



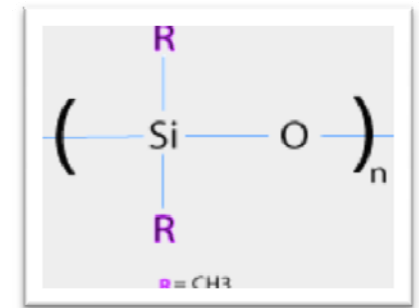
# Silicones

# Background for Silicones

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## ▶ Silicones

- ▶ Silicones are polymers that include silicon together with oxygen, carbon and hydrogen
- ▶ Available in liquid, gel, rubber and hard plastic form.
- ▶ Silicones are inert, heat-resistant and non-stick material
- ▶ Organic groups like methyl, ethyl or phenyl are attached to the silicon atom.
- ▶ Can be tailored to find wide variety of applications as sealants, adhesives and heat resistant tiles of space shuttles.



# Scientist

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## **Dr. P. P. Wadgaonkar**

Scientist, Polymer Science & Engineering Division

### **Areas of interest :**

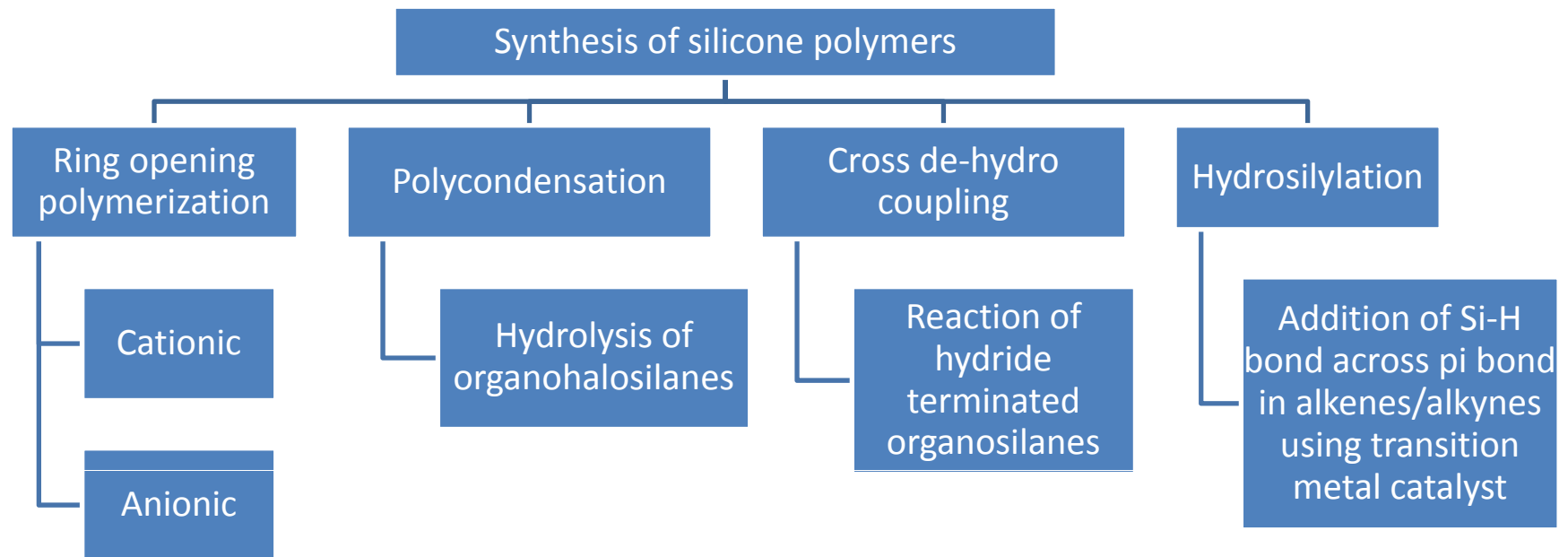
- ▶ New monomer synthesis
- ▶ Polymer additives
- ▶ Controlled polymerization methods

**Web:** <http://www.ncl-india.org/people/showframe.jsp?personid=72>

# NCL Competencies

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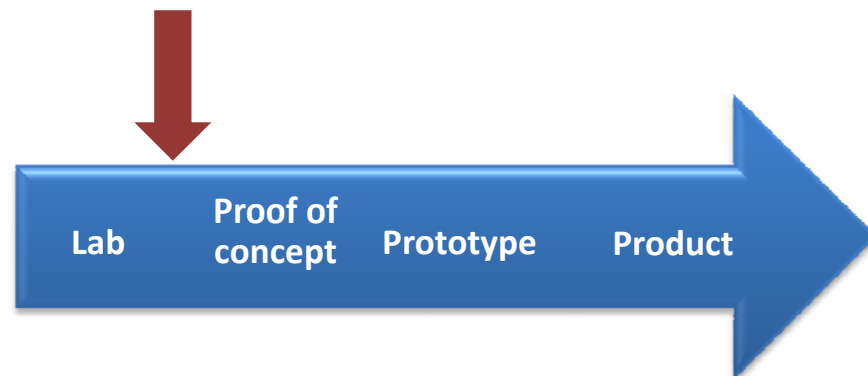
- ▶ Chemistry
- ▶ Modification
- ▶ Application (incl. rheology, coloring, etc.)



## Representative Markets

Healthcare	
Automotive	
Construction	
Agriculture	
Entertainment	
Infrastructure	
Personal care	
Industrial	
Water	

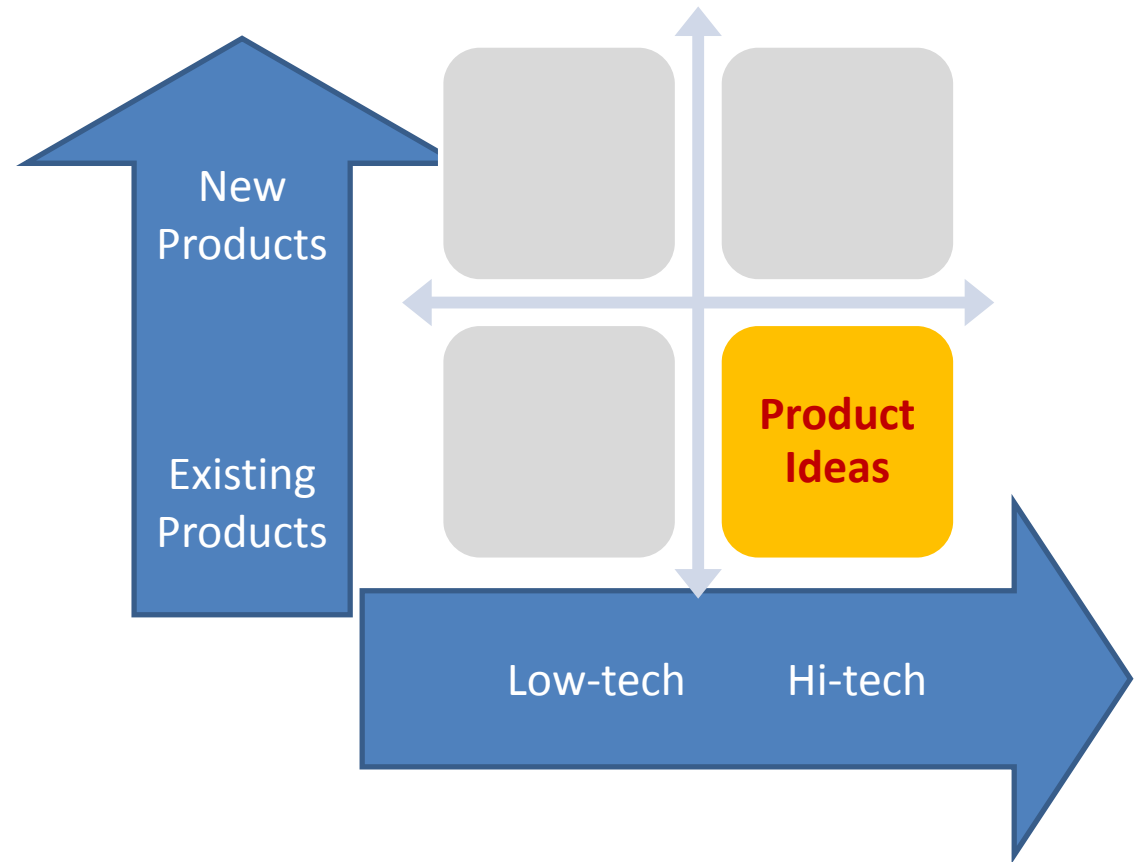
## Technology Status



## 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



# Silicones

# Hair Care

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## Use

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- ▶ Hair care products

## Mechanism

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- ▶ The serum forms a film on the hair improving hair feel, lubricity making it easy to comb.

## Key Engineering Parameters

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- ▶ Emulsifier: non ionic
- ▶ Amount of silicone present in products 2-22%

## Price

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- ▶ John Frieda frizz ease hair serum- Rs 470/50ml

## Market Segments

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- ▶ Indian shampoo market- Rs 1100 cr
- ▶ Shampoo, conditioners, hair serums, creams

## Manufacturers/Distributors

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- ▶ Foreign
  - ▶ Lakme Hair serum
  - ▶ Pantene Pro V
  - ▶ **Tresemme silk serum**
  - ▶ John Frieda frizz ease hair serum

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**Source:** <http://www.tresemme.com.au/product.aspx?id=no-frizz-serum>  
[http://www.johnfrieda.com/products/product\\_detail.asp?productLine=frizz\\_ease&pid=52](http://www.johnfrieda.com/products/product_detail.asp?productLine=frizz_ease&pid=52)  
<http://www1.dowcorning.com/DataFiles/090007c8800c8434.pdf>

# Silicone Hydrogel Soft Contact Lens

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## Use

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- ▶ Extended eye-wear

## Mechanism

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- ▶ Silicone lenses transmit more oxygen to eyes and are not prone to dehydration during use.

## Key Engineering Parameters

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- ▶ Allows up to 6 times more oxygen to pass
- ▶ Less drying of the lenses
- ▶ Lower risk of eye infection
- ▶ Blocks UV

## Price

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- ▶ Ciba Focus Night & Day- Rs 2061/ pack

## Market Segments

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- ▶ Disposable contact lens market- Rs 120 cr
- ▶ 17 million users of vision correction aids & only 5 % use lenses

## Repr. Manufacturers

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- ▶ Foreign
  - ▶ **Ciba Focus Night & Day** (30days)
  - ▶ Bausch & Lomb's PureVision (30 days)
  - ▶ Vistakon Acuvue Advance

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Source: [http://www.us.cibavision.com/lenses/night\\_and\\_day.shtml](http://www.us.cibavision.com/lenses/night_and_day.shtml)

<http://www.acuvue.co.in/contact-lenses-products/acuvue-oasys-contacts.html>

<http://www.allaboutvision.com/contacts/silicone-hydrogel.htm#you>

<http://www.thehindubusinessline.com/2008/06/28/stories/2008062851290500.htm>



# Rubber Glass

## Use



- ▶ For special effects, display applications and packaging

## Mechanism

- ▶ When shattered it simulates broken glass and ice

## Key Engineering Parameters

- ▶ Weight: 28.6 CU.IN/LB
- ▶ Mixed viscosity: 1200 cps
- ▶ Pot Life: 120 mins
- ▶ Demold time: 16 hrs

## Price

- ▶ Silicone glass: Rs 4439/kg

## Market Segments

- ▶ Entertainment industry

## Repr. Manufacturers

- ▶ Foreign
  - ▶ **Smooth-on**
  - ▶ Breakaway glass .inc
  - ▶ Action Props, Inc

**Source:** [http://www.smooth-on.com/Silicone-Rubber-an/c2\\_1113\\_1138/index.html](http://www.smooth-on.com/Silicone-Rubber-an/c2_1113_1138/index.html)  
<http://www.alfonsosbreakawayglass.com/index.php>  
<http://www.actionprops.com/page/page/1866812.htm>

# Silicone Medical Adhesive Remover

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## Use

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- ▶ Releases adhesive dressings and tapes in seconds

## Mechanism

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- ▶ Fluid will track between the adhesive & the skin, creating a layer of silicone, which is a release agent, so the adhesive falls away from the skin.

## Key Engineering Parameters

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- ▶ Melting Point less than  $-20^{\circ}\text{C}$
- ▶ Vapour pressure 5600 psia for siloxane

## Price

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- ▶ Niltac aerosol- Rs 1550 (50 ml)

## Market Segments

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- ▶ Healthcare

## Repr. Manufacturers

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- ▶ Foreign
  - ▶ Trio healthcare

Source: <http://www.ttwmedical.com/products/Niltac>  
[http://www.niltac.com/website/sting\\_free\\_medical\\_adhesive\\_remover.html](http://www.niltac.com/website/sting_free_medical_adhesive_remover.html)

# Leak-proof Silicone Dispenser

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## Use

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- ▶ Silicone valves in dispensers

## Mechanism

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- ▶ Silicone acts as an integral seal and does not let the liquid through unless the bottle is squeezed

## Key Engineering Parameters

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- ▶ Silicone to meet FDA and USP class VI criteria

## Price

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- ▶ Magellans Rs 921/pc
- ▶ Traex Flowcut squeeze dispenser: Rs 1746/pc

## Market Segments

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- ▶ Travelling
- ▶ Bottles for athletes

## Repr. Manufacturers

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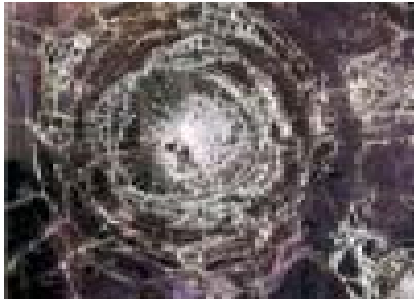
- ▶ Foreign
  - ▶ Norpro squeeze bottle with silicone spout
  - ▶ **Magellans**
  - ▶ Traex Flowcut squeeze dispenser

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Source: <http://www.thefind.com/search?query=silicone+squeeze+bottle+dispenser>  
<https://www.inventables.com/technologies/silicone-dispenser>

# Silicone Structural Sealant

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## Use

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- ▶ Structural glazing

## Mechanism

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- ▶ Sealant absorbs energy allowing the window frame to bend and twist & adhering the broken glass to the film.

## Key Engineering Parameters

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- ▶ Tensile adhesion strength -150 psi,
- ▶ Tear strength of 49 ppi
- ▶ Movement capability +/-50

## Price

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## Market Segments

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- ▶ Construction industry

## Repr. Manufacturers

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- ▶ Foreign
  - ▶ Dow corning

Source: <http://www.dowcorning.com/content/publishedlit/62-780-01.pdf>

# Silicones for High Beam LEDs

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## Use

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- ▶ Seals and protects LEDs

## Mechanism

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- ▶ As encapsulants and lenses in a variety of LED device designs

## Key Engineering Parameters

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- ▶ High transparency in UV-visible region
- ▶ Stable transmission in the visible region (400-800 nm) when exposed to a temperature of 200°C over seven days
- ▶ Thermal stability from -45 to >260°C

## Price

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## Market Segments

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- ▶ Automobiles
- ▶ Lights
- ▶ Cell phones

## Repr. Manufacturers

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- ▶ Foreign
  - ▶ Dow Corning

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**Source:** <http://www.ledsmagazine.com/features/3/3/1>

<http://www.dowcorning.com/applications/search/products/Details.aspx?prod=04044025&type=PROD>

<http://www3.dowcorning.com/DataFiles/090007b28109f3df.pdf>

[http://www.dowcorning.com/content/etronics/etronicsled/etronics\\_led\\_tutorial2.asp?DCWS=Electronics&DCWSS=](http://www.dowcorning.com/content/etronics/etronicsled/etronics_led_tutorial2.asp?DCWS=Electronics&DCWSS=)

# Silly Putty



## Use

- ▶ Toy, rehabilitative therapy for hand injuries & stress reduction
- ▶ Astronauts secure tools at zero gravity

## Mechanism

- ▶ Unusual flow characteristics due to Polydimethylsiloxane, a viscoelastic liquid.

## Key Engineering Parameters

- ▶ Specific gravity is 1.14
- ▶ Flows under low stress
- ▶ Breaks under high stress

## Price

- ▶ Silly Putty Rs 3/gm
- ▶ Funrise silly putty- Rs 188

## Market Segments

- ▶ Entertainment industry
- ▶ Toys
- ▶ Healthcare

## Repr. Manufacturers

- ▶ Foreign
  - ▶ **Crayola Inc** (Silly Putty)
  - ▶ SportsHealth (Power Putty)
  - ▶ Funrise Toy Corp

**Source:** <http://www.crayola.com/crafts/detail/silly,-slippery-letters-craft/>  
<http://www.healthiestuff.com/powerputty/index.shtml>

<http://www.powerputty.com/retail.htm>  
[http://www.sillyputty.com/silly\\_science/science\\_faqs.htm](http://www.sillyputty.com/silly_science/science_faqs.htm)

# Silicone Prosthetics

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## Use

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- ▶ Prosthetics – eyes, ears, fingers, nose, face masks, special effects

## Mechanism

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- ▶ Silicones are engineered to produce natural skin like finished products & are inert, hence not rejected by the body

## Key Engineering Parameters

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## Price

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- ▶ Partial hand: Rs 16,965
- ▶ Finger: Rs 1,615
- ▶ Foot: Rs 21,680

## Market Segments

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- ▶ Healthcare
- ▶ Entertainment industry

## Repr. Manufacturers

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- ▶ Foreign
  - ▶ Medical Art Resources Inc, USA
  - ▶ Anaplastics, USA
  - ▶ Hybrid, UK
- ▶ Indian
  - ▶ Technomed India pvt ltd, New Delhi

# Prosthetic Silicone Formulations



## Type A Medical Adhesive-

bonding silicone elastomers to one another, as well as to some synthetics and metals



## Prosthetic Silicone

**Elastomer-** Two component room temperature curing system for manufacturing prosthetics



## Ocular Silicone Lubricant-

lubricates prosthesis reducing discomfort, irritation and external discharge from the eye socket

## Price

Type A Medical Adhesive- Rs 1444/50gm

Prosthetic Silicone Elastomer- Rs 3120

Ocular Silicone Lubricant- Rs 789/14gms

## Repr. Manufacturers

- ▶ Foreign
  - ▶ Factor II



# A Template for Skin Regeneration

SILICONES

## Use

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- ▶ Skin regeneration

## Mechanism

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- ▶ Dermal layer of skin is replaced with bovine collagen matrix
- ▶ Silicone layer helps to control moisture loss from wound
- ▶ After adequate vascularization silicone patch is replaced with epidermal autograft.

## Key Engineering Parameters

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## Price

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- ▶ Integra: ~ Rs. 180 cm<sup>2</sup>

## Market Segment

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- ▶ Burn treatment

## Repr. Manufacturers

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- ▶ Foreign
  - ▶ Integra LifeSciences Corporation



## Use

- ▶ Short term tamponade for re-attachment of the retina

## Mechanism

- ▶ Filling of the eye with liquid silicone to hold the retina in place
- ▶ Silicone oil is removed after few months

## Key Engineering Parameters

- ▶ Viscosity : 5.000-5900 mPas
- ▶ Refractive index : 1.40
- ▶ Specific Gravity : 0.97 g/cm<sup>3</sup> at 25°C
- ▶ Surface tension : 21 mN/m against air
- ▶ Interfacial tension : 40 mN/m against water

## Price

- ▶ Sil-5000:Rs 2300 – 3800 / 10 ml.

## Market Segment

- ▶ Ophthalmic care

## Repr. Manufacturers

- ▶ Foreign
  - ▶ Dutch Ophthalmic Research Center International BV

# Silicone Gel for Personal Care and Cosmetic Applications

SILICONES



## Use

- ▶ Skin and sun care
- ▶ Shine/oil control facial products
- ▶ Color cosmetics (foundations, etc)
- ▶ Hair styling (cuticle coats, gels, etc.)

## Mechanism

- ▶ Acts as a sensory enhancement agent when added in cosmetic applications.

## Key Engineering Parameters

- ▶ Particle size: 10 – 100 microns
- ▶ Viscosity: 200,000 to 350,000 cP at 25°C

## Price

## Market Segment

- ▶ Cosmetics and personal care

## Repr. Manufacturers

- ▶ Foreign
  - ▶ GE silicones

## Use

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- ▶ Fabrication of healthcare and medical devices, including less than 30 day implantation

## Mechanism

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- ▶ Platinum catalyzed two component system
- ▶ Suitable for liquid injection molding

## Key Engineering Parameters

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- ▶ Viscosity: 110 000 cP
- ▶ Extrusion rate: 270 g/min
- ▶ Tensile strength: 5.1 N/sq. m
- ▶ Hardness: 5 to 25 shore A

## Price

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## Market Segment

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- ▶ Medical devices
- ▶ Liners

## Repr. Manufacturers

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- ▶ Foreign
  - ▶ Bluestar silicones
  - ▶ Dow corning



Muffing pan



Batting brush



Anti-skid mat



Silicone spatula

## Use

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- ▶ Non-stick
- ▶ Stable at temperatures up to 450°C

## Price

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## Market Segment

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- ▶ Kitchenware

## Repr. Manufacturers

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- ▶ Foreign
  - ▶ Le Creuset