# NPS-20

## Benchtop Flame Spray Pyrolysis System for Nanoparticle Synthesis


- ☐ BENCHTOP FLAME SPRAY PYROLYSIS (FSP) UNIT
- ☐ LAB-SCALE SYNTHESIS OF NANOPARTICLES
- ☐ FULY INTEGRATED TURNKEY SYSTEM
- ☐ RAPID SCREENING OF MATERIAL COMPOSITIONS AND PROCESS CONDITIONS


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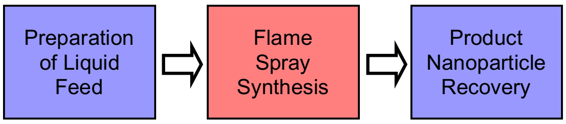
## FSP process description

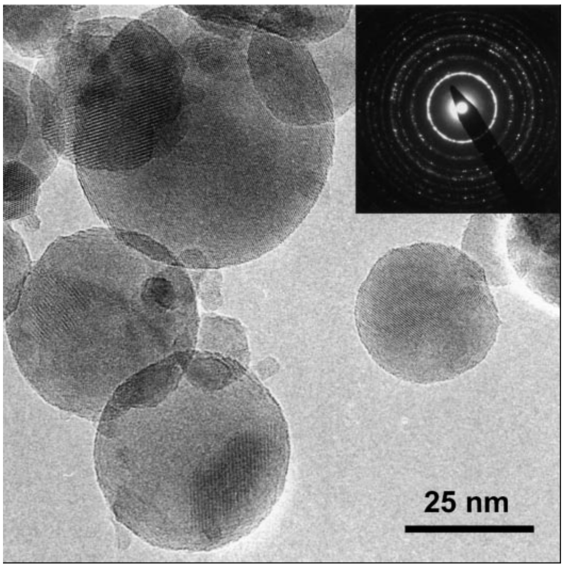
Flame Spray Pyrolysis (FSP) is a versatile and cost-efficient production process for nanoparticles. It relies on the combustion of liquid raw materials containing metal or transition metal compounds at temperatures up to 3000°C. Product nanoparticles are formed within milliseconds and collected as a dry powder on a filter.




The FSP process benefits from an extremely short process chain, enabling the production also of complex nanoparticles in a single step.

## Product Nanopowders

FSP typically produces highly-crystalline oxide nanopowders but phosphates and pure metals have been synthesized as well. A typical size range for primary particles is 5 to 50 nm depending on the process conditions. These primary particles form larger agglomerates.




Examples of product nanopowders include simple metal oxides like $TiO_2$, $Al_2O_3$, $ZrO_2$ as well as complex oxides such as YSZ, CGO, perovskites or spinels. Also, noble metal nanoparticles can be made and deposited onto oxide support particles in the flame. For some compositions, surface-coated or matrix-imbedded nanoparticles can be produced.

Applications of FSP nanoparticles include:

- Catalysts
- Battery materials
- Ceramics
- Pigments
- Dental and biomedical materials
- Gas sensors
- Polymer nanocomposites
- Electroceramics
- ...

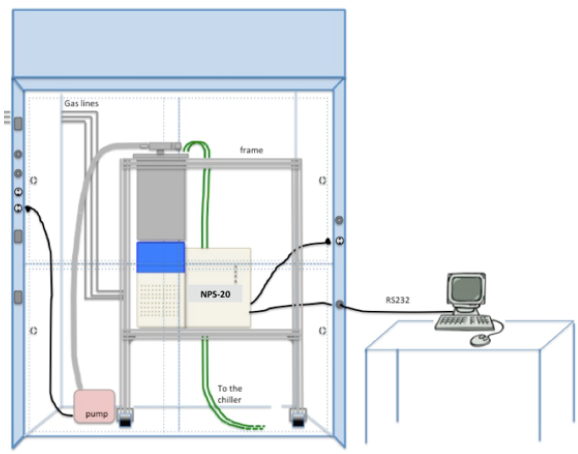
## Raw materials

The starting materials for FSP are low-cost metal compounds such as carboxylic acid salts, nitrates, or organometallics. These so-called "precursors" are mixed or dissolved in standard organic solvents (e.g. alcohols, aromatics) that provide the energy for the flame synthesis.

Oxygen is preferably used to disperse the liquid precursor and to complete combustion. A concentric methane-oxygen "supporting" flame ignites the precursor-solvent spray and assures stable combustion. In addition to this, an optional sheath gas (oxygen, air or inert gas) can be employed to envelope the flame and modify the combustion environment.

**NPS-20** is a turnkey bench-top flame spray pyrolysis unit for nanoparticle synthesis at the research and early product development level. NPS-20 has been designed for fast screening of the broad parameter space of material compositions and process conditions available in FSP synthesis to speed up nanomaterial development.

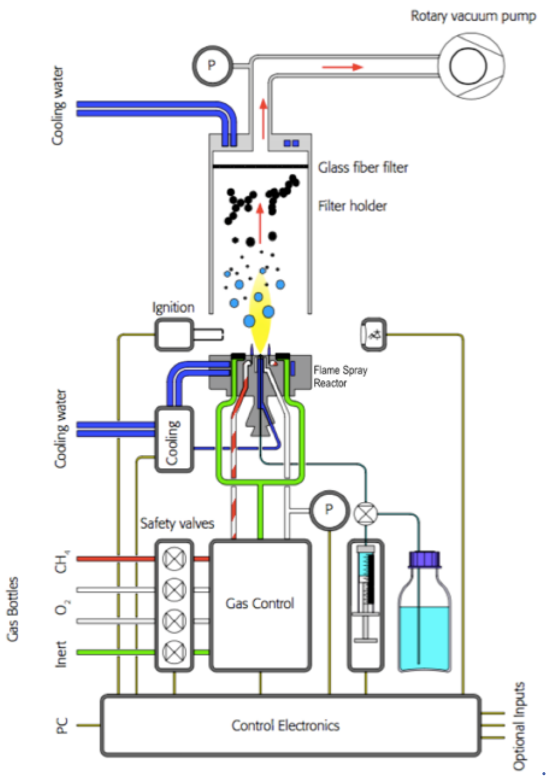
The NPS-20 can be placed on a laboratory bench or is delivered with a mobile rack on request. In any case the system must be placed in a chemical fume hood or similar enclosed and vented area for operation.




## Main features

- Lab-scale flame spray reactor
- Low-pulsation syringe pump for precise feeding of liquid precursor.
- 4 mass flow controllers for delivering the process gases: dispersion oxygen, supporting flame methane and oxygen and optional sheath gas.
- Automatic flame ignition system.
- Flame detector.
- Integrated microprocessor and electronic board for process control.
- Control software and communication via RS 232.
- Glass fibre filter and dry rotary vane vacuum pump for the collection of product powders.
- Pressure and temperature gauges for monitoring the filter status.

## Schematic of the NPS-20



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# NPS-20

## Technical Specifications

### Mechanical data

| | | |
|---|---|---|
| Supporting frame | Approx. overall dimensions (L x W x H) | 110 x 60 x 160 cm |
| Pump | Dimensions (L x W x H) | 50 x 29 x 25 cm |
| | Weight | 31 kg |
| NPS-20 | Dimensions (L x W x H) | 71 x 43 x 53 cm |
| | Weight | 75 kg |
| Filter holder | Approx. overall dimensions (L x W x H) | 30 x 30 x 70 cm |
| | Weight | 15 kg |

### Electrical data

| | |
|---|---|
| Power supply | 110 – 230 VAC, 50 – 60 Hz |
| Power consumption | 100 W |
| Communication | RS-232 |
| Interfaces for external interlocks | 3 |
| Process control | PC |

### Technical data

| | |
|---|---|
| Inlet gas connections | 4 lines with 1/8" compression fittings |
| Inlet gas pressure | 6 – 9 bar |
| Supporting flame CH4 flow rate | 0 – 5 L/min |
| Supporting flame O2 flow rate | 0 – 5 L/min |
| Dispersion gas type | O2, Air |
| Dispersion gas flow rate | 0 – 10 L/min |
| Sheath gas type | O2, Air, inert gas |
| Sheath gas flow rate | 0 – 20 L/min |
| Precursor flow rate | 0 – 15 mL/min |
| Precursor syringe volume | up to 50 ml |
| Minimum cooling water flow | 0.5 – 2.5 L/min |
| Maximum cooling water inlet temperature | 20 °C |
| Maximum cooling water pressure | 10 bar |
| Cooling water connection | fittings for ID 8mm OD 10mm |

### Pump specifications

| | | |
|---|---|---|
| Power supply | | 110 – 220 V @ 50 – 60 Hz |
| Nominal displacement | 50 Hz | 25 $m^3$/h |
| | 60 Hz | 30 $m^3$/h |
| Ultimate Pressure | | 120 mbar |
| Nominal motor rating 3~ (1~) | 50 Hz | 0.9 (0.9) kW |
| | 60 Hz | 0.9 (0.9) kW |
| Noise level (DIN 45635) | 50 Hz | 60 dB(A) |
| | 60 Hz | 62 dB(A) |

### Filter specifications

| | |
|---|---|
| Material | Borosilicate glass microfiber |
| Thickness | 350 µm |
| Porosity | 1 µm |

### Filter holder specifications

| | |
|---|---|
| Materials | Stainless steel, anodized aluminum, brass, Viton |
| Cooling water connections | 2 hoses for 8 mm I.D. tubing |
| Cooling water flow | 2 – 10 L/min |

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| | |
|---|---|
| Maximum cooling water inlet temperature | 20 °C |
| Maximum cooling water pressure | 10 bar |

**Sensors**

| | | |
|---|---|---|
| Pressure | Type | Analog |
| | Range | -1 – 3 bar |
| | Materials | Stainless steel, ceramic |

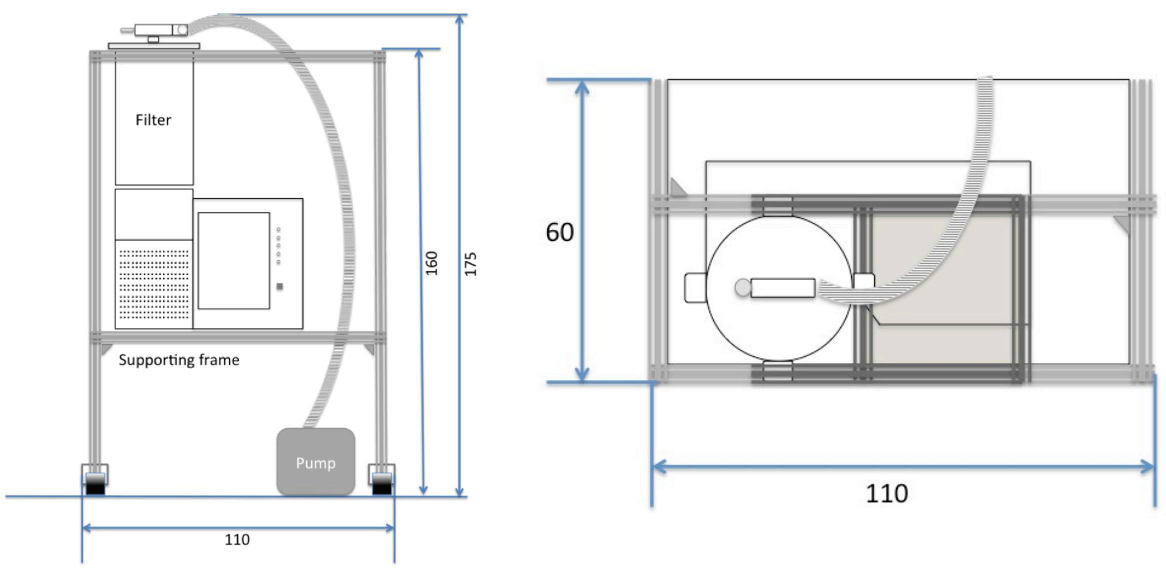
**Environment**

| | |
|---|---|
| Operating temperature range | 0 °C – 45 °C |
| Operating humidity | 20% - 90% non condensing |
| Storage temperature | -20°C – 75°C |
| Storage humidity | 20% - 90% non condensing |
| Placement | Vented fume hood |

**Material compatibility**

| | | |
|---|---|---|
| Materials in contact with gases | | Stainless steel, brass, ceramic, Viton, FKM, NBR |
| Materials in contact with precursor: | | |
| | Nozzle capillary | Stainless steel, Kel-F |
| | Precursor flask | Glass |
| | Syringe | Glass and PTFE |
| | Precursor delivery tubes | PTFE |
| | 3-way valve | PEEK |
| Materials in contact with cooling water | | Stainless steel, brass, PTFE |

## Layout




*Front and top view, dimensions in cm.*

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