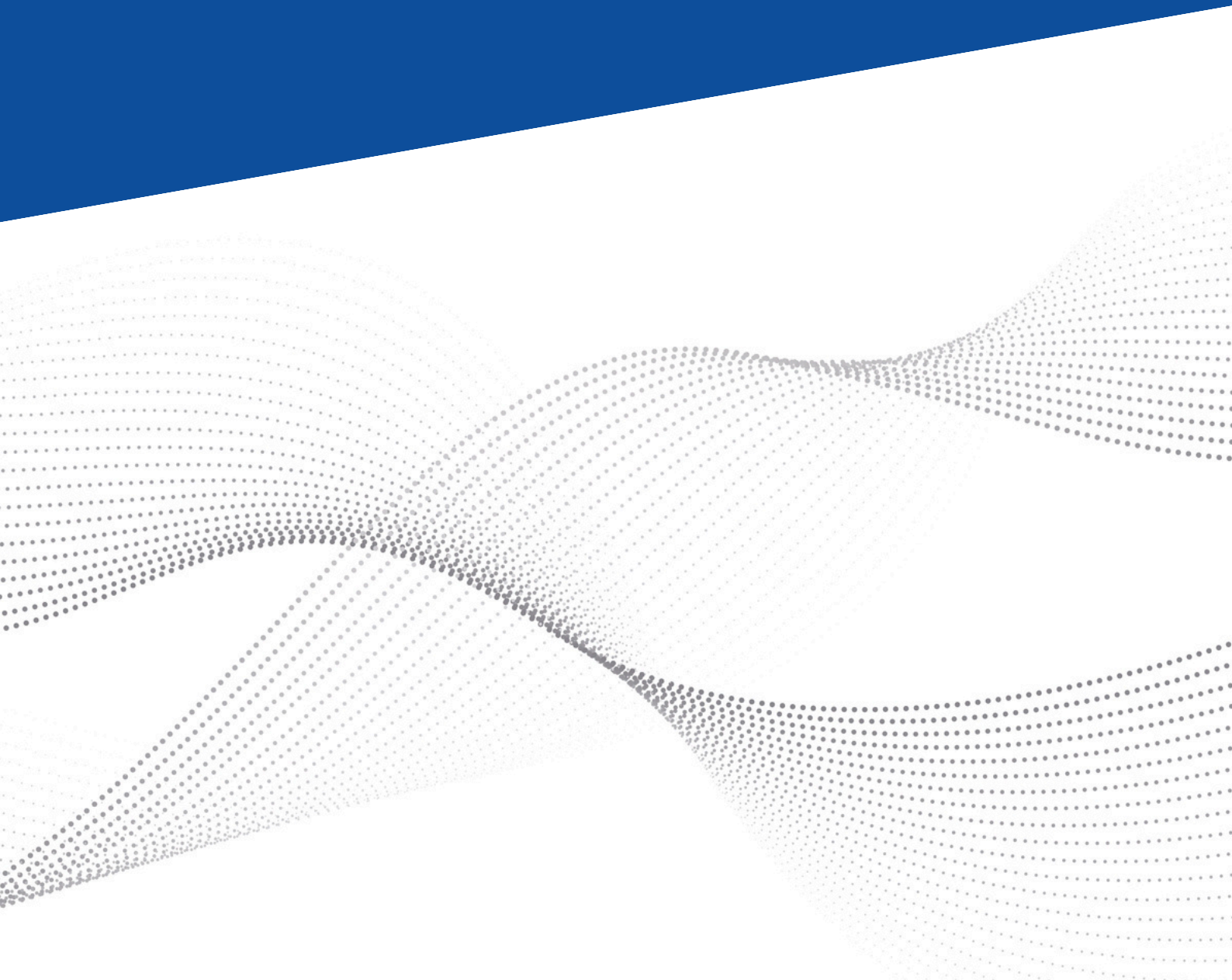


JETMILLMFG

The Ultimate Guide to Micronization



1. What is Micronization?

A micron is a unit of length that is equal to one millionth of a meter. Micronization refers to a method in which substances are processed into very small particles, typically ranging in size from 0.1 to 10 microns.

2. Why is Micronization Important?

Micronization is important for various reasons.

2.1 Increased Surface Area

By reducing the particle size to the micron level, the surface area of the substance is significantly increased. This can enhance the dissolution rate, bioavailability, and overall effectiveness of pharmaceuticals and other products.

2.2 Improved Mechanical Properties

Ultrafine powders can exhibit unique mechanical properties such as increased strength, ductility, and hardness, which can be beneficial in advanced material applications.

2.3 Enhanced Optical Properties

The small size of ultrafine particles can lead to interesting optical effects, such as improved color saturation, increased light absorption, and unique light scattering properties.

2.4 Greater Chemical Reactivity

Ultrafine powders often have higher chemical reactivity due to their increased surface area, making them useful in catalysis, chemical reactions, and material synthesis.

Overall, micronization plays a vital role in enhancing the performance, quality, and usability of a wide range of products across various industries.

3. Methods of Micronization

Micronization methods can be divided into two main categories: traditional techniques and modern techniques.

3.1 Traditional Techniques

Dry grinding and wet grinding are two common methods used for particle size reduction. Dry grinding

involves the process of reducing particles to smaller sizes without the presence of any liquid or solvent. Wet grinding is the process of reducing particles to smaller sizes using a liquid or solvent to aid in the breakdown of the material.

3.1.1 Jet Mill

A [jet mill](#), also known as micronizer, is a grinding equipment used in super fine particle size reduction. In a jet mill, particles are introduced into a high-speed stream of gas inside a grinding chamber. The kinetic energy in the stream of gas causes interparticle collision, and as the high-velocity particles hit against each other, they break apart, creating finer particles.



Figure 1: Jet mill

Advantages of Jet mills

- Fine particle size and uniform distribution
- Suitable for heat-sensitive material at a low temperature
- High product purity due to minimal or no mechanical wear

Disadvantages of Jet mills

- Require compressed air as an energy source
- Not suitable for high ductile substance

3.1.2 Air Classifier Mill

An [air classifier mill](#) combines a mechanical mill with an internal air classifier in a single machine. The material is fed into the mill and impacted by hammers or pins rotating at high speeds. After the grinding process, the air classifier inside the mill separates the particles based on their size. This classification process allows for the controlled size distribution of the final product.

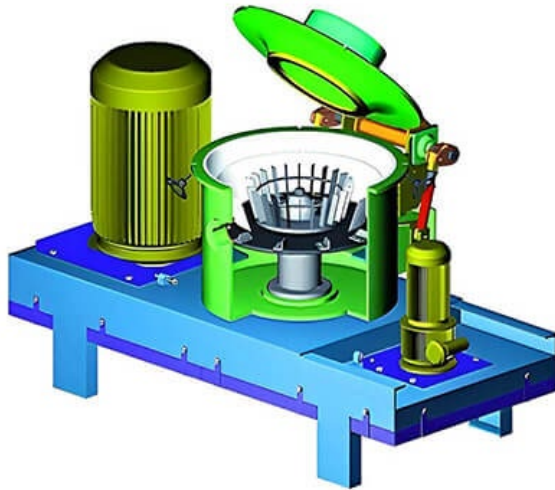


Figure 2: Air classifier mill

Advantages of Air classifier mills

- Combines Grinding and Classification
- Uniform Particle Size Distribution
- Relatively low energy consumption

Disadvantages of Air classifier mills

- Significant initial investment cost
- Heat generated during the grinding process
- Require regular maintenance and replacement of parts

3.1.3 Ball Mill

A cylindrical shell rotates around its horizontal axis. As the ball mill rotates, the grinding media (balls) inside it impact and grind the material into a fine powder. The balls impact the material, causing it to break into smaller particles through impact and attrition forces. The rotation speed of the ball mill can be controlled to achieve optimal grinding performance.

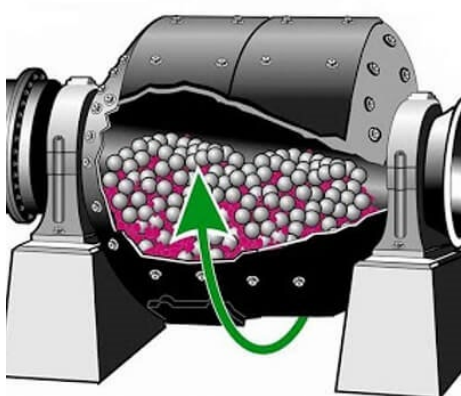


Figure 3: Ball mill

Advantages of Ball mills

- Continuous operation for large-scale production
- Easy to operate and maintain thanks to a simple design

Disadvantages of Ball mills

- Require long grinding time
- Potential for contamination due to wear of the grinding media
- Significant noise and vibration

3.1.4 Bead Mill

Bead mills are primarily used for wet grinding processes where the material being processed is in a liquid or slurry form. The grinding media and the material are agitated in the mill, leading to particle size reduction and dispersion. Bead mills are effective in reducing the size of particles to achieve a finer and more uniform particle size distribution. Bead mills are commonly used for dispersing pigments, dyes, and other additives in liquid formulations.



Figure 4: Bead mill

Advantages of bead mills

- Suitable for ultra-fine processing
- High grinding uniformity

Disadvantages of bead mills

- High energy consumption during operation
- Maintenance challenge due to complex internal structure
- Challenges in bead size and material selection

3.1.5 Colloid Mill

A colloid mill consists of a rotor and a stator that work together to process the materials. The high-speed rotation creates intense shear forces that reduce the size of solid particles in a liquid. Colloid mills are effective in reducing the particle size of solids and achieving a fine dispersion in liquids. The higher the shear, the finer the resulting particle size. They can process materials such as solids suspended in a liquid, semi-solids, and liquids containing solid particles.



Figure 5: Colloid Mill

Advantages of colloid mills

- Suitable for highly viscous products
- Adjustable gap settings between rotor/stator for particle size control
- CIP and SIP available

Disadvantages of colloid mills

- Not suitable for large-scale production
- Prone to wear and tear

3.1.6 High Pressure Homogenizer

A high-pressure homogenizer consists of a positive displacement pump that generates high pressure to force the material through a narrow orifice or valve. As the material passes through the narrow gap, the intense pressure and velocity create shearing forces that further break down particles into smaller sizes. Additionally, the sudden drop in pressure after passing through the orifice can induce cavitation, leading to additional particle disruption.

Advantages of High-pressure homogenizers

- High uniformity and stability of final products
- Various applications such as emulsification, dispersion, and cell disruption



Figure 6: High-pressure homogenizer

Disadvantages of High-pressure homogenizers

- Significant amount of energy
- Not suitable for high viscosity products
- High requirements for mechanical sealing

3.1.7 Comparison of Traditional Micronization

Method	Dry / Wet	End Fineness	Application
Jet Mill	Dry Grinding	1 μm – 50 μm	Used for micronizing of solids in pharmaceuticals, chemicals, food, cosmetics, minerals
Air Classifier Mill	Dry Grinding	10 μm – 400 μm	Mass continuous production, suitable for mineral and chemical industry
Ball Mill	Dry Grinding	0.1 μm - 30 μm	Widely used for grinding material such as cement, coal, limestone and pigment
Bead Mill	Wet Grinding	50 nm – 10 μm	Typically used in the production of coatings, inks and various chemicals
Colloid Mill	Wet Grinding	2 μm – 40 μm	Fine grinding and emulsification in food, cosmetics and chemical industry
High Pressure Homogenizer	Wet Grinding	1 μm – 5 μm	Homogenization in the production of dairy products, cosmetics, pharmaceuticals

3.2 Modern Techniques

Supercritical fluid technology is an advanced micronization technique that leverages the unique properties of supercritical fluids to achieve fine particle size reduction. A supercritical fluid is a substance at a temperature and pressure above its critical point, where it exhibits properties of both liquids and gases. Carbon dioxide is the common supercritical medium due to its low critical temperature and pressure, non-toxicity, non-flammability.

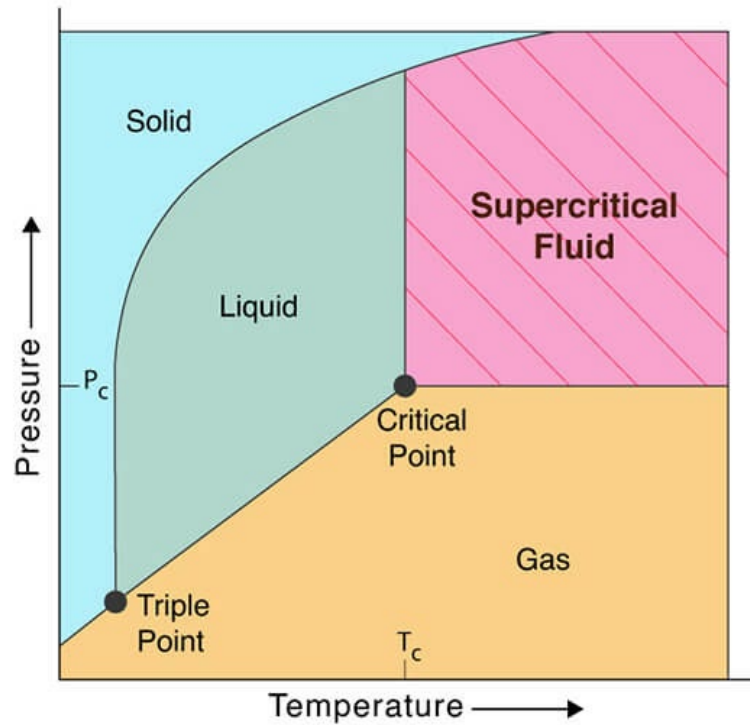


Figure 7: Supercritical fluid

3.2.1 Rapid Expansion of Supercritical Solution (RESS)

In the RESS process, organic material is dissolved in $scCO_2$ and then rapidly expanded through an expansion nozzle, resulting in a sudden pressure drop to atmospheric levels. This causes the dissolved substance to precipitate as fine particles. The RESS technique is effective for producing uniform and pure micronized particles, especially for thermally sensitive materials.

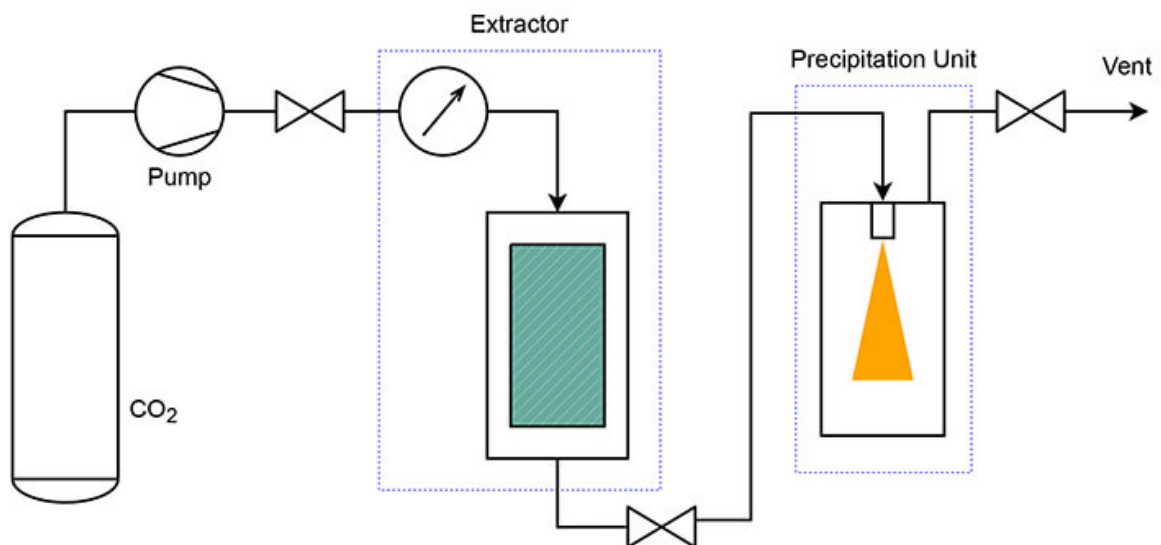


Figure 8: RESS

3.2.2 Supercritical Anti-Solvent (SAS)

SAS mainly micronizes substances that are insoluble in supercritical fluids. When a supercritical fluid is mixed with a solution containing a dissolved substance, the supercritical fluid reduces the solubility of the substance, causing it to precipitate as fine particles.

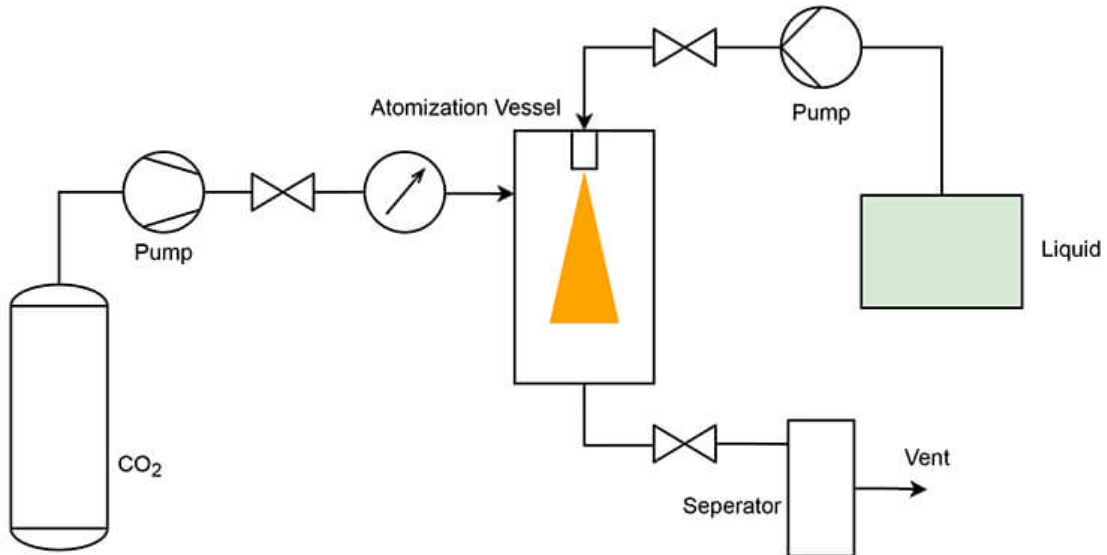


Figure 9: SAS

3.2.3 Particles from Gas Saturated Solution (PGSS)

The substance is first dissolved in a liquid solvent. The solution is then brought into contact with scCO₂ at high pressure. The saturated solution is then rapidly expanded through a nozzle into a low-pressure chamber. Due to the drop in temperature and solubility, the solute precipitates out of the solution, forming fine particles.

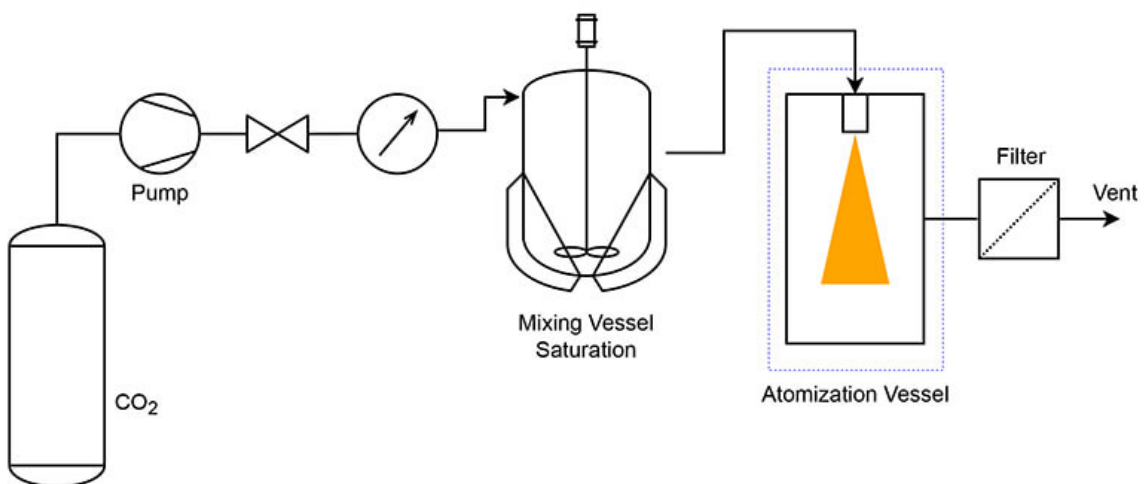


Figure 10: PGSS

3.2.4 Comparison of Modern Techniques

Item	RESS	SAS	PGSS
Role of SCF	Solvent	Anti-Solvent	Solute
Driving force	Pressure	Solubility	Temperature
Working Pressure Dependence	SCF	SCF	Morphology
Working Temperature Dependence	SCF	SCF	Highest
Particle Size	Micro & Nano	Micro & Nano	Micro & Nano

4. Future Trends

We are faced with more challenges to meet the more demanding requirements. Future trends in micronization are expected to focus on innovation, sustainability, efficiency, and customization.

- Nanotechnology Integration

With the increasing demand for nanoscale materials, micronization processes will integrate nanotechnology principles to produce nanoparticles with specific properties.

- Online control of product fineness

By implementing the online monitoring and control system, we make sure the production of high-quality micronized products with the desired fineness characteristics.

- Product purity improvement

Reducing product contamination is a constant issue. Improving product purity is essential to ensure the quality and meet regulatory requirements.

- Reduction of energy consumption

Green micronization processes will offering advantages such as reducing energy consumption and minimizing waste generation.

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