Electrospinning Method

Major features of the electrospinning method is to spin a variety of materials (mainly polymers) into nanofiber shapes and control of fiber shapes is relatively easy.

Research up to now realized electrospinning of the following materials.
(See Fig.1)

- Industrial thermoplastic polymer
- Biodegradable polymer
- Polymer blend
- Composite materials mixed with inorganic compounds

In recent years spinning cases of the ceramic nanofibers such as Alumina, Zirconium oxide, Titanium oxide and Lead zirconate titanate are reported frequently.

Electrospinning method usually uses solutions in which materials dissolve in solvents as spinning materials.

Electrospinning system, as shown in Fig. 1, consists of a high voltage power supply, polymer solutions, a storage tank, a spinneret and a grounded collector. Polymer solutions will be pushed out of a tank to a spinneret at a constant speed.

High voltage at 20kV to 40kV will be applied to a spinneret and polymer solution jet will be injected to a collector when electrical attraction exceeds surface tension of polymer solutions. Solvents in jets are gradually volatilized and jets will reduce to nanometer level when they reach a collector.

Electrospun nanofibers forms membranes shown in Fig. 2. Orientations of fibers depend on a collector.
Nanofiber membranes are known that its total surface area per volume is much more than that of micrometer-size fiber membranes.

As a result, nanofibers obtain unprecedented characteristics by having chemical or physical modifications, and new applications in various fields are expected.

As shown in Fig. 3, even if the same polymer is spun, fibers in different shapes, such as smooth-surface fibers, beaded fibers and porous fibers, can be made by changing spinning parameters.

Parameters in terms of electrospinning are generally divided into three groups of solution characteristics, spinning environment and spinning conditions. (Fig. 4)

### Solution Characteristics
- Solution concentration
- Viscosity
- Conductivity
- Elasticity
- Surface tension

### Spinning Environment
- Ambience temperature
- Humidity
- Barometric pressure

### Spinning Conditions
- Voltage to apply
- Solution discharge amount
- Distance between collector and spinneret
- Winding speed of a collector
How to combine such parameters will be “knowhow.” It is most difficult to find out the best spinning conditions to obtain desired shape of nanofibers, which usually takes a long time period. So much time has been taken by many people to figure out relevancy between such parameters and shapes of fibers, however, it is becoming clearer in these days.

Polymer concentration of spinning solution is obviously the most important factor to control diameters of polymer fibers. Also, design of a collector will be important to control orientation of fibers. Aligned nanofiber samples made with a disk collector is shown in Fig. 5. There are several important parameters to be controlled such as fiber diameters, surface shapes and orientations.

Applications of Nanofibers

Applications of nanofibers below are currently thought to be promising, and research in such fields is progressing at many colleges, laboratories and corporations.

- **Healthcare**
  - Regenerative medicine, wound treatment, drug delivery system
- **Environmental engineering**
  - Water filter, dust filter, face mask
- **Functional goods**
  - Functional clothes, functional food
- **Electronic materials**
  - Battery materials, high conductivity materials, transparent conductive film

**Healthcare**

Japanese ministry of economy and industry reports that the market size of goods related to regenerative medicine is presumed to be USD150billion worldwide and USD13billion in Japan. On the other hand a sales record of such products approved by FDA is USD 1billion in 2012 in U.S.A., a leading country in industrializing regenerative medicine.

One of the applications is the artificial blood vessels made by Tokyo Denki University shown in Fig. 6. The group of Prof. Funakubo is developing artificial blood vessels and organs in the field of regenerative medicine.
The group is reportedly making experiments to implant artificial blood vessels in rats' bodies. In such research use of nanofibers is thought to be advantageous in manufacturing 3D structures and scaffold materials of cells. Other than the field of regenerative medicine applications are being developed in wound treatment, drug delivery system and dosage form.

**Environmental engineering**

In the field of environmental engineering nanofibers are well known with products such as filters or face masks.

Targeted molecules can be eliminated at high efficiency with water processing filters made of nanofibers making use of their high performance of filtering.

As one of the applications filters to eliminate cesium are under development. Extremely small particles of cesium, which were not collected only with meltblown nonwovens, can be collected by integrating nanofiber nonwoven layers to meltblown nonwovens. (From the patent publication list)

**Functional goods**

In recent years some research results report that a variety of textiles can be spun using not only a single and simple nanofiber but also composite materials or textiles, composite materials with particles or coating materials of functional objects.

A cooperative team of University of Lincoln in England and Iranian Food Science and Technology Research contributed a total analysis of electrospinning method adequate to using for foods to "Food Hydrocolloids" an academic journal.

Dr. Nick Tucker of University of Lincoln, one of the authors explains that the electrospinning method helps new supplementary food compound be produced, and design and performance of delivery system be progressed in this article. That is, nanofibers spun with the electrospinning method are expected to be used for food delivery system to protect nutrients between processing and storage or during transfer to another location inside a body.

**Electronic materials**

In the field of electronic materials nanofibers are expected for applications such as:

- Electrodes or separators for high efficiency solar batteries, fuel cells, and secondary batteries.
- Transparent conductive filters (electrodes) for displays, touch panels and functional glass.

The group of Associate Professor Matsumoto at Tokyo Institute of Technology is developing transparent conductive films, which are expected to be replacements for ITO that is currently used for electrodes and display panels.

Those films feature that they have as high visible light transmission rate as that of ITO at 80% and high conductivity at 450Ω/sq of surface resistance, and are very thin, light, flexible and unbreakable.
Research trends of nanofibers

1) Number of nanofiber-related articles

The internet database report tells that number of articles related to nanofibers exceeds 8,000 in Japan as of 2015.

As shown in Fig. 7, number of contributions have been rapidly increasing since 2006. More than 1,000 articles are being contributed and researches are actively being made all over Japan.

2) Research trends

Commercial products that contain nanofibers such as high performance filters and face masks have already been available in the market. They made use of nanofibers of high dust collection efficiency and low pressure loss.

In the field of regenerative medicine materials that utilize high adhesion to cells and porosity of nanofibers are developed for scaffolds.

Research for composite materials of nanofibers and particles are being conducted worldwide. Materials for the following applications are also under development by making use of features of the both.

- Electrodes
- Separation membranes
- Conductive membranes
- Sensors
- Wound treatment
- Drug delivery system
- Functional food
- Functional clothes
- Functional paint

![Graph showing transition of number of articles related to nanofibers](from the website of JST J-GLOBAL)

![Scaffold that consists of PGA/Collegen composite nanofibers for regenerative medicine by blood vessel induction](from the website of NIMS)

Structure of dust collectors and filters (from the website of NEDO)

[References]
- Scaffold material utilizing nanofibers and its application
- Patent application No. 2014-87735
  - https://www.j-platpat.inpit.go.jp/web/all/top/BTmTopPage
- Patent application No. 2013-12423
  - https://www.j-platpat.inpit.go.jp/web/all/top/BTmTopPage
- "High-tech nanofibres could help nutrients in food hit the spot"
  - The website of University of Lincoln
  - http://www.lincoln.ac.uk/news/2015/06/1102.asp
- "Flexible and unbreakable transparent conductive film"
  - The website of Tokyo Institute of Technology
- Search with "electrospinning" at the website of J-GLOBAL
  - http://jglobal.jst.go.jp/
- Development of high performance and energy-saving nanofiber filter The website of NEDO
- "The functions of shapes III - Nanofiber"
  - The website of NIMS
*FOFSBMTQFDJpDBUJPOT0QUJPOBMQBSUT4UBOEBSEQBSUT*  

**NANON-01A**  
**Electrospinning System for R & D**

The model NANON-01A is a nanofiber electrospinning system for lab use. A variety of materials can be spun by programming spinning conditions and combining system parts such as spinnerets and collectors.

- **Spinning high uniformity and quality nanofiber sheets**  
  Unique technology of MECC creates stable electronic fields, enabling spin of nanofibers of uniform fiber diameter and with very few droplets.

- **Quick and easy programming with a 10-key controller**  
  With a 10-key controller programming of parameters can be made quickly and easily. Parameter combinations for 10 materials can be preprogrammed for instant operation.

- **Easy replacement of system parts**  
  System parts such as spinnerets and collectors can be replaced quickly and easily.

- **Spinning aligned membranes of super low orientation**  
  Membranes of super low orientation can be spun using a drum or a disk collector. (patented)

- **Unique cleaning mechanism for spinnerets**  
  A device automatically to clean tips of spinnerets be integrated to the system to save much operation time.

### Purpose of Use

<table>
<thead>
<tr>
<th>Purpose of Use</th>
<th>Research and development</th>
</tr>
</thead>
</table>

### Typical objects

<table>
<thead>
<tr>
<th>Typical objects</th>
<th>Nonwovens / Aligned membranes</th>
</tr>
</thead>
</table>

### High voltage supply

<table>
<thead>
<tr>
<th>Voltage</th>
<th>0.5kV to 30kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current</td>
<td>50μA</td>
</tr>
</tbody>
</table>

### Traverse speed

<table>
<thead>
<tr>
<th>Traverse speed</th>
<th>0 to 300mm/s</th>
</tr>
</thead>
</table>

### Programmable parameter

- High voltage output
- Pump discharge volume
- Collector rotation speed
- Frequency and interval of cleaning
- Moving distance of spinneret
- Moving speed of spinneret

### Collector rotation speed

- Drum: 50 to 3000rpm
- Mandrel: 50 to 100rpm

### High voltage supply

- 50 to 150mm

### Fan exhaust volume

- 12m³/hr or more

### Pump discharge

- 0.1 to 60ml/hr

### Syringe volume

- 2.5 / 5.0 / 10.0 ml

### Safety device

- High voltage interlock
- Door lock (option)
- Emergency stop button
- High voltage lamp
- Strengthened glass
- Purification filter for exhaust

### General specifications

- Ambient temperature: 20 to 30°C
- Ambient humidity: 30% to 70% (without dews)
- Rated voltage: 85 to 125VAC / 170 to 250VAC
- 50Hz / 60Hz
- Power consumption: 1kW or less
- External dimensions: 830W x 630D x 880H (mm)
- Internal dimensions: 550W x 400D x 580H (mm)
- Weight: 140kg or less

### Standard parts

<table>
<thead>
<tr>
<th>Parts</th>
<th>Model</th>
<th>Model number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collector</td>
<td>Plate collector</td>
<td>C-PL</td>
</tr>
</tbody>
</table>

### Optional parts

<table>
<thead>
<tr>
<th>Parts</th>
<th>Model</th>
<th>Model number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collector</td>
<td>Drum Collector_Ø200W200</td>
<td>C-DR/D200W200</td>
</tr>
<tr>
<td></td>
<td>Drum Collector_Ø100W200</td>
<td>C-DR/D100W200</td>
</tr>
<tr>
<td></td>
<td>Drum Collector_Ø200W30</td>
<td>C-DR/D200W30</td>
</tr>
<tr>
<td></td>
<td>Disk Collector</td>
<td>C-DI</td>
</tr>
<tr>
<td></td>
<td>Mandrel Collector</td>
<td>C-MA</td>
</tr>
<tr>
<td></td>
<td>RtoR Collector_NANON</td>
<td>C-RR/NA</td>
</tr>
<tr>
<td></td>
<td>Y-axis Slide Collector</td>
<td>C-YA</td>
</tr>
<tr>
<td>Spinneret</td>
<td>Clip Spinneret_75</td>
<td>S-CL/75</td>
</tr>
<tr>
<td>Pump</td>
<td>Syringe Pump</td>
<td>IC3100</td>
</tr>
</tbody>
</table>

*The number (e.g. 75) with spinnerets is width of the arm.*
NF-201
Electrospinning System for R & D

The model NF-201 is a high-end nanofiber electrospinning system for lab use. A variety of materials can be spun into different shapes of nanofibers by programming spinning conditions and combining system parts such as spinnerets and collectors. Large-size samples up to 600mm x 600mm can be spun with this system.

- **A variety of system parts**
  High quality system parts such as spinnerets, collectors, pumps and power supplies are available for different materials and applications. A device to heat solutions which cannot be spun at normal temperature and spinnerets with multiple jet outlets are optionally available.

- **3-axis slider unit for ideal spinning**
  Spinning operations of high flexibility is realized by the latest 3-axis slider unit.

- **Integrating pipe spinnerets**
  High-efficiency pipe spinnerets can be integrated to the system preparing for mass production.

- **Obtaining large samples**
  A large nonwovens sample up to 600mm x 600mm can be created.

- **Spinning high uniformity nanofiber sheets**
  Thick nanofiber sheets of high uniformity can be spun by integrating a negative high voltage supply.

- **Unique cleaning mechanism for spinnerets**
  A device automatically to clean tips of spinnerets be integrated to the system to save much operation time.

<table>
<thead>
<tr>
<th>Purpose of Use</th>
<th>Collector type</th>
<th>Collector rotation speed</th>
<th>Needles to collector</th>
<th>Fan exhaust volume</th>
<th>Pump discharge</th>
<th>Syringe volume</th>
<th>Safety device</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research and development</td>
<td>Nonwovens / Aligned membranes</td>
<td>Drum 50 to 3000rpm</td>
<td>50 to 250mm</td>
<td>60m³/hr or more</td>
<td>0.1 to 60ml/hr</td>
<td>2.0 / 5.0 / 10.0 / 20.0 ml</td>
<td>· High voltage interlock · Door lock · Emergency stop button · High voltage lamp · Strengthened glass · Purification filter for exhaust</td>
</tr>
</tbody>
</table>

**General specifications**

| Ambient condition | Temperature: 10 to 40°C | Humidity: 30% to 60% (without dews) |
| Recommended spinning conditions | Temperature: 25 to 35°C | Humidity: 30% to 40% |

**Power consumption**

| Power consumption | 1.5kVA or less |

**Dimensions**

| Dimensions | 1450W x 1100D x 2000H (mm) |

**Weight**

| Weight | 700kg or less |

<table>
<thead>
<tr>
<th>Standard parts</th>
<th>Collector</th>
<th>Pump</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parts</td>
<td>Model</td>
<td>Model number</td>
</tr>
<tr>
<td>Collector</td>
<td>Plate collector</td>
<td>C-PL</td>
</tr>
<tr>
<td>Collector</td>
<td>Clip Spinnneret_100</td>
<td>S-CL/100</td>
</tr>
<tr>
<td>Pump</td>
<td>Syringe Pump (2 units)</td>
<td>P-SY</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Optional parts</th>
<th>Collector</th>
<th>Pump</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parts</td>
<td>Model</td>
<td>Model number</td>
</tr>
<tr>
<td>Collector</td>
<td>Plate Collector_600x150</td>
<td>C-PL/600x150</td>
</tr>
<tr>
<td>Collector</td>
<td>Plate Collector_600x600</td>
<td>C-PL/600x600</td>
</tr>
<tr>
<td>Collector</td>
<td>Drum Collector_200W200</td>
<td>C-DR/200W200</td>
</tr>
<tr>
<td>Collector</td>
<td>Drum Collector_200W600</td>
<td>C-DR/200W600</td>
</tr>
<tr>
<td>Collector</td>
<td>Disk Collector</td>
<td>C-DI</td>
</tr>
<tr>
<td>Collector</td>
<td>Mandrel Collector</td>
<td>C-MA</td>
</tr>
<tr>
<td>Collector</td>
<td>RotoCollector_NF(200)</td>
<td>C-RR/NF</td>
</tr>
<tr>
<td>Collector</td>
<td>RotoCollector_450</td>
<td>C-RR/450</td>
</tr>
<tr>
<td>Collector</td>
<td>RotoCollector_600</td>
<td>C-RR/600</td>
</tr>
<tr>
<td>Collector</td>
<td>Vertical Plate Collector_200</td>
<td>C-VPL/200</td>
</tr>
<tr>
<td>Collector</td>
<td>Vertical Plate Collector_600</td>
<td>C-VPL/600</td>
</tr>
<tr>
<td>Collector</td>
<td>Vertical Clip Spinnneret_100</td>
<td>S-VCL/100*</td>
</tr>
<tr>
<td>Collector</td>
<td>Tubeless Spinnneret_100</td>
<td>S-TU/100</td>
</tr>
<tr>
<td>Collector</td>
<td>Coaxial Spinnneret_100</td>
<td>S-CA/100</td>
</tr>
<tr>
<td>Collector</td>
<td>Ultra-thin Coaxial Spinnneret_100</td>
<td>S-UCA/100</td>
</tr>
<tr>
<td>Collector</td>
<td>11-Syringe Nozzle</td>
<td>S-11N/100</td>
</tr>
<tr>
<td>Collector</td>
<td>MJS_4 (8, 12) holes Nozzle</td>
<td>S-MJ/4N (8N, 12N)</td>
</tr>
<tr>
<td>Collector</td>
<td>Solution Heating Unit</td>
<td>S-HU/100</td>
</tr>
<tr>
<td>Collector</td>
<td>Pipe Spinnneret</td>
<td>S-PN</td>
</tr>
<tr>
<td>Collector</td>
<td>Gear Pump</td>
<td>P-GR</td>
</tr>
</tbody>
</table>

*The number (e.g. 100) with spinnerets is width of the arm.
**NW-101**

**Nonwoven Nanofiber Electrospinner**

The model NW-101 is an electrospinning system to spin nanofiber nonwovens of high uniformity at high speed. Nanofibers of which diameter is from 10 nanometer to several micrometer can be spun with materials such as PVDF.

- **Development of innovative pipe spinnerets**
  Newly-developed pipe spinnerets with 30 or 60 jet outlets increased productivities 3600% at a maximum compared to existing systems with one syringe. (patent pending)

- **High speed spinning of 600mm-wide membranes**
  600mm-wide membranes can be spun at 10,000mm per minute with the state-of-the-art technology.

- **Individual control of 3 high voltage supplies**
  The NW-101 can integrate 3 positive power supplies and 1 negative supply which can be controlled individually, enabling spinning with 3 different solutions at the same time.

- **High performance collector to convey very thin materials**
  Only 0.2mm-thick steel belt collector was introduced to carry thin base materials without being peeled. The conveyor speed can be programmed in the range from 20 to 10,000mm per minute.

- **Spinning thick and uniform nanofiber sheets**
  By applying negative high voltage at a maximum of 10kV to the collector nonwovens of more than 100μm-thick can be obtained. (patented)

- **Quick and easy programming of spinning conditions**
  Parameters to spin nanofiber sheets can be easily programmed with a 10-key controller. (See the table below.)

---

### Purpose of Use

<table>
<thead>
<tr>
<th>Purpose of Use</th>
<th>Research and development Pilot production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical objects</td>
<td>Nonwovens</td>
</tr>
</tbody>
</table>

### High voltage supply (Positive)

| Voltage: 0.0kV to 40.0kV Current: 0.0 to 100.0μA |
| Up to 3 units can be integrated. |

### High voltage supply (Negative)

| Voltage: 0.0kV to -10.0kV Current: 0.0 to -300.0μA |
| Discharge Solution viscosity: 100 to 5000mPa·s Up to 3 units can be integrated. |

### Gear Pump

- Positive high voltage output 1, 2, 3
- Negative high voltage
- Automatic pump discharge 1, 2, 3
- Manual pump discharge 1, 2, 3
- Spinning distance
- Conveyance speed
- Duration to retain high voltage after stopping spinning

### Programmable parameter

- Sensor for remaining materials
- Potentiometer to detect tensions
- Sensor for meandering of materials
- Maximum width: 600mm
- Maximum roll diameter: φ250mm
- Maximum length: 50m

### Pipe spinneret

- 30 or 60 jet outlets / bar
- 4 or 6 bars can be installed.

### Collector

- 600mm W x 0.2mm t x 3.3m L
- Material: SUS304
- Speed: 20 to 10,000mm/min
- Materials to carry:

### Roll to roll unit

- Option

### Safety device

- High voltage interlock
- Door lock
- Emergency stop button
- Signal tower
- Sensor for exhausting
- Strengthened glass

*The standard NW-101 system integrates 2 positive high voltage supplies, 1 negative high voltage supply, 2 gear pumps and 4 bars of pipe spinnerets with 60 jet outlets.

---

### General specifications

<table>
<thead>
<tr>
<th>Ambient temperature</th>
<th>Research and development</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient humidity</td>
<td>30% to 70% (without dews)</td>
</tr>
<tr>
<td>Rated voltage</td>
<td>85 to 264VAC · 50Hz / 60Hz</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Power consumption</th>
<th>500VA or less</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions with R to R without R to R</td>
<td>2700W x 1285D x 1870H (mm)</td>
</tr>
<tr>
<td>1990W x 1285D x1870H (mm)</td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td>1000kg or less</td>
</tr>
</tbody>
</table>
**EDEN**

**Electrospinning System for Pilot Production**

The model EDEN is a nanofiber electrospinning system for pilot production. The system can spin nanofiber sheets of 1300mm-wide onto a continuous paper roll. The same spinning conditions as that of lab systems can be utilized, enabling spinning of high quality nanofiber sheets effectively.

- The EDEN integrates multiple jet spinnerets (MJS) and spins nanofibers of more than 100μm-thick and of 1300mm-wide.
- Changeover of materials can be made easily and quickly.
- 12 pieces (4 pcs x 3 rows) of MJS can be integrated.
- Safety devices such as high voltage interlock, prefilters, signal tower and emergency switches are equipped with the system.

*The EDEN is basically a custom-made product and we build the system on having information about materials and requests from a customer. Please feel free to consult our sales representative.*

*The exhaust system outside the EDEN, which has only prefilters, to be prepared by a customer.*

---

**[ Nanofiber Samples ]**

- Nonwovens
- Aligned sheet
- Layered aligned sheet
- Interconnected structure
- Tubular scaffold
- Tubular fiber bundle
- Nanofiber coating on substrate
- Aligned fiber made with disk collector
- Core-sheath nanofiber made with coaxial spinneret
- Core-sheath nanofiber made with ultra-thin coaxial spinneret
- Nanofiber cotton
- 200mm-wide sheets made with R to R collector
## System Selection - Comparison of functions

<table>
<thead>
<tr>
<th>Photo of system</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Model name</td>
<td>NW-101</td>
<td>NF-201</td>
</tr>
<tr>
<td>Purpose of use</td>
<td>Pilot production of nonwovens</td>
<td>Research and development</td>
</tr>
<tr>
<td>Typical nanofibers to spin</td>
<td>600mm-wide nonwovens</td>
<td>600mm-wide nonwovens Aligned membrane Core and sheath fiber 600mm-wide nanofiber roll</td>
</tr>
<tr>
<td>Standard collector</td>
<td>Steel belt</td>
<td>Plate 200x150mm</td>
</tr>
<tr>
<td>Optional collector and roll-to-roll unit</td>
<td>R to R 600mm</td>
<td>Plate 600x150mm Plate 600x600mm Vertical Plate 200mm Vertical Plate 600mm Drum φ200 w200 Drum φ200 w600 Disk Mandrel R to R 200mm R to R 450mm R to R 600mm</td>
</tr>
<tr>
<td>Standard spinneret</td>
<td>60-holes pipe spinneret (4 bars)</td>
<td>Clip 100mm</td>
</tr>
<tr>
<td>Optional spinneret</td>
<td>60-holes pipe spinneret ( 2 additional bars) 30-holes pipe spinneret ( 4 or 6 bars)</td>
<td>Vertical Clip 100mm Tubeless 100mm Coaxial 100mm Ultra-thin coaxial 100mm Multiple Jet 4, 8, 12 holes Solution Heating 11-syringe Nozzle Pipe Spinneret (2 bars)</td>
</tr>
<tr>
<td>Standard pump</td>
<td>Gear pump (2 units)</td>
<td>Syringe pump (2 units)</td>
</tr>
<tr>
<td>Optional pump</td>
<td>Gear pump *1 additional unit.</td>
<td>Gear pump</td>
</tr>
<tr>
<td>Controller</td>
<td>10 (ten) key</td>
<td>Touch panel, 10-key</td>
</tr>
<tr>
<td>Distance between needle and collector</td>
<td>100 to 200mm</td>
<td>50 to 250mm</td>
</tr>
<tr>
<td>Standard power supply</td>
<td>Positive 40kV (2 units) Negative -10kV</td>
<td>Positive 50kV</td>
</tr>
<tr>
<td>Optional power supply</td>
<td>Positive 40kV</td>
<td>Negative -10kV High frequency supply (for solution heating)</td>
</tr>
<tr>
<td>Traverse speed</td>
<td>n/a</td>
<td>300mm/sec</td>
</tr>
<tr>
<td>Rotation of drum and mandrel collectors</td>
<td>n/a</td>
<td>Drum 100 - 3000rpm (Drum φ200w600: 100rpm) Mandrel 50 - 100rpm</td>
</tr>
<tr>
<td>Conveyor speed</td>
<td>10,000mm/min (max.)</td>
<td>n/a</td>
</tr>
</tbody>
</table>

*Design and specifications of systems and/or parts on this catalog may change without notice.*
Components for Electrospinning; Collector series

Nanofibers will be spun by jets of polymer solutions spraying from a spinneret, to which high voltage at 20 to 40 kilovolts is applied, to a grounded collector. A variety of nanofibers can be made by choosing collectors of different shape, size and function.

Plate Collector

Good for spinning nonwoven sheets. It is convenient to use the collector to calculate spinning conditions.

- Sample size:
  - 200 x 150mm
  - 600 x 150mm
  - 600 x 600mm

Drum Collector

Nonwoven sheets and aligned fibers can be spun by varying rotation speed.

- Sample size:
  - A4 x 2 sheets (200x600mm)
  - 450 x 628mm
  - 600 x 628mm

Mandrel Collector

Tubular nanofiber structure can be spun. Mandrels of preferred diameter can be custom made.

- Diameter of rods:
  - 1, 2, 4, 6, 8, 10 (mm)

Disk Collector

Aligned nanofiber bundles can be spun.

- Filamentous samples of 628 mm-long can be obtained.

Roll to Roll Collector

The collector can be integrated to NANON and NF series to spin nanofiber sheets. Aluminum foil can be used as base materials.

- Sample size:
  - 200mm x 10m
  - 450mm x 10m
  - 600mm x 10m

Y-axis Slide Collector

The plate collector was modified so that its Y-axis will be moved. A controller unit is required. Stroke: +/- 25mm Speed: 0 to 10mm

<table>
<thead>
<tr>
<th>Plate Collector</th>
<th>Drum Collector</th>
<th>Mandrel Collector</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Product</strong></td>
<td><strong>Model</strong></td>
<td><strong>System</strong></td>
</tr>
<tr>
<td>Plate collector</td>
<td>C-PL</td>
<td>NANON, NF</td>
</tr>
<tr>
<td>Plate collector_600x150</td>
<td>C-PL/600x150</td>
<td>NF</td>
</tr>
<tr>
<td>Plate collector_600x600</td>
<td>C-PL/600x600</td>
<td>NF</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Drum Collector</th>
<th><strong>Model</strong></th>
<th><strong>System</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Drum Collector_6200W200</td>
<td>C-DR/D200W200</td>
<td>NANON, NF</td>
</tr>
<tr>
<td>Drum Collector_6100W200</td>
<td>C-DR/D100W200</td>
<td>NANON</td>
</tr>
<tr>
<td>Drum Collector_6200W30</td>
<td>C-DR/D200W30</td>
<td>NANON</td>
</tr>
<tr>
<td>Drum Collector_6200W600</td>
<td>C-DR/D200W600</td>
<td>NF</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mandrel Collector</th>
<th><strong>Model</strong></th>
<th><strong>System</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mandrel Collector</td>
<td>C-MA</td>
<td>NANON, NF</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Roll to Roll Collector</th>
<th><strong>Model</strong></th>
<th><strong>System</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>RtoR Collector_NANON</td>
<td>C-RR/NA</td>
<td>NANON</td>
</tr>
<tr>
<td>RtoR Collector_NF</td>
<td>C-RR/NF</td>
<td>NF</td>
</tr>
<tr>
<td>RtoR Collector_450</td>
<td>C-RR/450</td>
<td>NF</td>
</tr>
<tr>
<td>RtoR Collector_600</td>
<td>C-RR/600</td>
<td>NF</td>
</tr>
<tr>
<td>RtoR Controller</td>
<td>C-RR-OP</td>
<td>NANON</td>
</tr>
<tr>
<td>RtoR Wiring Adapter _NANON</td>
<td>C-RR-WIRE/NA</td>
<td>NANON</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Disk Collector</th>
<th><strong>Model</strong></th>
<th><strong>System</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Disk collector</td>
<td>C-DI</td>
<td>NANON, NF</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Y-axis Slide Collector</th>
<th><strong>Model</strong></th>
<th><strong>System</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Y-axis Slide Collector</td>
<td>C-YA</td>
<td>NANON</td>
</tr>
<tr>
<td>Y-axis Collector Controller</td>
<td>C-YA-OP</td>
<td>NANON</td>
</tr>
</tbody>
</table>
Components for Electrospinning ; Spinneret series

Spinnerets also called "nozzles" take tens of kilovolts charge on their outlets and polymer solution jets will be injected to grounded collectors to spin nanofiber sheets. Use of spinnerets of different shape and function makes a variety of nanofibers.

**Clip Spinneret**

The standard spinneret for the NANON and the NF can spin various nanofiber sheets in a short time. Handling is easy because only the metal connector have to be cleaned.

**Coaxial Spinneret**

The spinneret can spin hollow and coaxial nanofibers. New-type nanofibers can be spun by it with functional materials.

Diameter of a core: 0.8mm
Diameter of a sheath: 2.5mm

**Solution Heating Unit**

The spinneret is to spin nanofibers by heating solutions up to 200°C. Materials which cannot be spun at normal temperature can be spun using this device.

**Tubeless Spinneret**

The spinneret can directly integrate a syringe to save solutions. Ideal for evaluation of spinning performance of various solutions and textiles.

**Ultra-thin Coaxial Spinneret**

The spinneret can spin hollow and coaxial nanofibers.

Diameter of a core: 0.2mm
Diameter of a sheath: 0.8mm

**Multiple Jet Spinneret (MJS)**

The spinneret can spin nanofibers more than 10 times efficient compared to standard spinnerets. It spins wide materials with relatively low voltages.

<table>
<thead>
<tr>
<th>[Clip Spinneret]</th>
<th>[Solution Heating Unit]</th>
<th>[11-syringe Nozzle]</th>
<th>[Multiple Jet Spinneret]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Product</strong></td>
<td><strong>Model</strong></td>
<td><strong>System</strong></td>
<td><strong>Product</strong></td>
</tr>
<tr>
<td>Clip Spinneret_75</td>
<td>S-CL/75</td>
<td>NANON, NF(75)*</td>
<td>11-syringe Nozzle_100</td>
</tr>
<tr>
<td>Clip Spinneret_100</td>
<td>S-CL/100</td>
<td>NF(100)</td>
<td></td>
</tr>
<tr>
<td><strong>[Tubeless Spinneret]</strong></td>
<td><strong>[Coaxial Spinneret]</strong></td>
<td><strong>[Ultra-thin Coaxial Spinneret]</strong></td>
<td></td>
</tr>
<tr>
<td>Product</td>
<td>Model</td>
<td>System</td>
<td></td>
</tr>
<tr>
<td>Tubeless Spinneret_75</td>
<td>S-TU/75</td>
<td>NANON, NF(75)</td>
<td></td>
</tr>
<tr>
<td>Tubeless Spinneret_100</td>
<td>S-TU/100</td>
<td>NF(100)</td>
<td></td>
</tr>
<tr>
<td>Coaxial Spinneret_75</td>
<td>S-CA/75</td>
<td>NANON, NF(75)</td>
<td></td>
</tr>
<tr>
<td>Coaxial Spinneret_100</td>
<td>S-CA/100</td>
<td>NF(100)</td>
<td></td>
</tr>
<tr>
<td>Ultra-thin Coaxial Spinneret_75</td>
<td>S-UCA/75</td>
<td>NANON, NF(75)</td>
<td></td>
</tr>
<tr>
<td>Ultra-thin Coaxial Spinneret_100</td>
<td>S-UCA/100</td>
<td>NANON, NF(100)</td>
<td></td>
</tr>
</tbody>
</table>

*MJS models are available with 4, 8 and 12 holes in different hole sizes. Please consult our sales representative.

*The number in ( ) or after / is width of the arm.
Components for Electrospinning:
High voltage / High frequency power supply

The DC high voltage power supply to apply high voltage at tens of kilovolts to spinnerets to spin nanofibers. There are 30kV/40kV/50kV models of positive or negative polarity, which can be integrated to the NF or the EDEN. A high frequency power supply is also available to heat solutions in case materials cannot be spun at normal temperature.

<table>
<thead>
<tr>
<th>Product</th>
<th>Model</th>
<th>System</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Voltage Unit_30P100</td>
<td>HVU-30P100</td>
<td>+30kV, 100μA</td>
</tr>
<tr>
<td>High Voltage Unit_30N100</td>
<td>HVU-30N100</td>
<td>-30kV, -100μA</td>
</tr>
<tr>
<td>High Voltage Unit_40P100</td>
<td>HVU-40P100</td>
<td>+40kV, 100μA</td>
</tr>
<tr>
<td>High Voltage Unit_40N100</td>
<td>HVU-40N100</td>
<td>-40kV, -100μA</td>
</tr>
<tr>
<td>High Voltage Unit_50P100</td>
<td>HVU-50P100</td>
<td>+50kV, 100μA</td>
</tr>
<tr>
<td>High Voltage Unit_50N100</td>
<td>HVU-50N100</td>
<td>-50kV, -100μA</td>
</tr>
<tr>
<td>High Frequency Supply</td>
<td>IHP-101</td>
<td>Heatable from 50°C to 200°C</td>
</tr>
</tbody>
</table>

Syringe pump / Gear pump

A syringe pump and a gear pump are available to supply spinnerets with solutions.

**Syringe Pump**
A syringe pump for the NANON.

<table>
<thead>
<tr>
<th>Product</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Syringe Pump</td>
<td>IC3100 (KDS)</td>
</tr>
<tr>
<td>Syringe Pump Adapter_NANON</td>
<td>P-SY-AD/NA</td>
</tr>
</tbody>
</table>

**Gear Pump**
A gear pump for the NW and the EDEN, which can supply solutions continuously.

<table>
<thead>
<tr>
<th>Product</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gear Pump</td>
<td>P-GR</td>
</tr>
<tr>
<td>Gear Pump Controller</td>
<td>P-GR-OP</td>
</tr>
</tbody>
</table>

Connectors

Connectors to joint syringe needles with spinnerets. There are some models for each spinneret.

<table>
<thead>
<tr>
<th>Product</th>
<th>Model</th>
<th>Spinneret</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metal Connector M-529-055A</td>
<td>M-529-055A-CA</td>
<td>Clip</td>
</tr>
<tr>
<td>Metal Connector M-529-057</td>
<td>M-529-057-CA</td>
<td>Coaxial</td>
</tr>
<tr>
<td>Needle Connector M-529-755</td>
<td>M-529-755-TU</td>
<td>Tubeless</td>
</tr>
<tr>
<td>Luer-lock Connector VRF106</td>
<td>M-VRF106</td>
<td></td>
</tr>
<tr>
<td>TAC Connector BF32-M3-SUS</td>
<td>M-TAC-BF32</td>
<td></td>
</tr>
<tr>
<td>Hose Nipple MS-3H-6</td>
<td>M-MS-3H-6</td>
<td></td>
</tr>
</tbody>
</table>

Miscellaneous

**Dehumidifier**
Controls humidity inside the spinning chamber. (Off-the-shelf product only for the NANON)

**Charcoal Filter**
To absorb organic solvents.

**Neutral Filter**
To collect nanofiber particles.

**Tefron tube**
Supplies solutions between a syringe and a spinneret.

**Syringe**
Syringe to supply solutions. (Volume: 5ml)

**Cleaning string**
String to clean a tip of a spinneret. Made of fire-resistant materials.

**Syringe Needle**

- 27g (15mm, 22mm)
- 22g (19mm)
- 18G (15mm, 19mm)
Making Samples

Experienced staff at MECC are willing to provide technical supports with knowledge and data that have been accumulated for a long time period. They calculate spinning conditions to judge feasibility to spin designated materials into nanofibers, which can save much time and cost to be spent by our customers. Any samples of small quantity or wide and long sheets can be made upon request.

[Workflow of sample making]

1. Inquiry by phone or e-mail
2. Hearing by MECC staff
   - Material · Size · Thickness · Weight · Fiber diameter
3. Preparation of materials
   - To be arranged by a customer or MECC
4. Preliminary test
   - Judgment of feasibility of spinning nanofibers
5. Discussion, Quotation
   - Discussion about specs and cost
6. Order placing
   - Having an order from a customer
7. Making samples, Delivery
   - Delivery of samples

[List of materials spun to nanofibers]

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Chemical Name</th>
<th>Min/Max Fiber Diameter</th>
<th>Biodegradability Polymer</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVDF</td>
<td>Polyvinylidene fluoride</td>
<td>300nm / 1.4μm</td>
<td></td>
</tr>
<tr>
<td>PEO</td>
<td>Polyethylene oxide</td>
<td>400nm / 1.3μm</td>
<td></td>
</tr>
<tr>
<td>PVA</td>
<td>Polyvinyl alcohol</td>
<td>300nm / 2.3μm</td>
<td></td>
</tr>
<tr>
<td>PLLA</td>
<td>Poly-L-lactic acid</td>
<td>400nm / 3.0μm</td>
<td></td>
</tr>
<tr>
<td>Nylon6, 6</td>
<td>Nylon6</td>
<td>300nm / 2.7μm</td>
<td></td>
</tr>
<tr>
<td>Nylon6</td>
<td></td>
<td>100nm / 1.0μm</td>
<td></td>
</tr>
<tr>
<td>PET</td>
<td>Polyethylene terephthalate</td>
<td>400nm / 1.8μm</td>
<td></td>
</tr>
<tr>
<td>PS</td>
<td>Polystyrene</td>
<td>400nm / 8.5μm</td>
<td></td>
</tr>
<tr>
<td>PU</td>
<td>Polyurethane</td>
<td>400nm / 1.2μm</td>
<td></td>
</tr>
<tr>
<td>PMMA</td>
<td>Poly methyl methacrylate</td>
<td>900nm / 3.0μm</td>
<td></td>
</tr>
<tr>
<td>PP</td>
<td>Polypropylene</td>
<td>1.5nm / 12.0μm</td>
<td></td>
</tr>
<tr>
<td>PE</td>
<td>Polyethylene</td>
<td>900nm / 3.0μm</td>
<td></td>
</tr>
<tr>
<td>PSU</td>
<td>Polysulfone</td>
<td>400nm / 1.4μm</td>
<td></td>
</tr>
<tr>
<td>PAN</td>
<td>Polyacrylonitrile</td>
<td>300nm / 5.0μm</td>
<td></td>
</tr>
<tr>
<td>PCL</td>
<td>Polycaprolactone</td>
<td>500nm / 15.0μm</td>
<td>〇</td>
</tr>
<tr>
<td>PLGA*</td>
<td>Poly (lactic-co-glycolic acid)</td>
<td>1.0μm / 3.0μm</td>
<td>〇</td>
</tr>
<tr>
<td>PES</td>
<td>Polyethersulphone</td>
<td>400nm / 2.6μm</td>
<td></td>
</tr>
<tr>
<td>PEG</td>
<td>Polyethylene glycol</td>
<td>700nm / 2.4μm</td>
<td></td>
</tr>
<tr>
<td>CA</td>
<td>Cellulose acetate</td>
<td>400nm / 5.1μm</td>
<td>〇</td>
</tr>
</tbody>
</table>

Note: Materials of a certain manufacturer may be difficult to be spun or some materials may not be adequate for mass production.

*Copolymer

[Photo of samples]

- Aligned sheet (PLLA)
- Nanowovens (PAN)
- Hollow nanofiber (PLLA)
- Nanofiber bundle (PLLA)

[SEM images]

- Nanowovens
- Aligned sheet
- Beaded nanofiber
- Porous nanofiber
- Nanofilament
Typical Customers

JAPAN
- Tokyo University
- Kyoto University
- Tokyo Institute of Technology
- Tohoku University
- Kyushu University
- Nagoya University
- Kobe University
- AIST
- RIKEN

KOREA
- KAIST
- UNIST
- Joowon Industrial

SINGAPORE
- National University of Singapore
- Nanyang Technological University
- Clearbridge

THAILAND
- TISTR

CHINA
- Zhejiang University
- Shanghai Jiao Tong University
- Sichuan University
- Beijing University of Chemical Technology
- Nanjing Biaojiao Scientific and Technical

TAIWAN
- National Taiwan University
- National Taiwan Normal University
- Ming-Chi University of Technology
- Academia Sinica

SAUDI ARABIA
- King Saud University
- KFUPM

EGYPT
- Zewail University
- American University of Cairo

INDIA
- Naval Material Research Laboratory
- DIK

GERMANY
- Centi

PORTUGAL

Spain
- LEITAT

ITALY
- M. Penati Strumenti
- CNR - IPCB
- IIT - Istituto Italiano di Tecnologia
- Università degli Studi di Pavia

IRELAND
- Trinity College

POLAND
- IFTR of Polish Academy of Sciences

RUSSIA
- Labtest

AUSTRALIA
- University of Wollongong

U.S.A.
- University of Washington
- Vanderbilt University
- Georgia Southern University

CANADA
- University of British Columbia
- University of Guelph

Corporate Profile

Name: MECC CO., LTD.
Address: 196-1 Fukudo, Ogori-shi, Fukuoka 838-0137 JAPAN
President: Toshio Yanagihara
Business Operation: Development and manufacturing of electronic equipment
- Operation of cable television (broadcasting and internet provider)
Number of Employees: 55
Capital: JPY 40,000,000. (USD 400,000)
Establishment: May 1973
Correspondent Bank: Nishinihon City Bank, Fukuoka Bank, Mizuho Bank
Factory: 196-1 Fukudo, Ogori-shi, Fukuoka 838-0137 JAPAN
Access:
- 45 minutes’ drive from Fukuoka airport
- 8 minutes’ drive from JR Tosu station

MECC Headquarters

Location of Fukuoka, Japan
From Fukuoka: Tokyo 900km, Seoul 550km, Shanghai 870km
Contribute to the World with "Only One" Technology.