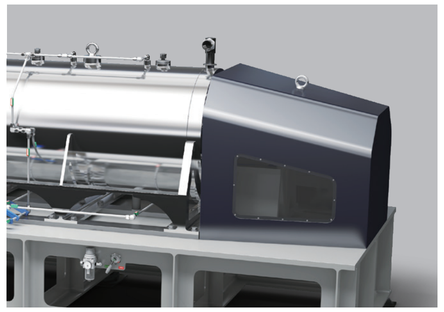
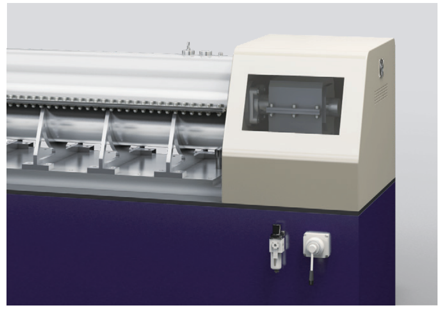
LCTR® - series

Taylor Reactor





Mass production from Lab.

Laminar

www.laminarm.com

Laminar Co., Ltd.

#512, 27, Dunchon-daero 457beon-gil, Jungwon-gu, Seongnam-si, Gyeonggi-do, 13219, Republic of Korea
Tel. +82-31-737-2375 Fax. +82-31-737-2757 E-mail. sales@laminarm.co.kr

Laminar

Global New Technology

Laminar

Pioneered in the new field of chemical reactor

Since the establishment in 2010, Laminar Co.,Ltd based on Technology has developed a new concept of chemical reactor named as Taylor Reactor(LCTR, Laminar Continuous Taylor Reactor) and pioneered in the new fields of chemical reactors. Furthermore, going on to enlarge the general reactor market fields.

Through continuous technology development and research, Laminar will continue to make efforts to apply it to more diverse processes and promises to provide better products to our customers and the best technology services from continuous maintenance to process support.
We will always do our best to meet your expectations.

Due to innovative R&D activity, we are developing the new functional chemical reactor fields.

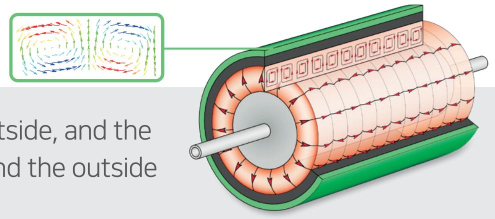
CE certificate

CE certificate

ISO 9001

ISO 14001

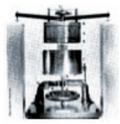
Taylor Flow



The reactor session is made up with two cylinders, inside and outside, and the solution to be reacted is fed into the space between the inside and the outside cylinder through the feeding ports.
As soon as the inside cylinder is rotated by the motor, the solution is also starting to move and then forming a strong stream in the direction of rotation. Simultaneously, two forces of Centrifugal and Coriolis are generated so strongly that the solution in the reactor moves fast for the outside cylinder. The faster the inside cylinder is rotated, The more unstable the flow comes to be.
By this phenomena, the eddy current flow is created regularly in the shape of the double rings each of which is self-rotated in the opposite direction, along the rotated inside cylinder. It is shaped like a band in the reactor. This means a Taylor flow in which is called.

HISTORY

1900 — Maurice MarieAlfred Couette



[viscometer]

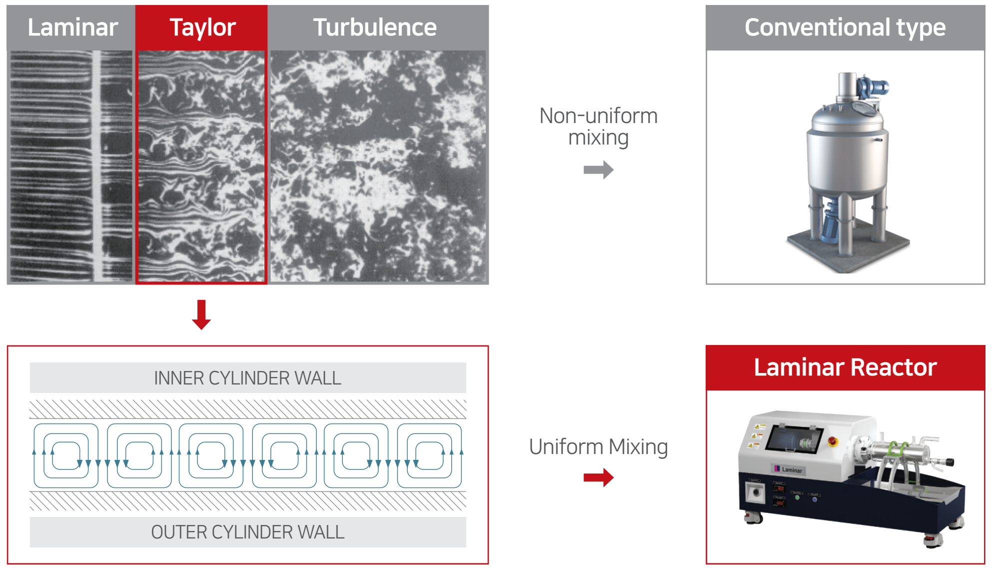
Physicist
Viscometer
Heat Engineering

1950 — Geoffrey Ingram Taylor

Physicist
Mathematician
Fluid dynamics
Wave theory

1980 — Heat exchanger

2010 — Chemical Reactor



A Taylor fluid flow can generate a turbulent flow easily by changing the rotational speed of an inner cylinder, so it is much used to study the stability of a fluid. Rayleigh performed a stability analysis for a non-viscous fluid for the first time

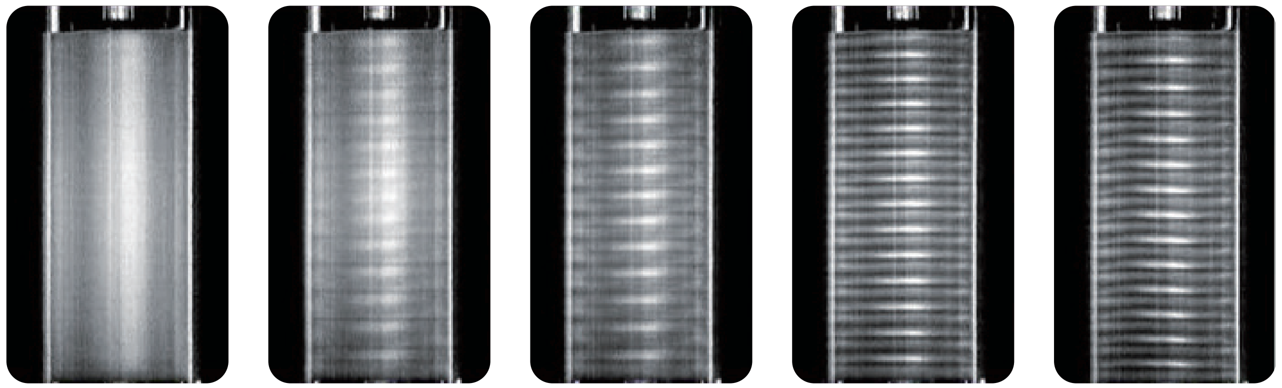
For a viscous fluid, Taylor reported that a Taylor vortex occurs in a domain larger than the critical Taylor number based on linear theory. The instability condition of a flow can be represented as a Taylor number(Ta), which is defined by a rotational direction Reynolds number and a reactor shape factor(d/ri) as follows:

$$Ta = \frac{\omega_i r_i d}{v}\left(\frac{d}{r_i}\right)^{1/2}$$

where d is the distance between two cylinders, r_i is the radius of the inner cylinder, ω_i is the rotational angular speed of the inner cylinder, and v is the dynamic viscosity of the fluid.

$Ta<Ta_c$	:	laminar flow
$Ta_c<Ta<800$	:	laminar vortex(single periodic) flow
$800<Ta<2000$	:	laminar vortex(double periodic) flow
$2000<Ta<10000\sim15000$	:	turbulent vortex flow
$Ta>15000$	:	turbulent flow

Radius Ratio=0.80



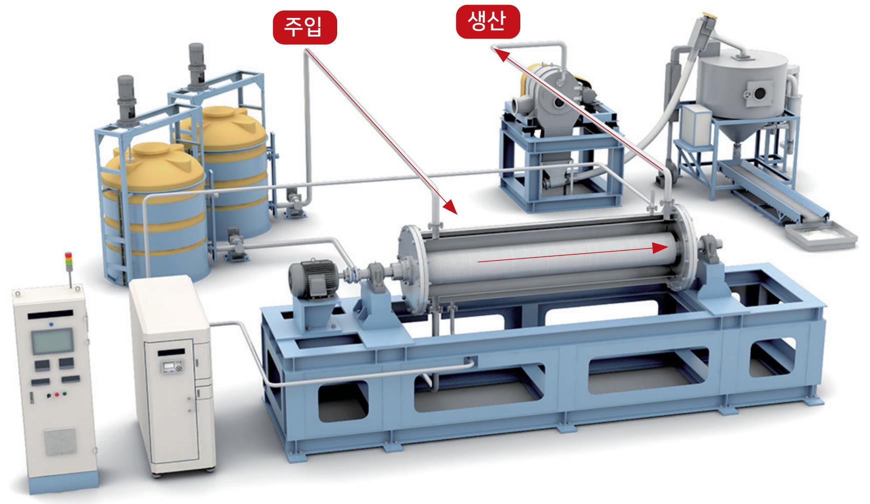
Re=52 Re=93 Re=104 Re=301 Re=601

LCTR®- series Advantages

CONTINUOUS QUALITY TIME COST

Continuous production

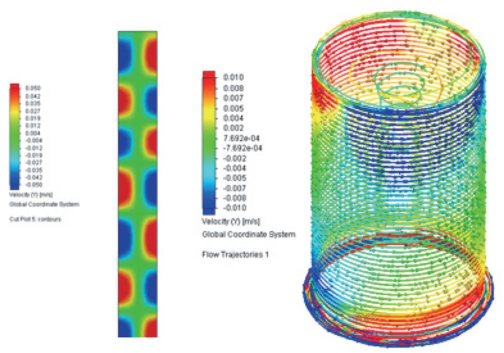
Possible to produce the volume same as you inject under the continuous production system



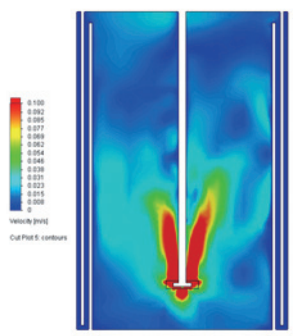
High-purity materials

Possible to reduce the formation of impurity due to that there is no any dead-zones in the reactor as an ideal fluid flow

CFD

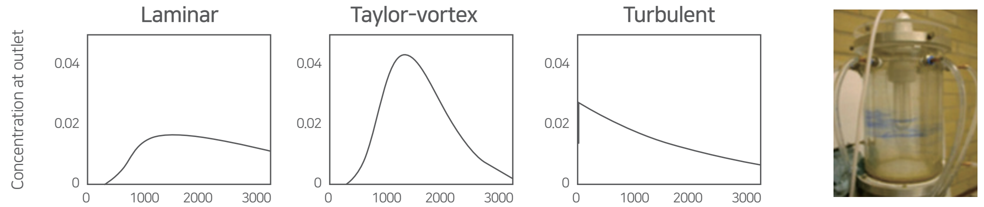


Laminar Reactor



Conventional Reactor

Demonstration of mixing

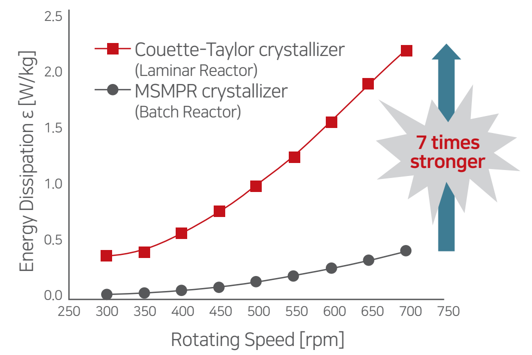


From : A. Syed and W.-G Fruh (2003). Journal of Chemical Technology and Biotechnology 78, 227-235

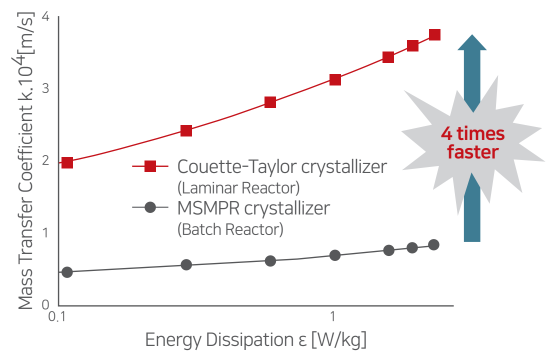
Time reduction

Possible to shorten the reaction time by one third, due to 7 times stronger mixing force and 3 times faster mass transfer velocity

Mixing force



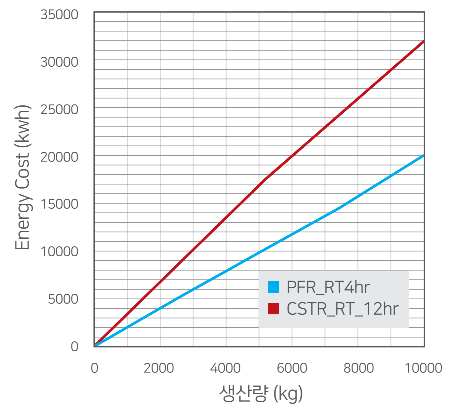
Mass transfer velocity



Nguyen-Anh TUAN, Jeong-ki Kang, Jong-Min Kim, Sang-Mok CHANG, Choul-Ho Lee, Woo-sik KIM, "Drowning-out Crystallization of Guanosine 5-Monophosphate(GMP) in Continuous Couette-Taylor Crystallizer" 8th International Conference on Separation Science and Technology, Karuizawa, Japan, (Oct 2-4, 2008)

Cost reduction

40% energy savings



Division	LCTR® (kW)	CSTR (kW)
Pump	2.06	0.69
Heat Exchanger	10.67	5.25
Agitating & etc	21.01	12.56
Reaction time (h)	4	12
Energy Cost (kWh)	134.96	222.00

Hybrid reactor : Tank + Tubular

Tank

Tubular

Tank + Tubular

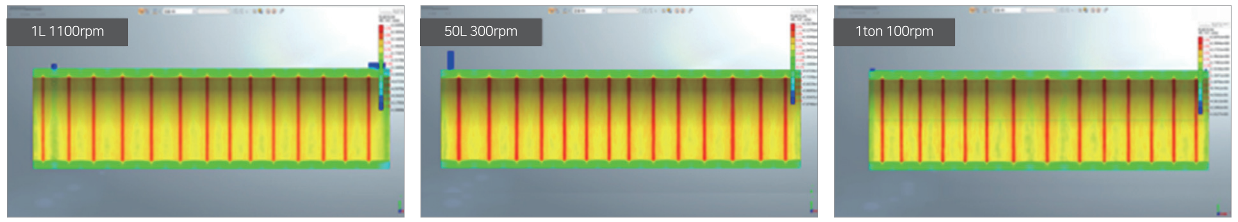
The development of a ideal chemical reactor functioning the continuous manufacturing system for high purity materials by utilizing fully the advantages of both Batch (easy to operate, the use of mixer, easy to check in operation) and Tubular (high purity production, high reproducibility, east to produce nano-materials)

Scale-up (From research use to mass production)

Scale-up research

If you want to scale-up the Taylor reactor according to the customer's needs, you can easily scale-up through the following factors.

1L → 50L → 1,000L



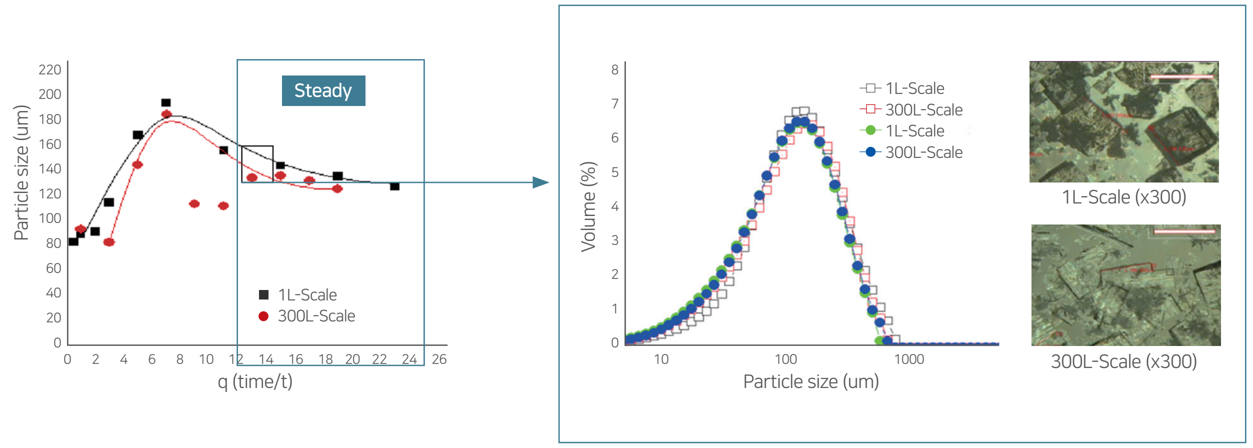
Volume (L)	Linear velocity (m/s)	Agitation speed (rpm)	The number of Taylor flow
1	4.29	1100	14
50	4.35	300	14
1000	4.58	100	14

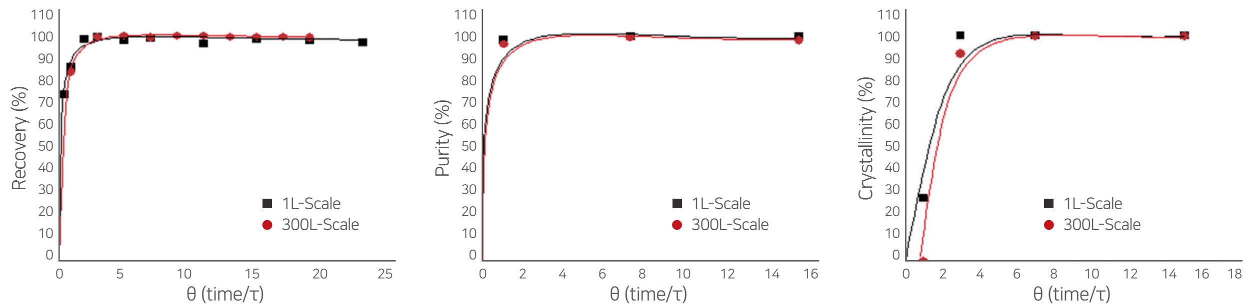
Scale-up projects using Taylor reactor

- Co-precipitation for preparing precursors for Li-ion battery cathode materials
- Exfoliation of graphene and graphene oxide
- Purification of amino acid
- Ammonium phosphate production using waste phosphoric acid
- Particle size control technology using cooling and anti-solvent crystallization method
- Continuous organic synthesis

Scale-up results

The flow in a LCTR® is an ideal flow without dead-zones, so when its scale is increased from 1 L to 300 L, only controlling the agitation speed can produce products of the same property. We produce from 10 mL laboratory reactors to ton-level mass production reactors.

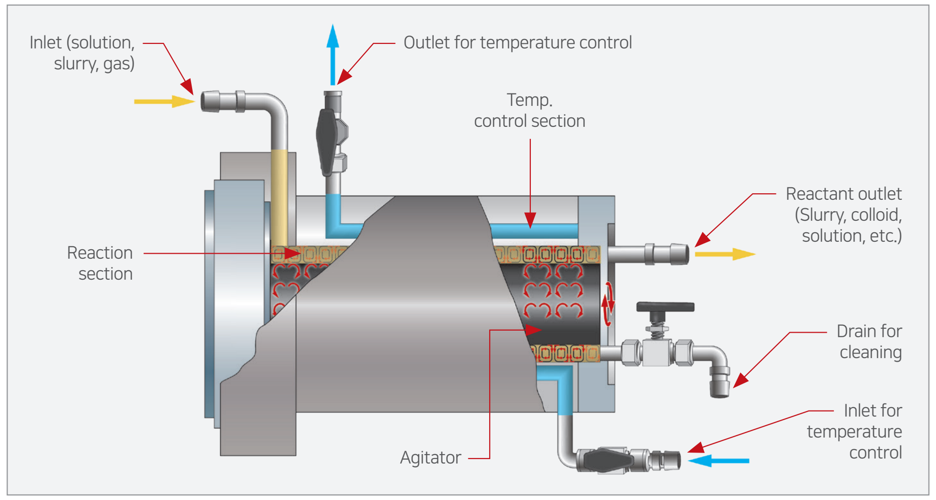


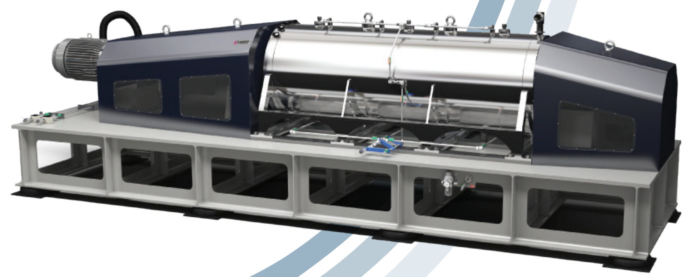


Recovery rate | Purity | Crystallinity

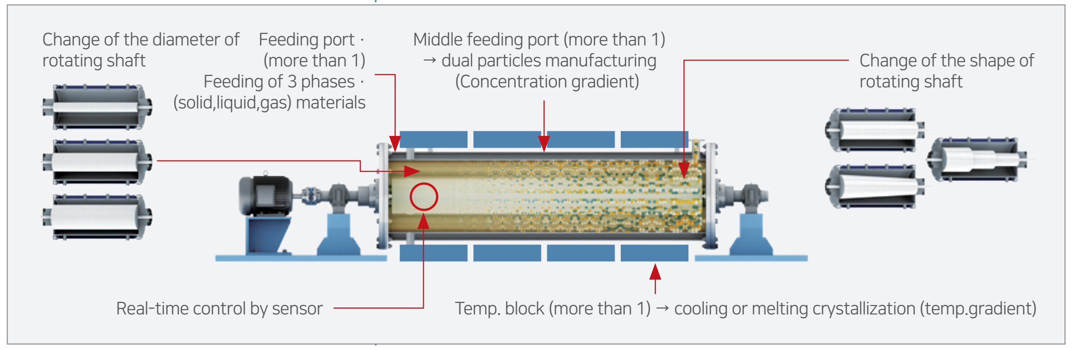
LCTR®- series

Internal structure diagram of the mixing part





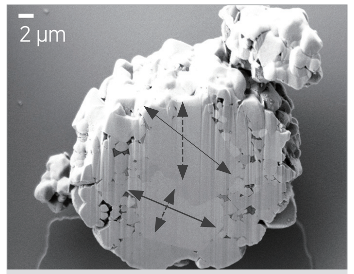
Option Custom-made available



Model	LCTR® Mini-V	LCTR® Lab II-V	LCTR® Lab II-H	LCTR® Tera		LCTR®- Peta			LCTR® Exa		
Capacity	20mL	100mL	200mL	1L	1L	5L	10L	50L	100L	500L	1000L
Max. Agitation speed	Normal type : 1500 rpm, High speed type : 5000 rpm					1200 rpm			300 rpm		
Temperature	Normal type : Up to 90 ℃, Low temperature type : -20 ℃, High temperature type : Up to 400 ℃					Normal type : Up to 90 ℃, Low temperature type : -20 ℃, High temperature type : Up to 400 ℃					
Material	SUS316 / Teflon Coating / Hastelloy-C, Inconel, etc					SUS316 / Teflon Coating / Hastelloy-C, Inconel, etc					
Dimension L/W/H (mm)	274 x 525 x 617	500 x 500 x 1178	1102 x 450 x 574	1470 x 700 x 1157	1400 x 700 x 1150	1760 x 500 x 851	2330 x 700 x 1200	3400 x 1300 x 1600	5800 x 2300 x 1850	6500 x 2500 x 2000	8500 x 3000 x 2300
Weight	40kg	85kg	120kg	450kg	650kg	600kg	1200kg	3000kg	5000kg	15000kg	25000kg
Suitable For	Pharmaceutical Research, QD, High Value Materials	Universally Used for Most Research & Development Projects for New Process, and Optimization of Manufacturing Process		Secondary Battery Development Projects (Smallest Model Offered with PH Control Function)		Pilot-scale Production, For Small Quantity Batch Productions			Mass Production		

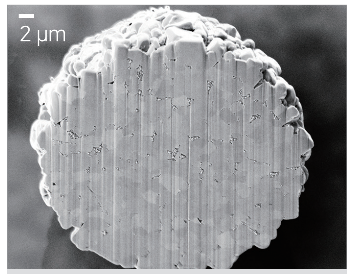
Applications

High density



Surface area = 0.53 m2/g

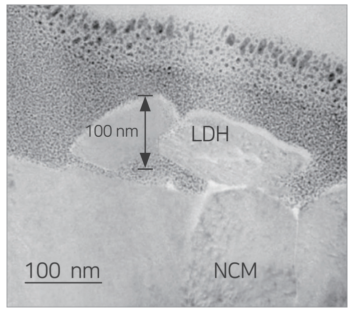
CSTR



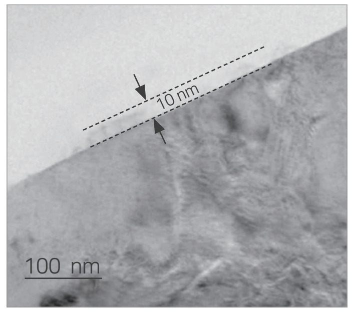
Surface area = 0.46 m2/g

LCTR®

Coating

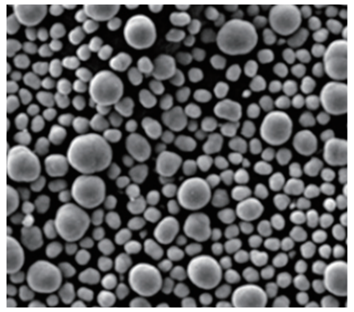


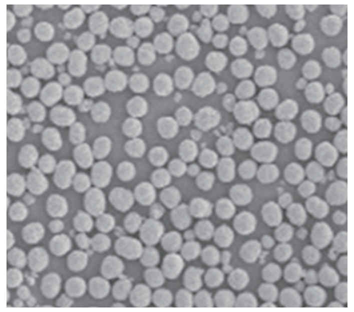
CSTR



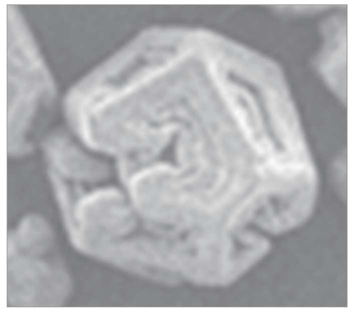
LCTR®

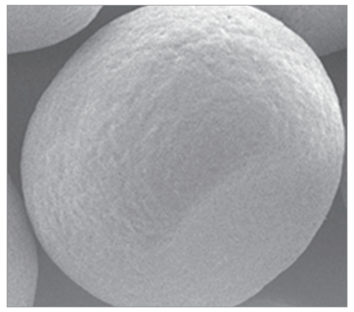
Uniform particle size


CSTR

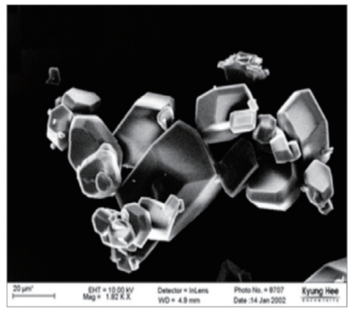

LCTR®

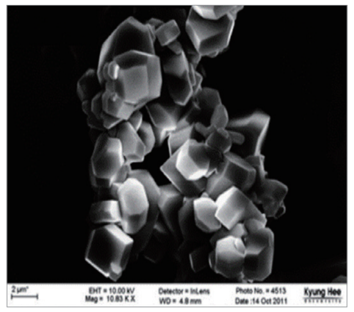
Spherical particles


CSTR

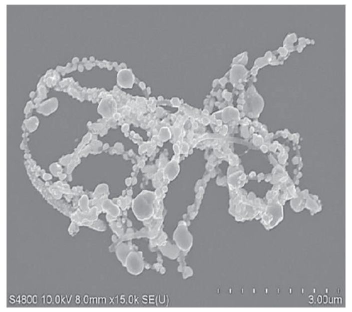

LCTR®

Time reduction


CSTR : 93 hr


LCTR® : 20 min

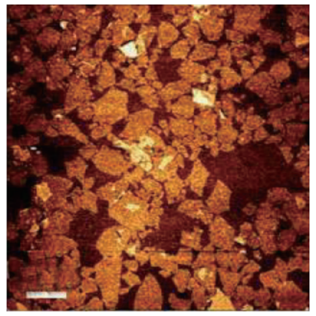
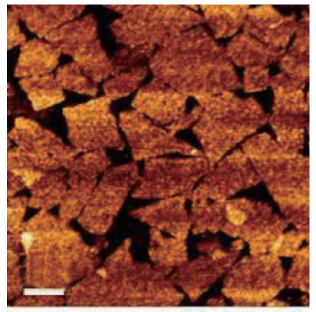
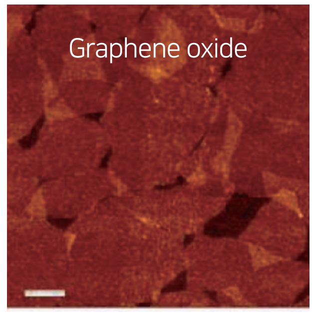
Nanocomposite


CSTR


LCTR®

Exfoliation

Graphite is easily exfoliation with graphene.

Low — Viscosity — High

Three-phase reaction (Gas·Liquid·Solid)

LCTR® is possible to manufacture the new materials by feeding Gas, Liquid and Solid under the condition of the presence of solvent.

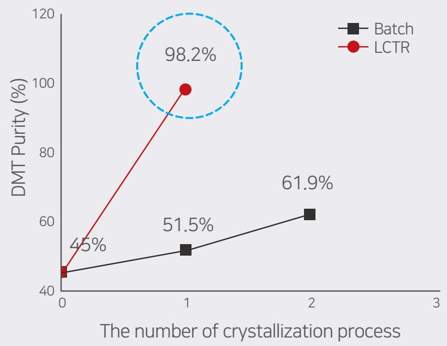
Liquid-Liquid reaction
ex) $LiCl + Na_2CO_3(l) \rightarrow Li_2CO_3$

Gas-Liquid reaction
ex) $2LiOH + 3CO_2(g) \rightarrow Li_2CO_3$

Solid-Liquid reaction
ex) $Al_2CO_3(s) + CuSO_4 \rightarrow Cu\text{-}Al_2CO_3$

High purity

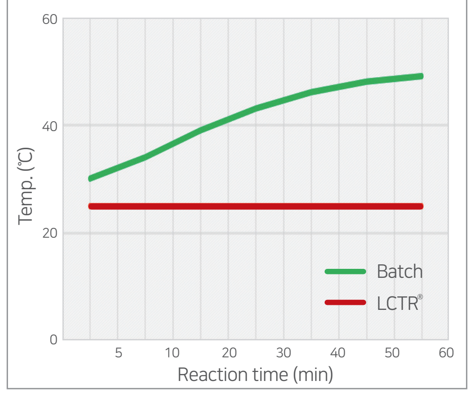
Separation with more than 95% purity at once



	Batch	LCTR®
Raw material (DMT) purity	45	
1회	51.5	98.2
2회	61.9	

Temperature control of exothermic reaction

It is possible to easily control the temperature of the exothermic reaction.



Applications

Products		
$Ba(NO_3)_2$	InP	$NiSO_4$
$BaSO_4$	K_2CO_3	OLED
$CaCO_3$	KNO_3	Pillar
CdSe	Li_2CO_3	Silver paste
$CoSO_4$	LLZO	SiO_2
$(CuCr)(OH)_2$	Lysine	Sulfamerazine
Cu-SiO_2	$(MnCo)(OH)_2$	TiO_2
Diamond	$NaHCO_3$	Tryptophan
Durene	NaI	WC
Fe, Mn 회수	NCA	Zinc Pyrithione
GMP	NH_4ClO_4	Zirconia Bead
Graphene	$NH_4H_2PO_4$	
Graphene Oxide	$(NiMnCo)(OH)_2$	

Processes		
Coating	Exfoliation	Precipitation
Co-precipitation	Extraction	Radical reaction
Core-shell process	Impregnation	Re-crystallization
Crystallization	Polymerization	Sol-gel process

Options

Pump

Research
Mass production

pH sensor

Acid/Alkali
Slurry

Balance

Checking the flow rate

Flowmeter

Proposed in accordance with the process conditions

Circulator

Temp. control of the reaction solution

Lubricator

Extend the life of mechanical seal

Storage tank

Solution storage

Solid-liquid separator

Centrifuge
Filter press

Dryer