YOCELL

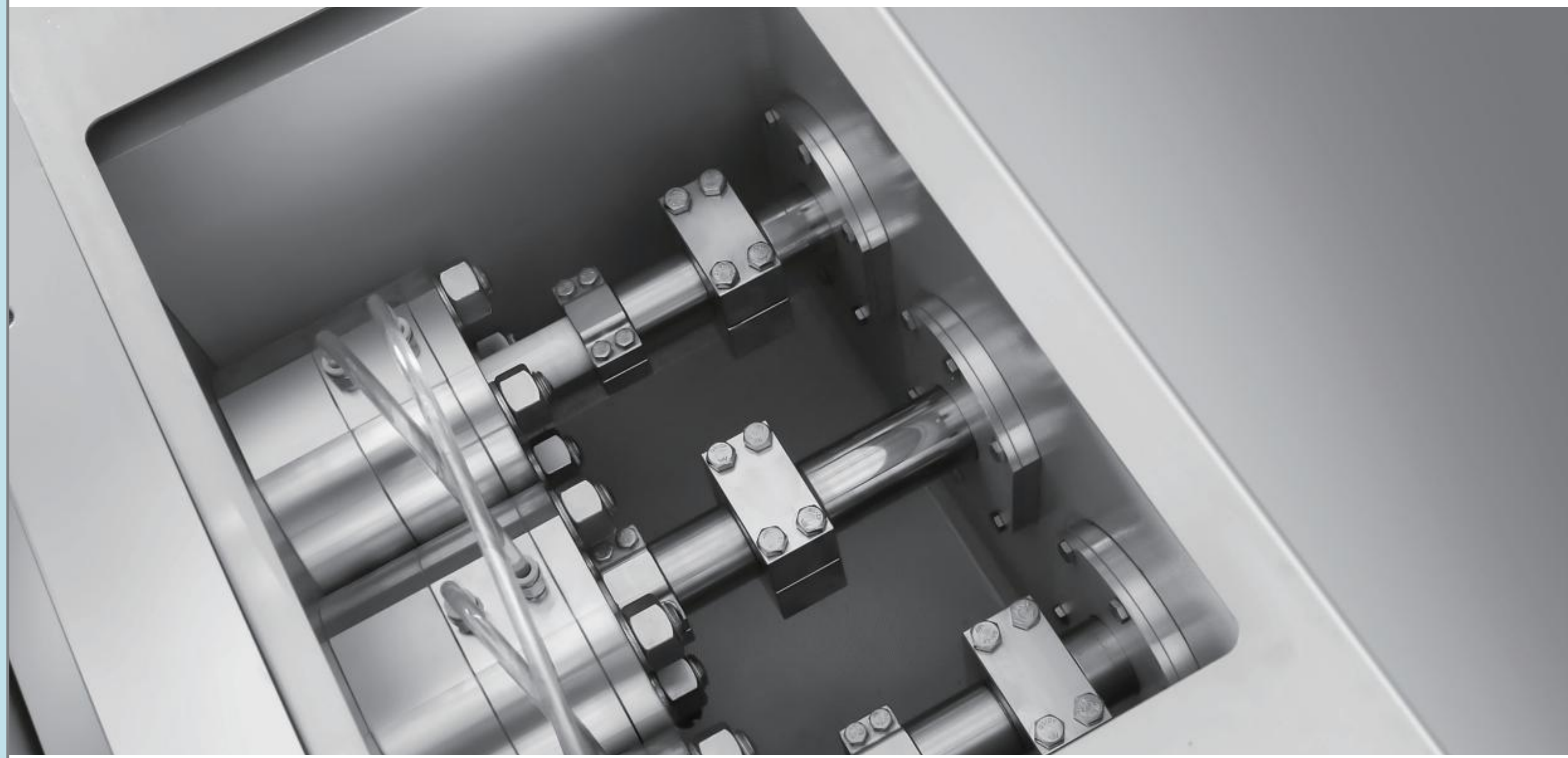
Add.: No. 176 Jufeng Road, 266199, Qingdao, China

Tel.: +86 532 80920900

Email: info@yocellbio.com

Web: www.yocellbio.com

YOCELL



High Pressure Homogenizer

homogenisation / emulsif ication / crushing / dispersion

www.yocellbio.com

About us

YOCELL Biotechnology is your trusted partner in the □eld of bioprocess.

YOCELL has a team of energetic young scientists and engineers. From initial R&D to production, we are committed to providing the most reliable solutions for biotechnology scientists and engineers around the world. Accepting the challenges of continuous innovation in biotechnology and solving problems from multiple perspectives are the most impressive qualities of the team.

Pragmatic

Always listen carefully to your needs and provide the most competitive solutions.

E□cient

Respond quickly and have a strong supply chain to ensure fast delivery.

Focus

Continuous attention and passion for innovation in the □eld of biotechnology control.

Contents

High Pressure Homogenization

Introduction

- High pressure homogenizers are mainly used in the biological, pharmaceutical, food and chemical industries for cell crushing, beverage homogenization, □ne chemicals, preparation of liposomes, fat emulsions, nano-mixes, microemulsions, lipid microspheres, emulsions, dairy products, I.V. □uids, dyes, solar panel coatings and conductive coatings, etc. High e□ciency with built-in heat exchange system to meet various requirements for di□erent conditions.

Working Principles

- Under the reciprocating motion of the plunger, the material is transported to a valve group with adjustable size, and is subjected to extremely strong compression. When passing through the current limiting slit, the material hits the valve at a very fast speed, resulting in cavitation e□ect, impact e□ect and shear e□ect, so that the aggregated material is evenly dispersed.

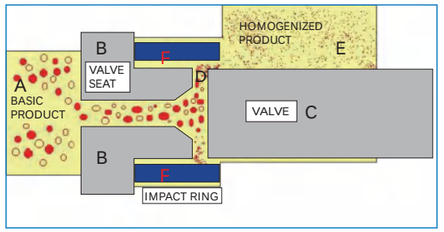


Fig.1
- The working principle of the high pressure homogeniser

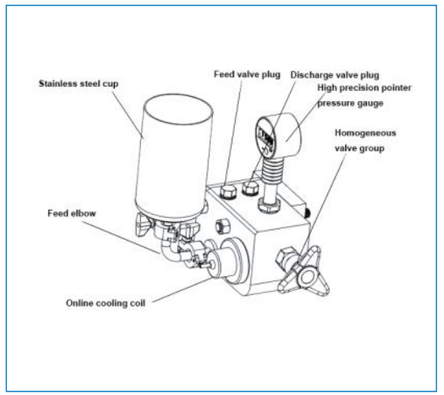


Fig.2
- Homogenising module construction diagram

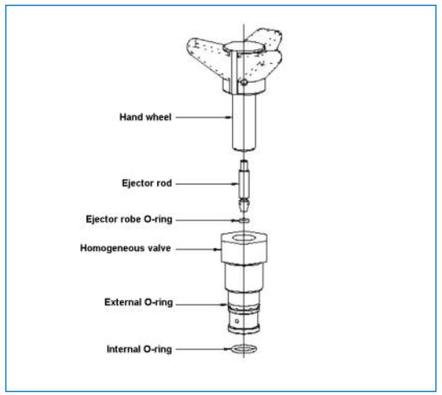


Fig.3
- Diagram of the homogenising valve

Yocell Homogenizers Series: A Complete Range For Any Needs

Laboratory, Pilot and Production

- From the initial concept, through to pilot tests and □nal analysis: we do our best to help you □nd the most suitable formulation with the shortest development time and maximum safety of results.

Laboratory Type YC-BASIC series

- Flowrate: 10-30 L/h
- Minimum throughtput: 15-50ml

Pilot Type YC-PILOT series

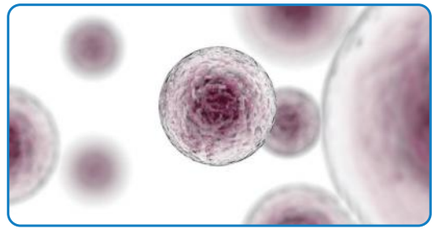
- Flowrate: 30-100 L/h
- Minimum throughtput: 50ml

Production Type YC-100/150 series

- Flowrate: 120-2000 L/h
- Minimum throughtput: 2-3L

Suitable For Any Applications

- From food to cosmetics, from pharmaceuticals to chemistry and also biotechnological with a focus on process performance, adherence to speci□c technologies and a spirit of innovation, based on a development strategy in collaboration with our customers' R&D centres and established and potential applications, Yocell o□ers a wide range of high pressure homogenisers capable of guaranteeing and repeatedly delivering quality performance.



Pharmaceutical

- Injection
- Nutrients
- Ointment

Cell disruption

- E. coli
- Yeast
- Algae

Cosmetics

- Liposome emulsions
- Skin care cream
- Lipstick

Food / beverage

- Dairy products
- Fat substitutes
- Flavours
- Fat substitutes

Chemical / Material

- Graphene
- Nanocellulose
- Lithium battery

Laboratory Type High Pressure Homogenizer

YC BASIC series

YC-NANO10

- Minimum throughtput:15 mL
- Maximum operating pressure:1500 bar
- A wide range of experimental needs can be met

YC-BASIC15

- Minimum throughtput: 25 mL
- Maximum operating pressure: 1300 bar
- Special model for biological cell disruption

YC-BASIC30

- Minimum throughtput: 50 mL
- Maximum operating pressure： 1000 bar
- Food and chemical general purpose models

Main Features

- **Homogenising valves**

  Specially designed homogenising valves for di□erent samples, allowing for better homogenisation at lower pressures.

- **Modular structure, easy to operate and maintain**
- **Automated operation**

  —Automatic sample injection, continuous operation, no venting required.

- **Safety control**

  —Automatically cut o□ the controller circuit.

- **Equipment materials**

  —Adopt 316L stainless steel with high hygienic level, high-temperature resistant, wear-resistant and anti-corrosion.
  —The core components are made of special ceramics, which are durable and have a long service life.

- **Temperature controllable**

  —The inlet and outlet of the cooling joint are connected to the constant temperature bath, which e□ectively controls the temperature rise of the homogeneous material.

- **Triple overvoltage safety protection system**

  —Equipped with BOS inverter for overload start protection.
  —Equipment adopts Italian GEFRAN, when pressure exceeds 10% of sensor range value, the sensor will send the signal of the unit, and then the machine stops for self-protection.
  —Equipped with safety valve for pressure relief system.

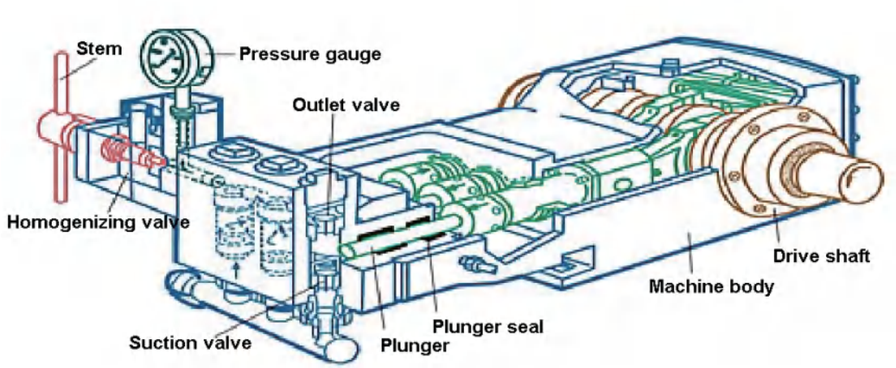


Fig.4

- High pressure homogeniser construction diagram

Technical Parameter

Model	YC-NANO10	YC-BASIC15	YC-BASIC30
Material	316L stainless steel The core components are made of special ceramics		
Flow rate	10 L/h	15 L/h	30 L/h
Maximum operating pressure	1500 bar	1300 bar	1000 bar
Pressure gauge	0~2000 bar digital display, accuracy: 1 bar		
Minimum throughput	15 mL	25 mL	50 mL
Material consumption	0 ml(no residue)		
Feed pellet size	＜500 μm		
Product viscosity	<2000 cPs		
Power	1.5 kW, 220V/50Hz	1.5 kW, 220V/50Hz	2.2 kW, 380V/50Hz

Parameters For Reference

Model	Application	Homogeneous pressure(bar)	Homogeneous times	Results
YC-NANO10	E.coli fragmentation	750~850	2~3 passes	Cell fragmentation rate: 99%
YC-BASIC15	Hansenula polymorpha yeast	1200~1300	3~4 passes	Cell fragmentation rate: 90%
YC-BASIC15	Itraconazole	1350	2 passes	Drugs reach nanoscale dimensions
YC-BASIC30	Magnesium aluminium carbonate suspension	1300	3 passes	D90 decreased from 8.439μm to 1.474μm
YC-BASIC30	n-alkane emulsions	1250	3 passes	D90 decreased from 2.793μm to 90.9nm

Pilot Type High Pressure Homogenizer

YC PILOT series

- YC-PILOT series is for R&D and pilot. Its application industries include preparations, biology, food, etc.
- Comply with GMP and FDA hygiene standards
- High crushing rate, one-time crushing rate can exceed 95%.
- High hygienic level, and can meet the requirements of food and drug production.

YC-PILOT

- Minimum throughtput: 50mL
- Maximum operating pressure: 1500 bar
- Multifunctional pilot models

YC-PILOT16

- Minimum throughtput: 50 mL
- Maximum operating pressure: 1000 bar
- Technical requirements for di□erent conditions can be met

Main Features

Special design

- Special design of feeding valve allows direct feeding without exhaust.

High-precision

- Equipped with high-precision pressure sensor and digital display panel.

Control system

- Equipped with frequency conversion control system, and the flow can be adjusted according to requirements.

Equipment material

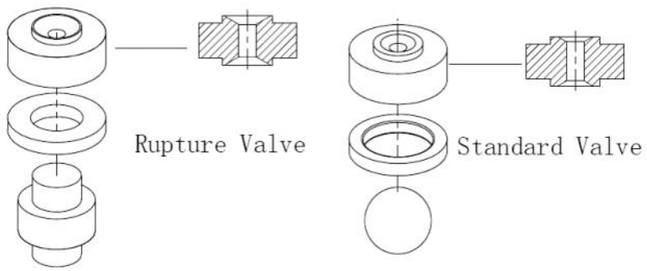
- Adopt 316L stainless steel with high hygienic level, high-temperature resistant, wear-resistant and anti-corrosion.
- The core components are made of special ceramics, which are durable and have a long service life.

Temperature controllable

- The inlet and outlet of the cooling joint are connected to the constant temperature bath, which effectively controls the temperature rise of the homogeneous material.

Safety control

- Automatically cut off the controller circuit.



- The YC-PILOT high pressure homogeniser is supplied with a set of R-type (crushing) homogenising valves: consisting of an impingement head, a stainless steel collision ring and a tungsten carbide valve seat. The valve seat is double sided and can be used on both sides, doubling the service life.
- The homogenising valve type R is commonly used in the biological industry, e.g. for cell wall breaking, algae crushing, etc.

Technical Parameters

Model	YC-PILOT	YC-PILOT16
Material	316L stainless steel The core components are made of special ceramics	
Flow rate	30~40 L/h	50~60 L/h
Maximum operating pressure	1500 bar	1000 bar
Minimum throughput	50 mL	50 mL
Material consumption	0 ml (no residue)	
Feed pellet size	< 500 μm	
Product process viscosity	< 2000 cPs	
Power	5.5 kW, 380V/50 Hz	

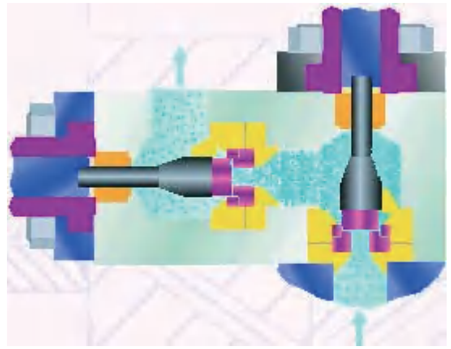


Fig.5

- Diagram of the secondary homogenising valve

Homogenising Technology

One-stage and two-stage homogenisation technology:

- For product emulsi□cation, one-stage homogenising manifolds can be applied to most product emulsions; for higher emulsi□cation results, two-stage homogenising manifolds, with approximately 10% of the total pressure applied to the second stage, greatly improve the particle size after emulsi□cation and homogenisation (more homogeneous and stable). For dispersion applications, the one-stage homogenising manifold usually performs very well.

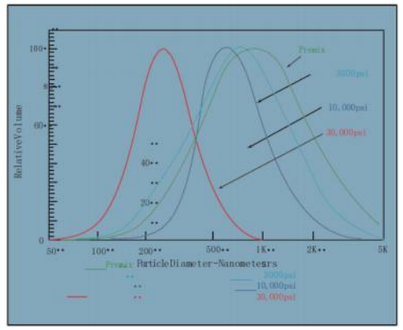


Fig.6

- As the pressure increases, the average particle size of the product also increases with smaller and smaller

Multi-circulation homogenisation technology:

More than one homogenising cycle is necessary if a more perfect and narrow particle size separation is to be sought. This can be achieved by passing the same homogeniser through two or more cycles. The use of discrete cycle homogenisation through the homogeniser is very intentional for multi-circulation homogenised products. Multi-circulation homogenised products are generally used in applications such as intravenous □uids, blood substitutes and parenteral emulsions.

Production Type High Pressure Homogenizer

YC 100/150 series

- YC100/150 series o□er the largest capacity the highest pressure on the market with the lowest total cost of ownership. Customer can bene□t from a superior pump operational e□ciency. These state of the art homogenizers represent excellent functions in wide range of industries: dairy, food, beverages, pharmaceutical, chemicals, biotech and cosmetics.

Main Features

- **High crushing rate**
  more than 95% at one time.
- **Special feeding valve design**
  no need to exhaust, direct feeding.
- **Frequency conversion control system**
  can adjust the □ow rate according to the requirements.
- **Built-in cooling system**
  directly absorbing the heat generated by crushing, ensuring the activity of the intracellular material. GMP compliant design, CE certi□ed.

Technical Parameters

Model	YC150-12	YC150-22	YC150-30	YC100-37
Material	316L stainless steel The core components are made of special ceramics			
Flow rate	120~150 L/h	200-300 L/h	300-500 L/h	800~1000 L/h
Maximum operating pressure	1500 bar	1300 bar	1500 bar	1000 bar
Material consumption	0 mL (no residue)			
Feed pellet size	< 500 μm			
Product viscosity	< 2000 cPs			
Power	11 kW, 380V/50Hz	18.5 kW, 380V/50Hz	30 kW, 380V/50Hz	37 kW, 380V/50Hz

Optional Configuration

Optional units	Optional	Description
Homogenising valves	Standard	High pressure homogenising valves: for particle size reduction, emulsi□cation, cell crushing, etc.
	Optional	Bacteria-breaking valves: specially designed for breaking bacteria, its special construction allows for better crushing results at a lower pressure (800 to 1000 bar).
Pressurised modules	Standard	Manual pressurisation: manual pressure increase by means of a pressure regulating handwheel, with precise pressure adjustment and real-time pressure display by means of a pressure gauge.
	Optional	Automatic pressurisation module: automatic pressure adjustment by setting pressure, saving manpower.

Micro-□uidization High Pressure Homogenizer

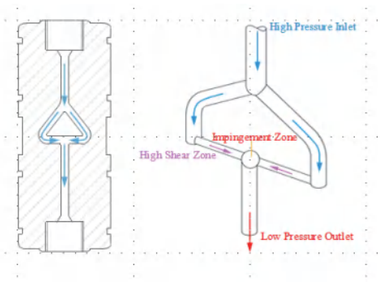
Laboratory、Pilot and Production

- Yocell has a range of micro jet high pressure homogenisers from □exible bench top laboratory products to pilot and production machines to meet a variety of homogenisation needs. The supersonic jet collision of the liquid under very high hydraulic pressure through its unique diamond micro-porous channels creates a strong shear force that homogenises the liquid to a stable and homogeneous nanometre level for particle size re□nement, clear appearance, increased stability, active delivery and improved skin feel.

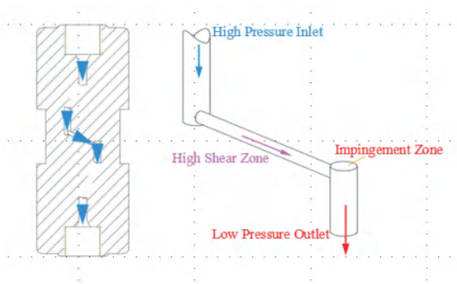
Working Principles

- The high-pressure micro□uidizer technology uses hydraulic pressure up to 200Mpa to pass materials through special diamond micro-porous channels (Y-type and Z-type) in the interactive cavity, forming supersonic jets of strong shear, impact and cavitation to emulsify and disperse particles in the liquid at the nanoscale, thus improving the product's transparency and aesthetics, stability, encapsulation rate, permeation and absorption, slow release targeting, reducing allergies, masking odours and improving taste. The result is an improved product that is transparent, aesthetically pleasing, stable, encapsulated, permeable, absorbable, slow release, targeted, allergenic, odour masking and taste improving.

Core Components



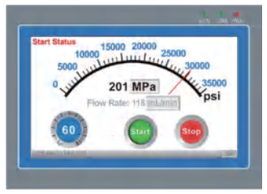
Y TYPE Chamber internal Jet path



Z-TYPE Chamber internal Jet path

Diamond Interaction Chambers
With Y-type and Z-type

Ceramic Plunger



PLC control

Features

- The micro-□uidization homogeniser is a new generation of high pressure homogeniser for nanoscale emulsi□cation and dispersion.

Extremely small and uniform nanoscale particle size distribution

- Its unique diamond micro-porous channel counter-jet technology provides extremely small and uniform nanoscale particle size distribution results.

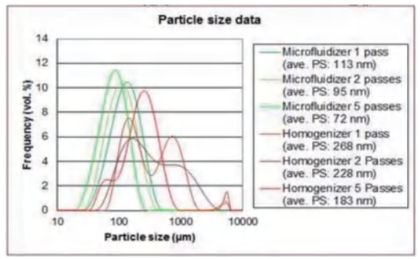
Stable working pressure

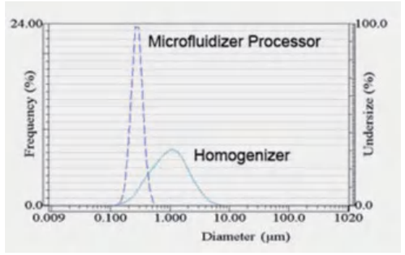
- The hydraulic booster mode can provide a stable working pressure of up to 200Mpa, which is commonly used in high value added nanoscale homogenisation applications in various industries where particle size control is required.

Corrosion resistance materials

- The maximum working pressure is 3100 Bar(45000 Psi). All parts touching with medium are 316L stainless steel,17-4ph stainless steel, titanium alloy, tungsten carbide, PTFE, UHMWPE or other corrosion resistance materials.

Micro-□uidization Homogeniser VS High Pressure homogenizer





- Easier to obtain smaller particle sizes than with valved homogenization techniques.
- Easier access to a more homogeneous particle size distribution than with valved homogenization techniques.

Application Areas

- With compact design, it's especially suitable for laboratory preparation of fat emulsion, liposome, nano suspension, micro-emulsion, lipid microsphere, nano-emulsions, dairy products, juice homogeneity,cell disruption,infusion solutions,□ne chemical engineering, dye, and etc.




Pharmaceutical

- Microemulsion (Nanoemulsion)
- Liposome
- Nano particles
- Fat emulsion
- Nano suspensions
- Inhalation formulation

Cosmetics

- Nano wrapped raw materials
- Liposomal cosmetics
- Essential oil delivery systems
- Bi□dic yeast crushing
- Liquid crystal system □nished products
- Collagen dispersion

Fine Chemical

- Hydrogen fuel cell catalyst
- Water electrolysis catalyst dispersion
- Chemical mechanical polishing solution
- Conductive polymers
- Graphene, carbon tube, carbon black
- Nano oxide dispersion
- MLCC binder dispersion

Food Industry

- Food nanomilk
- Macromolecular modi□cation
- Active substance lipid encapsulation
- Plant protein drinks
- Solids dispersion

Laboratory type
Micro-□uidization High Pressure Homogenizer

YC MH series

- The user-friendly, laboratory-scale micro□uidization high pressure homogenizer is designed for laboratory R&D and small-scale production at ultra-high pressure. YC-MH series is a type of benchtop electric micro-jet homogenizers which operated on the touch screen and controlled intelligently by program.

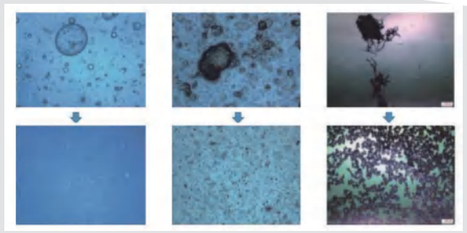
Unique Bene□ts

- Powerful: particle sizing under 100nm with PDI 0.1
- Small: integrated design delivers the light weight and small dimensions
- Smart: program parameter setting; Auto stop with time & volume
- Silent: noiseless performance
- Safety: pharmaceutical grade material, FDA & GMP approvable.

Applications:

Micro-emulsion (Nano-emulsion)
Liposomal drugs
Nanoparticles
Fat emulsion
Nanosuspensions
Inhalation formulations

Crushing e□ect



Technical Parameters

Model	YC-MH20k	YC-MH30k	YC-MH45k
Max. pressure	20,000 psi (≈1300 bar)	30,000 psi (≈ 2000 bar)	45,000 psi (≈3100 bar)
Flow rate	100 mL/min	120 mL/min	120mL/min
Min. sample	5 mL		
Feed viscosity	＜2000 cp		
Min.residue	1 mL		
Dimensions (W×D×H)	70×36×30 cm		
Weight	35 kg		
Max. feed temp.	90 ºC		
Power	1.5 kw 220V/50Hz		

Optional Con□guration

Items	Standard	Optional
Control system	High pressure programming control systems®: touch screen, speed control, auto stop control by time, pressure or temperature, settable volume control as low as 1mL.	
Pressure gauge	Digital display on the touch screen	
Parts	Single diamond interaction chamber	Multi-model diamond interaction chamber with cooling jacket
Feed port	300 mL stainless steel hopper	Multi-model stainless steel hopper
Outlet port	Luer exible hose	Multi-model Luer syringe
Material cooling	150 material heat exchanger	Multi-model material heat exchanger
Cooling system	None	Cryogenic cooling circulating pump
High pressure cylinder	316L stainless steel	Titanium alloy

Pilot Type
Micro-□uidization High Pressure Homogenizer

YC110IP-EH

- The second-generation pilot micro□uidization high-pressure homogenizer equipped with diamond interaction chambers. It has unique homogeneous dispersion e□ect, e□cient and stable structural design, and is used for homogeneous dispersion treatment of products in various industries.
- YC110IP-EH has 200Mpa pressure, 24L/H □ow rate, process easily enlarged. Hydraulic modular design, stable use under high pressure for more than 10 years.

Technical Parameters

Model	YC110IP-EH
Operating pressure	3000~30,000 psi(206 bar-2060 bar)
Flow rate	≈ 24 L/h (related to pressure, viscosity)
Min. Sample	120 ml
Dimensions (W×D×H)	80×80×130 cm
Weight	245 kg
Max. feed temp.	80 ℃
Power	4 kw, 380V/50Hz, 3 phase electrical service

Standard Con□guration

Standard

- The core of homogenizer adopts diamond interaction chamber, Y type and Z type can be con□gured, and the particle size can be homogenized below 100nm.
- The contact materials include SUS 316L stainless steel, SUS630 stainless steel, UHMWPE, PEEK, PTFE.
- Support high-pressure plunger seal cooling design to extend service life.
- Equipped with material heat exchanger, it can cooperate with cooling water to e□ectively control the discharge temperature, protect product activity.
- Standard with 1Lstainless steel hopper
- Equipped with emergency stop button.
- Equipped with roller wheels at the bottom for easy movement.

Optional Con□guration

- 2L, 4L stainless steel hopper
- Diaphragm pressure sensor with digital display
- Temperature detection and digital display of outlet port
- Explosion-proof design
- Cooling jacket for diamond interaction chamber
- IP, SIP
- Low design pressure and high □ow rate con□guration

Production type
Micro-□uidization High Pressure Homogenizer

- The second-generation production highpressure micro□uidization homogenizer equipped with diamond interaction chamber. It has unique homogeneous dispersion e□ect, e□cient and stable structural design, and is used for homogeneous dispersion treatment of products in various industries.

Technical Parameters

Model	YC7125IP-30K	YC7250IP-30K	YC500IP-30K
Operating pressure	3000~30,000psi		
Flow rate	≈ 120 L/h	≈ 240 L/h	≈ 480L/h
	Related to pressure, viscosity		
Dimensions (W×D×H)	180×74×145 cm	180×74×145 cm	180×150×160cm
Weight	815kg	1000kg	2000kg
Max. feed temp.	80 ℃		
Power	18.5kw, 380V/50Hz	37kw, 380V/50Hz	75kw, 380V/50Hz
	3 phase electrical service		

Standard Con□guration

Standard

- The core component of homogenizer adopts diamond interaction chamber, Y type and Z type can be con□gured, and the particle size can be homogenized below 100nm
- The contact materials include SUS 316L stainless steel, SUS 630 stainless steel, UHMWPE, PEEK, PTFE.
- Support high-pressure plunger seal cooling design to extend service life.
- Equipped with material heat exchanger, it can cooperate with cooling water to e□ectively control the discharge temperature, and protect product activity.
- Standard with 2L stainless steel hopper.
- Equipped with emergency stop button.
- Equipped with roller wheels at the bottom for easy movement.

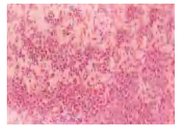
Optional Con□guration

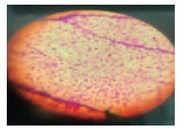
- 4L stainless steel hopper
- Diaphragm pressure sensor with digital display
- Temperature detection and digital display of outlet port
- Explosion-proof design
- Cooling jacket for diamond interaction chamber
- CIP, SIP
- 10K, 20K low design pressure and high □ow rate plunger system

Application Cases

Case 1. E. coli

YC-NANO10





Types of bacterial broken	E. coli.
Homogeneous pressure (bar)	750~850
Homogeneous times	2~3 passes
Cell fragmentationrate (%)	99%

Processing steps

- Dissolve the bacterium in bu□er: weigh the bacterium in a beaker, add 10 ml volume of bu□er in proportion to 1 g of bacterium and dissolve the bacterium to a particle-free state.
- Turn on the machine, add ice to the condensing unit, turn on the power button, turn on the refrigeration system and set the temperature to 4°C. Turn on the pump cycle and turn on the homogeniser.
- Set the pressure to about 10 bar and rinse the machine with puri□ed water for 3-5 cycles to clean the residual liquid from the machine.
- Add the sample in a gradient of 50 bar and slowly pressurise to 500-800 (±50) bar. After repeated homogenisation, collect the sample in a beaker and slowly lower the pressure to 10 bar in a gradient of 50 bar.
- Rinse the machine 3-5 times with water to rinse out the bacterial solution. Add 50 mL of 0.1 mmol/L NaOH to seal the machine. Close the machine. Turn o□ the refrigeration, drain the circulating water, turn o□ the pump circulation system and turn o□ the homogeniser.
- Centrifugation: Place the homogenised solution in a 50 mL centrifuge cylinder at 4°C and 16 000 rpm for 30 min.

Case 2. Hansenula polymorpha yeast

- The correlation between the parameters and the response surface was obtained by analyzing the response surface and contour plot of the □tted function. The optimum parameters for the recombinant Hansen's yeast cell high pressure homogenization process were □nally obtained as 1200 bar, 4 times homogenization and 12% yeast mass fraction. Under these conditions, the yeast cell fragmentation rate was 85.05%.

YC-BASIC15

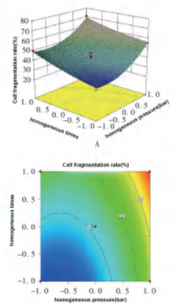


Fig. 1 Three-dimensional surface (A) and contour (B) plots of mutual-influence of homogeneous pressure and homogeneous times

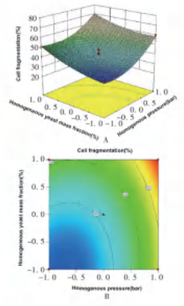


Fig. 2 Three-dimensional surface (A) and contour (B) plots of mutual-influence of homogeneous pressure and homogeneous yeast mass fraction

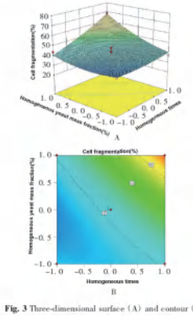
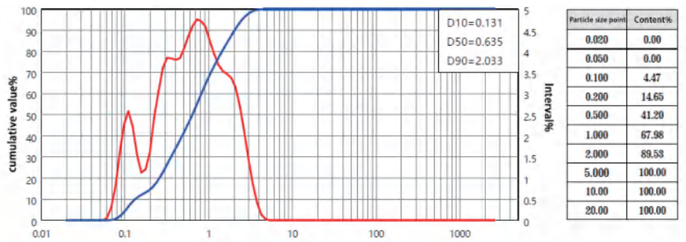


Fig. 3 Three-dimensional surface (A) and contour (B) plots of mutual-influence of homogeneous times and homogeneous yeast mass fraction

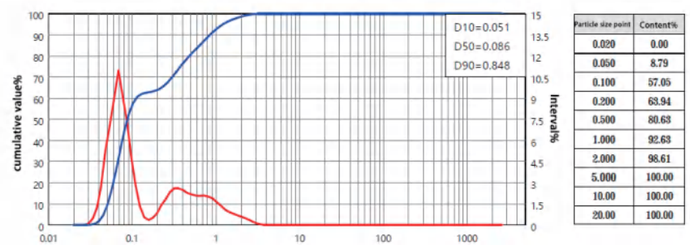
Case 3. Zinc oxide nanopaste dispersion

- Zinc oxide nanoparticles are multifunctional new inorganic materials with a particle size of about 1 to 100 nm. In recent years it has been found to exhibit many special functions in catalysis, optics, magnetism and mechanics, making it valuable for many applications in ceramics, chemicals, electronics, optics, biology and medicine, with special characteristics and uses that cannot be compared to ordinary zinc oxide. Nano zinc oxide can be used in textiles, coatings and other □elds as UV masking materials, antibacterial agents, □uorescent materials, photocatalytic materials, etc.

YC-BASIC30



Particle size point	Content%
0.020	0.00
0.050	0.00
0.100	4.47
0.200	14.65
0.500	41.20
1.000	67.98
2.000	89.53
5.000	100.00
10.00	100.00
20.00	100.00

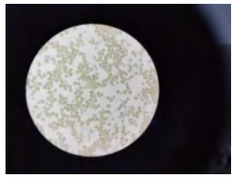


Particle size point	Content%
0.020	0.00
0.050	8.79
0.100	57.05
0.200	63.94
0.500	80.63
1.000	92.63
2.000	98.61
5.000	100.00
10.00	100.00
20.00	100.00

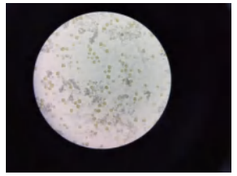
Comparison of particle size before and after zinc oxide dispersion

Case 4. Chlorella

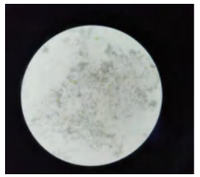
YC-PILOT



1 pass



2 pass



3 pass

Sample preparation:

- 100g chlorella dissolved in 1L of water, shear 8000 rpm for 1 minute

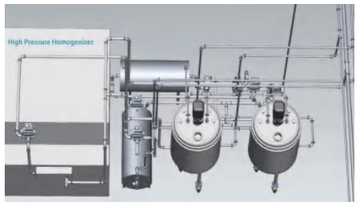
Homogenization process:

- YC-PILOT, □rst-stage pump head, low temperature control, special valve for wall breaking, wall breaking 3 times, 850-900bar. After the chlorella broke the wall once, some of the chlorella was not broken, and after 3 treatments, the wall was completely broken

- Chlorella is a universal single-celled chlorella of the genus chlorella, which is a spherical single-celled freshwater algae with a diameter of 3 to 8 microns.
- Chlorella contains a wide range of nutrients and can be taken as a nutritional supplement with anti-ageing and cosmetic bene□ts. It is a high quality source of nutraceuticals for food additives and health foods.

Engineering Reference

- Our company has a number of technicians specialising in biochemical industry, automation control, computer and mechanical engineering, with rich experience in engineering design and on-site construction. We help our customers to solve production and process problems.



- YOCELL o□ers a complete range of upstream and downstream biopharmaceutical process equipment and integrated solutions. We are able to meet the di□erent process requirements of our customers for homogenisation technology, including cell crushing, particle size reduction, emulsi□cation and uniform distribution of drugs. We help our customers to achieve high standards and e□ciency in their technical processes.