ S.R. Marketing
  - ▶ G.K.I Industries

Source: <http://www.gkionline.com/contact.htm>

<http://www.3m.com/Product/information/Polyester-Finishing-Putty.html>

<http://www.gkionline.com/putty.htm>

<http://www.easybond.co.in/polyester-car-putty.htm>

[http://heropaints.tradeindia.com/Exporters\\_Suppliers/Exporter11422.157530/Polyester-putty-.html](http://heropaints.tradeindia.com/Exporters_Suppliers/Exporter11422.157530/Polyester-putty-.html)